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High incidence and costs for anterior cruciate ligament reconstructions performed in Australia from 2003–2004 to 2007–2008: time for an anterior cruciate ligament register by Scandinavian model?

K. W. Janssen[1], J. W. Orchard[2], T. R. Driscoll[3], W. van Mechelen[4]

[1]Sanasport Sports Medical Centre Nijmegen, Nijmegen, The Netherlands, [2]School of Public Health University of Sydney, The Sports Clinic, University of Sydney, Sydney, New South Wales, Australia, [3]Sydney School of Public Health, The University of Sydney, Sydney, New South Wales, Australia, [4]VU University Medical Centre, EMGO+ Institute Department of Public and Occupational Health VUmc, Amsterdam, The Netherlands
Corresponding author: K. W. Janssen, VU University Medical Centre, EMGO+ Institute Department of Public and Occupational Health VUmc, Amsterdam, The Netherlands. Tel: +31 204448410, Email: kasperjanssen@thesportsphysician.nl

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The aim of this paper was to provide a descriptive epidemiology of anterior cruciate ligament (ACL) reconstructions in Australia. Data on all ACL reconstructions were collected from July 1, 2003 till June 30, 2008. Main outcome measures were the incidence of ACL reconstructions for Australia, per age group, sex and sport, including estimates of direct costs. There were 50 187 ACL reconstructions over the 5-year period studied. The population-based incidence of ACL reconstructions per 100 000 person-years was 52.0 [95% confidence intervals (CI): 51.6; 52.5], higher than previously published incidences from other western countries (Scandinavia 32–38). The population incidence rose rapidly through adolescence and early adulthood and then gradually declined. Males had a higher population incidence than females. Skiing had the highest incidence of ACL reconstructions per 100 000 person-years, followed by Australian rules football, rugby, netball and soccer. The total estimated hospital costs associated with ACL reconstruction surgery were over A$75 million (€45 million) per year. Further research is necessary to examine the causes for the higher population incidence of ACL reconstructions in Australia compared with other countries. The establishment of a national register of ACL injuries, similar to those developed in Scandinavia should be considered.

Anterior cruciate ligament (ACL) injury is a serious sports injury often resulting in hospital admission for surgery (Gianotti et al., 2009; Flood & Harrison, 2009), with the highest incidence seen in young adults playing multi-directional sports (Gianotti et al., 2009; Bahr & Engebretsen, 2009; Magnussen et al., 2010). An ACL injury has serious consequences for the injured athlete, in terms of not only treatment costs and time lost from sport but also a greatly increased risk of early osteoarthritis (Myklebust & Bahr, 2005; Renstrom et al., 2008).

There are no nationwide Australian data published on the incidence or costs of ACL reconstruction. Information on the magnitude, incidence and severity of injury is required to underpin appropriate injury prevention research and intervention (van Mechelen et al., 1992; Finch, 2006). We aimed to provide the first nationwide descriptive epidemiology of ACL reconstruction in Australia. We used data from the Australian Institute of Health and Welfare (AIHW), which include all ACL reconstructions performed in private and public hospitals. We focused on the following questions: what is the incidence (per age group, sex and sport) and what are the direct costs associated with surgery and hospital stay of ACL reconstructions in Australia? A further aim of this study was to compare these Australian data to existing international data (Owings & Kozak, 1998; Gianotti et al., 2009; Granan et al., 2008).

Methods

Compilation of the data set

Data for analysis were compiled by the AIHW from the National Hospital Morbidity Database. The AIHW identified the patients who had an ACL reconstruction as the main purpose of their hospital visit (AIHW, 2009). The principle diagnosis codes from ICD10-AM (Fifth Edition) (NCCH, 2006) used to select the patients are summarized in Table 1. Administrative data compiled by ICD-10 coding in Australia

Table 1. Principle diagnosis codes from ICD10-AM (fifth edition) (NCCH 2006) used to select the patients who had an anterior cruciate ligament (ACL) reconstruction

Code*	Description
M23.51	Chronic instability of knee
M23.61	Other spontaneous disruption of ligament(s) of knee
M23.81	Other internal derangements of knee
M23.91	Internal derangement of knee, unspecified
S83.51	Sprain and strain of anterior cruciate ligament
S83.53	Rupture of anterior cruciate ligament

*M23 stands for "Internal derangement of knee". S83 stands for "Sprain and strain involving (anterior)(posterior)" cruciate ligament of knee. The third digit determines the type of derangement. The fourth digit was used to isolate cases specific to the anterior cruciate ligament.

can provide highly reliable population-based estimates of hospitalization rates (Henderson et al., 2006).

