

Original paper

# Incidence of anterior cruciate ligament injury and other knee ligament injuries: A national population-based study

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## Abstract

There has been an intensive research effort directed at determining the cause of non-contact anterior cruciate ligament (ACL) injury over the past decade, but few studies have reported data on the incidence of ACL and other knee ligament injury in the general population. New Zealand's no-fault injury compensation data provides a national injury resource of data on claims for knee ligament injury. The goal of this paper was to provide a descriptive epidemiology of knee ligament injury in this country. Data were obtained for knee ligament injuries between 1 July 2000 and 30 June 2005. Injuries were categorised as non-surgical (NS), ACL surgeries (ACLS) and other knee ligament surgeries (OKLS). Incidence rates per 100,000 person-years were computed using population estimates. Costs and number of treatment/rehabilitation visits were obtained as an indication of severity. The incidence rate per 100,000 person-years was 1147.1 for NS, 36.9 for ACLS and 9.1 for OKLS. Males had a higher incidence rate than females for NS, ACLS, and OKLS. The mean (and median) number of treatment visits were NS: 6.6 (4), ACLS: 27.1 (24), and OKLS: 31.3 (24). The mean (median) treatment costs of these injuries were NS \$885 (\$129), ACLS \$11,157 (\$8574), and OKLS \$15,663 (\$8054). Analysis of injury descriptions for ACLS injuries indicated that 58% involved a non-contact mechanism of injury. These data underscore the high level of short-term disability associated with knee ligament injuries, especially ACL injuries that require surgery.

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## 1. Introduction

There has been an intensive research effort directed at determining the cause of non-contact anterior cruciate ligaments (ACL) injury over the past decade.<sup>1</sup> In view of this, it is surprising that few studies have reported data on the incidence of ACL and other knee ligament injury in the general population or in a sporting population. A comprehensive descriptive epidemiology, using population-based data, can identify high-risk subgroups within the general population, illuminate the settings and mechanisms of injury, and

help target intervention programs aimed at reducing these injuries.

It has been noted that although males account for the majority of injuries in the general population, when one accounts for physical activity (by examining specific sports), females are consistently observed to be at higher risk.<sup>2</sup> The fact that males account for more injuries than females in the general population is almost certainly due to their greater exposure to athletic tasks that predispose one to ACL injury, such as cutting and jumping, and to contact sports.

The paper provides a descriptive epidemiology of sport and general knee ligament injury of one country (New Zealand). New Zealand's (NZ) no-fault injury compensation system (administered by the Accident Compensation

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Corporation or ACC) means that NZ is uniquely positioned to provide a national detailed and national descriptive epidemiology including costs associated with treatment. Using this data, a comparison of the incidence and cost of ACL injury in relation to other knee injuries was conducted.

## 2. Methods

Data from ACC were used to provide a detailed descriptive epidemiology of knee ligament injury (including ACL injury). This national data system for tracking injury compensation includes data on costs and health care resource utilisation. Knee ligament injuries were categorised as non-surgical (NS), anterior cruciate ligament surgeries (ACLS) and other knee ligament surgeries (OKLS). Incidence rates were computed using population estimates. Criteria for selection were injuries that involved knee ligaments: anterior and posterior cruciate; lateral and medial collateral ligament; lateral and medial meniscus; and other ligament injuries. Claim data were extracted for the period between 1 July 2000 and 30 June 2005. All injury costs incurred up to, and including, 19 May 2006 were included.

The ACC is a NZ government taxpayer-funded monopoly, in existence since 1974, providing a 24-h no-fault personal injury scheme, currently legislated by the Injury Prevention, Rehabilitation and Compensation Act 2001. The ACC scheme provides universal no-fault coverage for most injury costs including medical treatment, income replacement, social rehabilitation and vocational rehabilitation, and ancillary services such as transport and accommodation.