Revisions of ACL reconstruction could not be separately identified in the database. Consequently revisions are included in our calculations. The revision percentage over 2003–2008 is known to be approximately 5–6% (Orchard, 2009). For convenience, when the term "reconstructions" is used in this paper, it refers to primary reconstructions and revisions.

The data covered all patients undergoing an ACL reconstruction that occurred between July 1, 2003 and June 30, 2008. Information on the number of patients, total direct medical costs per patient, length of (hospital) stay and, where available, "activity when injured" were included. Suppression rules were applied by the AIHW as requested by the states and territories to preserve patient privacy.

Calculation of ACL reconstruction incidence

Incidences of ACL reconstruction were calculated using population estimates as the denominator for each of the year covered by the study. Population data for Australia were obtained from the Australian Bureau of Statistics (2008). Incidence was defined as the number of ACL reconstructions in the study period divided by the sum of the concerning population over 5 years of age, over the study period, multiplied by 100 000 years, and corresponding 95% confidence intervals (CI) (using standard Poisson assumptions) were calculated. Thus, all incidences are expressed as ACL reconstructions per 100 000 person-years.

Activity coded data

The "activity when injured" (what the patient was doing when the injury occurred), when available, was extracted from the database for computing the ACL reconstruction incidence per sport and the incidence per sport by region. For the "activity when injured," only the geographical region of occurrence was available to protect the identity of individual patients and individual establishments. These regions were the North East region (Qld, NSW and ACT) and the South West region (Vic., SA, WA, Tas. and NT).

Defining sports/leisure injury cases only on the basis of reported activity codes is likely to lead to an underestimation of sport-related injuries, because of the considerable proportion of unspecified or missing activity codes. Therefore, we assumed the "activity when injured" data for the cases for which this information was provided to be a fair representation of the entire sample (Finch & Boufous, 2008). We calculated the estimated number of ACL reconstructions in each sport to be the known number of ACL reconstructions for that sport, multiplied by a factor to account for the proportion of cases with the activity code missing or unspecified.

Sports participation data

Sport participation numbers, for computing the incidence per sport, were extracted from the "Participation in exercise, recreation and sport surveys" (ERASS) from 2003 to 2008 (ASC, 2003–2008). The ERASS provides information on sport activities for persons aged 15 years and over. In contrast, our ACL data included people 5 years of age and above. In calculating sport-specific incidences, we did not omit persons <15 years of age because the ACL reconstructions per sport were not available in age groups. However, the number of ACL operations in persons under the age of 15 years is very low, comparable with New Zealand (Gianotti et al., 2009), and hence their inclusion does not substantially influence the calculated sport-specific incidences.

Estimating the costs

An estimate of the direct costs (i.e. hospital care and surgical costs only) of ACL surgery was calculated. For public hospitals, the average direct cost of ACL reconstructions was A$6223 (€3772), as provided by the AIHW. For private hospitals, we combined the average private hospital cost (which excludes medical practitioner fees) (DOHA, 2008) provided by the AIHW with the estimated average doctors' fees for the surgeon (A$2901), assistant surgeon (A$580), and anesthetist (A$650), using the rates recommended by the Australian Medical Association and the Australasian Society of Anaesthetists, for Medicare item 49542 (the most commonly used item number) resulting in an estimate of A$7915 (€4797) per ACL reconstruction. These estimated amounts are conservative, with the costs of an ACL reconstruction in New Zealand known to be about NZ$11 000 (€5789) (Gianotti et al., 2009).

Ethics

The AIHW provided data in a de-identified and aggregated format and data cells with fewer than five cases were suppressed. As such, the study methodology itself posed no risk to the privacy and confidentiality of individuals and was exempt from ethical review, according to NHMRC and AIHW guidelines.

Data analysis

Data were extracted using Excel. Analyses were performed using Excel and SPSS (version 16). Trend analysis was performed using ANOVA. A level of $P<0.05$ was set to determine statistical significance. Ninety-five percent confidence intervals for the incidences were calculated using an Excel add-in (Pezzullo, 2009).

Results

Absolute number of ACL reconstructions and incidence

There were 50 187 ACL reconstructions over the 5-year study period (just over 10 000 per year); 39 866 (79.4%) in the private sector and 10 321 (20.6%) in the public sector. The number of reconstructions

increased in most years of the study period. This was true for males and females, public and private hospitals, and nearly all age groups (Fig. 1). Trend analysis of the change in annual incidence showed a significant linear increase for males in the age groups 5–14 ($P = 0.005$), 35–44 ($P = 0.04$) and 45–54 years ($P = 0.04$); and for females in the age groups 15–24 ($P = 0.02$), 25–34 ($P = 0.03$) and 45–54 years ($P = 0.04$). The population-based incidence of ACL reconstructions per 100 000 person-years was 52.0 (95% CI: 51.6; 52.5). This incidence increased by 14% over the 5 years of the study, with a similar increase in males and females.

The ACL reconstruction incidence rose rapidly through adolescence and early adulthood and then gradually declined. Males had a higher incidence than females in all age groups under 75 years, above which there were very few cases. In some age groups (15–24 and 25–34 years), males had an incidence twice as high as that of females (Fig. 2).

ACL reconstruction incidence per sport

The "activity when injured" was fully specified for 9425 patients who were admitted for an ACL reconstruction (19% of total). In 6824 (72% of fully specified) of these patients, the "activity when injured" was sport related. Another 2155 were coded "U71 Unspecified sport or exercise activity", and hence could not be allocated to a specific sport. For the remaining 39 673 patients (79% of total), the activity was not provided. Allocating these in proportion to the known cases (Finch & Boufous, 2008), we estimated the "true" sport-related number of ACL injuries to be 36 337 (72% of total). The most frequently reported sports played at the time the person was injured were soccer, Australian rules football and netball. Skiing (alpine and downhill) had the highest incidence of ACL reconstructions per 100 000 annual participants, with Australian rules football, rugby (League and Union combined), soccer, and netball having the next highest incidences (Table 2). We combined rugby league and union in the sport-specific analysis.

Estimated direct costs of ACL surgery

The estimated mean annual hospital and surgery costs associated with ACL reconstructions over the 5-year studied period was over A$75 million (€45 million). These costs only include direct admission and treatment in the hospital setting.

Discussion

High incidence of ACL reconstructions in Australia

This descriptive epidemiology of ACL reconstructions in Australia has shown a relatively high number