People who have a personal injury make a claim to ACC at the time of seeking medical treatment from over 30,000 registered medical professionals throughout NZ. When making a claim, information about the injury is collected using standard forms to ensure levels of consistency for data analysis. The injured person (unless impaired) completes information about the activity surrounding the injury (e.g., location, activity prior, cause, narrative) along with their personal details (e.g., age, gender, contact details). The registered medical professional completes the form by providing information regarding initial diagnosis and other relevant medical information (e.g., surgical procedure). The claim is then filed with ACC and details are entered into a central database.

There is no disincentive for making a claim; people are not discriminated against, risk rated or penalised for the number of claims made. The guarantee of personal injury coverage is offset by the fact that one cannot sue for personal injury in NZ, except in the rare circumstances of exemplary damages (e.g., mental trauma or stress). There is a considerable incentive to make a claim, since the ACC will compensate for a wide range of injury-related costs, including medical care and loss of earnings. To make people aware of coverage, ACC undertakes a number of public information campaigns.

To ensure capture of high quality data and prevent fraud, ACC has in place a number of procedures. Given the volume

of information, errors transposing information from paper to an electronic database will occur. The ACC is subject to extensive data quality procedures. An ACC data quality audit assessed gender at 100% and age at 98% correct, respectively.<sup>3</sup> Other audit assessment figures are presented next to the relevant section in this paper.

Sports-related ACL surgeries were classified by “injury mechanism” (what the patient was doing when the injury occurred) based on a review of the short narrative injury descriptions included on the electronic claims record. People making claims can fill out a narrative box asking “What were you doing – what happened – how was the injury caused?” However, this is not a mandatory field and there is some variation in terms of the level of detail recorded in the narrative. The injuries were classified into one of four contact classifications: direct contact (external force was directly applied to the injured knee, and was probably the proximate cause of the injury); indirect contact (external force was applied to the athlete but not directly to the injured knee. External force was involved in the injury process but was probably not the proximate cause); contact unknown (insufficient detail to distinguish); or non-contact (forces applied to the knee at the time of injury resulted from the athlete’s own movement and did not involve contact with another athlete or object).<sup>4</sup>

Population data for NZ were obtained from official government data<sup>5</sup> and provide estimates of resident populations between each 5-year census, the most recent being 2001. The population of NZ over the study period was approximately 4.1 million people.<sup>6</sup>

Incidence rates (the number of injuries divided by the corresponding population times the number of study years, multiplied by 100,000) and corresponding 95% confidence intervals (95% CI) were calculated under standard large-sample Poisson assumptions. The mean, median and standard error of the number of visits and costs were also calculated. A limitation of the analyses for sports-related injuries is that the denominator of the number of participants in each sport in New Zealand is currently not routinely available.

## 3. Results

There were 238,488 knee ligament injury claims accepted by the ACC over this 5-year period. Of these, 9197 (3.9%) underwent surgery, with 7375 (80%) identified as ACLS. The population-based incidence rate per 100,000 person-years was 1147.1 (95% CI 1142.4; 1157.8) for NS, 36.9 (36; 37.8) for ACLS and 9.1 (8.7; 9.5) for OKLS.

Claim data summarising the location where the injury occurred are presented in Table 1. Only 59.5% of NS, 79.8% of ACLS and 81.5% of OKLS had location identified. An ACC data quality audit assessed the reliability of coding of location and activity to be 99% and 90% correct, respectively.<sup>3</sup> ACLS injury was more likely to be sports-related than the other two types of knee ligament injury. In 65% of ACLS injuries the location was a place of recreation or

Table 1

Number of injuries and percentage by location where the injury occurred for non-surgical knee ligament injuries (NS), ACLS, and other knee ligament surgery (OKLS) where location was identified

Location <sup>a</sup> where injury occurred	NS		ACLS		OKLS	
	Injury #	Percentage (%)	Injury #	Percentage (%)	Injury #	Percentage (%)
Commercial or Service Location	12,627	9.3	264	4.5	99	6.7
Farm	4,720	3.5	108	1.8	58	3.9
Home	35,639	26.1	655	11.1	441	29.7
Industrial Place	15,217	11.2	228	3.9	139	9.4
Other	12,283	9.0	489	8.3	175	11.8
Place of Recreation or Sports	44,323	32.5	3833	65.1	397	26.8
Road or Street	8,309	6.1	213	3.6	122	8.2
School	3,318	2.4	94	1.6	53	3.6
Total	136,436	100.0	5884	100.0	1484	100.0

<sup>a</sup> Location was missing for 40% of NS claims, 20% of ACLS claims, and 18% of OKLS claims. # = number.

sport, compared to 32% of NS and 27% of OKLS ( $\chi^2 = 2723$ , d.f. = 2,  $p < 0.001$ ).