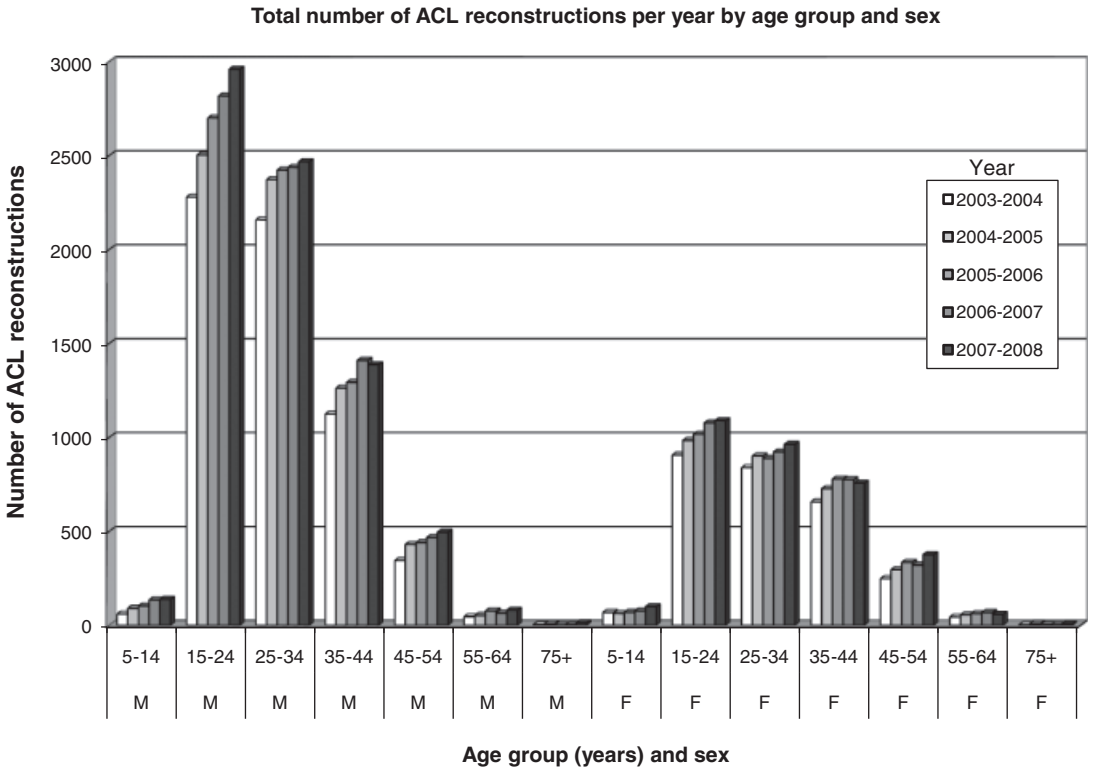

Fig. 1. Total number of anterior cruciate ligament (ACL) reconstructions per year by age group and sex.

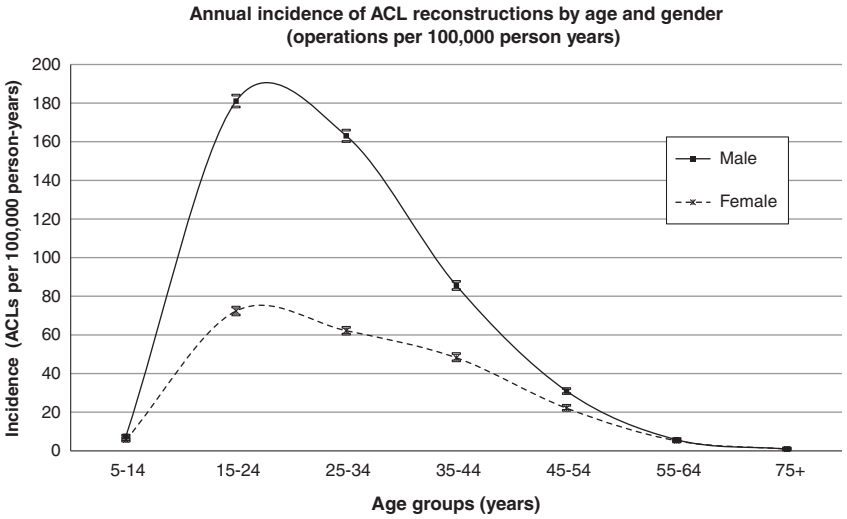

Fig. 2. Annual incidence of anterior cruciate ligament (ACL) reconstructions per 100 000 person-years by age and gender. Error bars indicate 95% confidence intervals.

Table 2. Sport-specific estimated absolute number of anterior cruciate ligament (ACL) reconstructions, estimated number of sport participants, and incidence rates (total, and per region with 95% CI), for the most commonly reported sports under ''activity when injured''