Fig. 1 presents the rate and 95% CI per 100,000 person-years for males and females by 5-year age groups for NS knee

ligament Fig. 1(A), ACLS Fig. 1(B), and OKLS Fig. 1(C) injuries. Age/sex specific incidence rates for the subset of injuries that involved sport are also shown for NS Fig. 1(D), ACLS Fig. 1(E), and OKLS Fig. 1(F) injuries.

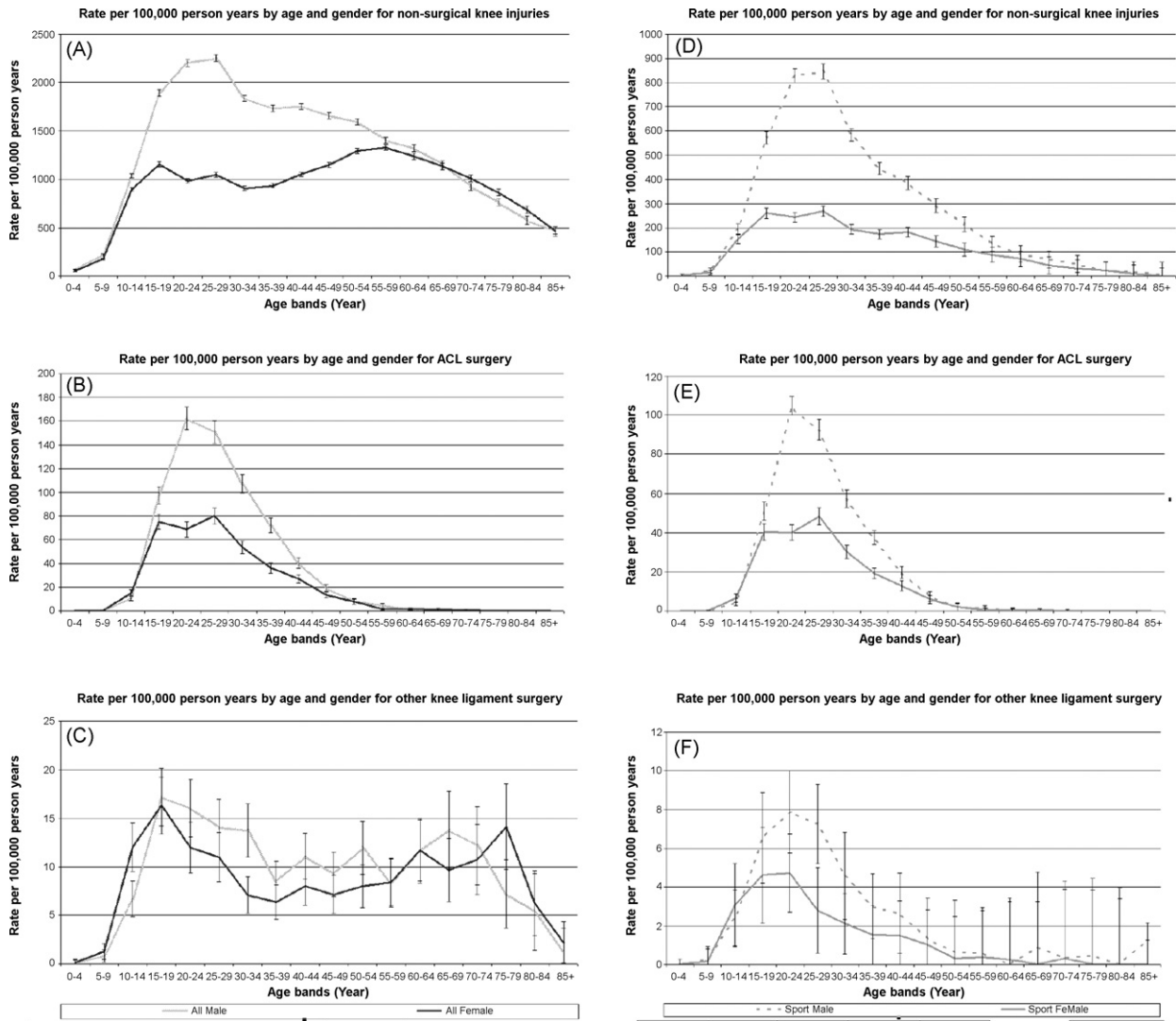


Fig. 1. Annual rate per 100,000 person-years by age and gender for total NS, ACLS, and OKLS injuries (A–C) and for sport-related NS, ACLS, and OKLS injuries (D–F). Error bars indicate 95% confidence intervals. Note that the scale used for incidence (y-axis) varies between charts.

Table 2  
Type of contact resulting in injury for sport related ACLS injuries, by sport

Sport	Contact				Non-contact		Insufficient information in narrative #	Total
	Contact, could be direct or indirect #	Direct contact #	Indirect contact #	Total contact #	#	%		
Rugby Union	349	74	57	480	276	36.5	196	952
Netball	76	24	33	133	483	78.4	130	746
Soccer	122	36	30	188	297	61.2	127	612
Touch Rugby	38	7	17	62	217	77.8	74	353
Skiing	119	4	7	130	58	30.9	35	223
Basketball	11	8	10	29	113	79.6	30	172
Rugby League	64	7	6	77	41	34.7	34	152
Hockey	19	4	4	27	44	62.0	14	85
Motor sports/motor cycling	31	8	17	56	15	21.1	8	79
Squash	7	0	4	11	31	73.8	15	57
Martial arts	8	6	4	18	29	61.7	7	54
Snowboarding	14	4	7	25	24	49.0	5	54
Other sports	85	17	21	123	266	68.4	69	458
Total	943	199	217	1359	1894	58.2	744	3997

# = number.

There were 27 cases (6 female and 21 male) where the person's age was not identified. All were non-surgical. Males had a higher rate than females in most of the age groups with males in some age groups having a rate over twice that of the females in that age group. For all types of knee injuries resulting from sports activities, the rates rose rapidly through adolescence and early adulthood and then gradually declined.

There were 3997 sport-related (based on activity at time of injury) injuries that required ACL surgery. Of these, 81%

contained enough narrative information the injury mechanism to be determined. Twelve sports accounted for 89% of sport ACLS and are presented for "injury mechanism" (what the patient was doing when the injury occurred) in Table 2. Nearly one-half (47%) of all ACLS injuries involved a non-contact mechanism. Excluding the ACLS injuries for which there was insufficient information to code mechanism from the denominator, the percentage of non-contact injuries was 58%.

Table 3  
Mean, median and standard error for the number of visits and cost of injury treatment to ACC for non-surgical knee ligament injuries, ACL surgery, and other knee ligament surgery

	Number of visits for treatments			Cost of treatment to ACC		
	Mean	Median	S.E.	Mean	Median	S.E.
All						
NS	6.64	4	0.02	\$885.31	\$129.31	\$6.81
ACL	27.09	24	0.2	\$11157.35	\$8574.25	\$110.67
OKLS	31.31	24	0.2	\$15662.99	\$8054.00	\$604.64
Pre-surgery: total						
ACL	14.27	12	0.15			
OKLS	15.32	10	0.41			
Post-surgery: total						
ACL	12.46	11	0.1			
OKLS	16.22	12	0.37			
Sport						
NS	7.54	5	0.04	\$1031.50	\$168.93	\$13.88
ACL	27.81	25	0.24	\$10939.99	\$8913.57	\$116.25
OKLS	26.9	22	1.01	\$9346.16	\$6214.16	\$524.54
Pre Surgery: sport						
ACL	14.4	13	0.17			
OKLS	12.6	9	0.64			
Post Surgery: sport						
ACL	12.5	11	0.1			
OKLS	14.6	12	0.62			