Activity when injured	Annual ACL reconstructions	Annual participants* 1000	Annual ACL reconstruction incidence per 100 000 participants		
			Total (95% CI)	Northeastern states (95% CI)	Southwestern states (95% CI)
Skiing (alpine and downhill)	847	203	417 (405–430)	541 (522–560)	234 (220–249)
Australian rules football	1162	425	273 (266–280)	307 (290–325)	266 (258–274)
Rugby (League and Union combined)	850	332	255 (248–263)	258 (250–266)	241 (221–263)
Soccer (indoor and outdoor combined)	2043	966	211 (207–216)	250 (245–256)	152 (147–158)
Netball	1085	576	188 (184–194)	192 (184–200)	186 (179–193)
Touch football	602	383	157 (152–163)	160 (154–166)	134 (119–151)
Basketball	564	516	109 (105–113)	99 (93–105)	117 (112–123)
Motorcycling	115	178	65 (60–70)	59 (52–66)	73 (65–82)
All sports/exercise participants*	7267	11 900	61 (60–62)	58 (56–60)	52 (50–54)
Entire population (>5 years)	10 037	19 303	52 (52–53)	54 (53–54)	49 (49–50)

*Definition of sports/exercise participants: over 15 years of age, participating at least once annually in physical activity for exercise, recreation or sport.

of such procedures in Australia, an increasing incidence per year, and high-risk subgroups within the general population (e.g. sport participants, males aged 15–34 years). The overall incidence of ACL reconstructions in Australia (52.0 per 100 000 person-years) is higher than other previously published nationwide and population incidences, including New Zealand (37.8) (Gianotti et al., 2009), the United States (30–33) (Csintalan, 2008; Lyman et al., 2009; Owings & Kozak, 1998), Sweden (32) (Granan et al., 2009), Norway (34) (Granan et al., 2008) and Denmark (38) (Lind et al., 2009). We found that the Australian incidence for men peaked higher (163–181 ACL reconstructions per 100 000 person-years for men aged between 15 and 34 years), than in New Zealand (150–160 ACL reconstructions per 100 000 person-years for men between 20 and 29 years) and the United States (123 ACL reconstructions per 100 000 person-years for men between 18 and 29 years). For women, we found lower incidences (62–72 ACL reconstructions per 100 000 person-years for women between 15 and 34 years) than in New Zealand (70–80 ACL reconstructions per 100 000 person-years for women between 20 and 29 years) but still substantially higher than the United States (40 ACL reconstructions per 100 000 person-years for woman between 18 and 29 years). The Australian incidence of 120 ACL reconstructions per 100 000 persons for the main at-risk age group of 15–34 years (men and women) is also considerably higher than the incidence from the Norwegian National Knee Ligament Registry (Granan et al., 2008), which observed an incidence of 85 per 100 000 persons in the highest at-risk age group of 16–39 years. Not all ACL injuries are diagnosed and not all diagnosed ACL injuries are operated on. Because not

all persons with an ACL injury are admitted to hospital and it is not known how many ACL injuries are treated conservatively in Australia, the population incidence of ACL injuries is not known. In Norway, it appears that the true population incidence for ACL injuries may be 50–100% higher than the reconstruction incidence (Granan et al., 2008) (Fig. 3).

The higher annual incidence of ACL reconstructions in males compared with females, seen in Australia, New Zealand and the United States, almost certainly reflects a participation bias (i.e. that males more often play sports of higher ACL injury risk, particularly the various football codes). Multiple previous studies have shown that females actually have a threefold or higher relative risk of ACL injury when they play the same sports as males (Arendt & Dick 1995; Renstrom et al., 2008).

The higher incidence of ACL reconstructions in Australia vs New Zealand probably reflects a higher primary ACL injury rate. In New Zealand, all costs associated with any injury (including sport) are fully paid for by the government Accident Compensation Corporation scheme (Gianotti et al., 2009), with no waiting list. In Australia, some patients may be discouraged from having surgery either because of a lengthy waiting list or substantial ''gap'' medical expenses. Furthermore, missing data are less likely in New Zealand than Australia, given their national registry of all sports injuries. A higher incidence of ACL injury in Australia compared with New Zealand could be due to participation in different sports, although the incidences of ACL surgery in north-eastern Australia (where similar sports are played as in New Zealand) are at least as high as south-western Australia, where the sport of Australian football is more often played by males. Difference in playing surface characteristics, such as ground hardness (Orchard et al., 1999) or grass types (Orchard et al., 2005), may be implicated in the higher Australian incidences. The lower incidences in New Zealand may also be at least partly due to the existence of a national body devoted to sports injury prevention (Orchard & Finch, 2002; Orchard et al., 2007). Comparisons of specific Australian ACL reconstruction incidences to Scandinavian countries are more problematic, as the climate and distribution of sports are substantially different. In addition, there are various factors that might influence the incidence of ACL reconstruction surgery. These include community expectations, availability of medical resources and funding arrangements. For example, it has been suggested that Scandinavian surgeons are less likely to recommend ACL reconstruction surgery because the surgeons' salaries are not funded on a fee-for-service basis (Kolling et al., 2007; Magnussen et al., 2010). Another factor could be that public hospital surgery is free in Australia but physiotherapy is at own expense.

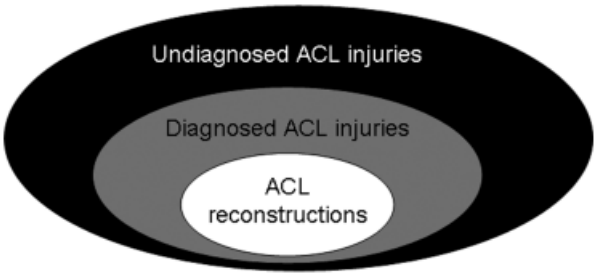

Fig. 3. Hidden total anterior cruciate ligament (ACL) injury burden.*

*The ovals are not in proportion to the true number of ACL injuries, because this number is not known.

Estimation of ACL reconstructions and incidence per sport

The majority of ACL injuries occur during sporting activities. Our estimate of 73% of ACL reconstructions resulting from sporting activities is comparable with the NZ percentage of 65% (Gianotti et al., 2009). The high proportion of missing activity codes in hospital data in Australia means that our estimates are possibly low estimates (Finch & Boufous, 2008). For example, our calculated incidence of 273 ACL reconstructions per 100 000 person-years in Australian rules football players is far lower than the annual incidence of 1 945 ACL reconstructions per 100 000 player years in the professional Australian rules Football League (Orchard et al., 2005). The identification of the highest risk sports assists with planning prevention efforts. The distribution of injury by sport is similar to that of New Zealand (Gianotti et al., 2009), and hence it may be possible to import some of their preventive programs.

Cost of ACL surgery

ACL reconstruction surgery is a substantial contributor to the burden of injury and health care costs in Australia, with estimated direct costs of over A$75 million (€45 million) per year. There are a number of additional costs that are known to occur in the treatment of ACL surgery that cannot be measured through current available data. These include costs related to post-operative rehabilitation and disability and income replacement as a result of days away from employment. If costs for non-surgical cases and some indirect costs were able to be included, the figure would easily exceed A$100 million (€61 million) per year.

Perspectives

Further research is necessary to examine the causes for the higher population incidence of ACL reconstruction surgery in Australia compared with other western countries. ACL injury is a substantial contributor to the burden of injury and health care costs in Australia. Despite this, the total number of ACL injuries occurring each year is not known, and there is little comprehensive information regarding the circumstances in which these injuries occur, and the reason some result in surgery and some do not. The importance of careful consideration of ACL surgery is confirmed by a recent RCT in which a strategy of rehabilitation plus early ACL reconstruction was not superior to a strategy of rehabilitation plus optional delayed ACL reconstruction, in young active adults with acute ACL tears (Frobell et al., 2010). The Scandinavian countries (Lind et al., 2009) have effective national registers that contribute to quality control and improvement of the surgical cruciate ligament procedures, whereas New Zealand effectively has an ongoing register of all sports injuries through their national insurance scheme. These registers also facilitate the planning and implementation of appropriate preventive measures. Given that Australia has a higher ACL reconstruction incidence than those countries, the development of an Australian register for both ACL injuries and ACL operations warrants consideration (Owings & Kozak, 1998; Magnussen et al., 2010). Although there would be significant start-up and ongoing costs associated with the funding of a national ACL register (Kolling et al., 2007), the potential costs savings and improvements in patient outcomes are also significant. It appears that countries that have devoted greater resources toward sports injury surveillance and prevention enjoy a lower nationwide incidence of ACL reconstructions than Australia.

Key words: knee surgery, anterior cruciate ligament, national registries, incidence, sports injuries.

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