The mean, median and standard error for the number of visits for treatment and the direct costs (NZD) of these injuries are reported in Table 3. The costs are to ACC and cover pre-operative exam surgery, hospital stay, post-operative rehabilitation, disability, income replacement as a result of days away from employment, etc., but do not include an estimate of the cost of the injury in terms of the quality of life or permanent disability. However, the cost to ACC and number of visits do provide a surrogate for severity. The high number of visits and direct costs associated with surgery is evident. There are no large differences between sports and general settings for ACL injury cost except for the OKLS injuries being more costly in general as opposed to sports settings.

#### 4. Discussion

This descriptive epidemiology, using NZ's population-based data, has identified high-risk subgroups within the general population (sporting participants, males aged 20–39 and 55–59), has illuminated the settings (predominately places of sport and recreation for ACL injury requiring surgery) and mechanisms of injury (predominately non-contact causes in netball, soccer, basketball and squash). Rugby union, netball, soccer and touch rugby were the sports with the greatest number of injuries over the 5-year-period analysed, accounting for 67% of the total of sport related knee ligament injuries. These sports are popular and are also the greatest number of sport ACC claims for all injury sites. We were surprised that males had a greater rate of injury in most age groups and as a whole. This tends to contrast what has appeared in the literature.<sup>1,2,4</sup> This could be due to the larger size of this study. We looked as the rate per year (rather than 5 years in this study) as a comparison and found the same trend and analysis. This study would have benefited from sport playing numbers as a denominator rather than population numbers to further examine this trend.

It is notable that 80% of knee ligament surgery involved the ACL, and that 65% of ACL injuries resulting in surgery occurred from participating in a sports/recreational activity. The other 35% of injuries occurred outside of sport such as home, commercial/industrial workplaces or road (see Table 1). While sport and recreation injuries provide the largest proportion of ACLS, the forces applied to the knee can be replicated at home as a result of a fall; workplaces that have hazards such a heavy machinery, working at heights, manual labour; and road crashes. This study is one of the first to report statistics such as these for an entire nation. As such it can represent the rates as a comparison to sport and recreation ACLS. A limit in our study was being able to determine where the injury first originated. A person may have had a knee injury at home or work that is later aggravated during sporting activity. Alternatively the injury could have first occurred during a sporting activity that re-occurs in a home or workplace.

Any epidemiological analysis of injury data is dependent upon the quality of the data collection systems. For the ACC data base it is possible there are some missing or inaccurate data caused by: writing down the wrong code on the data collection sheet; underreporting of costs (not numbers) due to patients selecting private surgery whereby only a set amount is paid out by ACC (the patient may have to pay a portion themselves or have further private medical insurance); people who just do not go to a registered health provider; registered health providers not advising surgery (unlikely due to payment); patients who have not made a claim yet (data have been analysed to 19th May 2006, however, there is no time limit on when a patient can make an acute injury claim to ACC). It is also true that, despite the fact that ACL repair is an elective surgery with costs covered by the ACC, some providers may decide it is in the best interest of the patient not to perform ACL reconstruction, especially if the patient is elderly and/or not physically active. The net effect of these limitations would bias downwards our incidence estimates. A further limitation of our analyses for sports-related injuries is that the denominator of the number of participants in each sport in New Zealand is currently not routinely available, but is expected to become available in 2008.

#### 5. Conclusions

The ACC data underscore the high level of short-term disability associated with knee ligament injuries, particularly those that result in surgery, in the general population. ACL injuries are particularly significant in this regard, since 80% of all knee ligament surgeries involved ACL surgery. Sports activities are the primary source of ACL injuries resulting in surgery (65%). This study emphasises the need to develop interventions designed to reduce the risk of ACL and other knee ligament injury, particularly in sports.

#### Practical implications

- Sport produces a high number of ACL surgeries.
- Males have higher knee ligament injury rates than females in the general population.

#### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.jsams.2008.07.005](https://doi.org/10.1016/j.jsams.2008.07.005).

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