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Original Research

Quantifying the likelihood and costs of hip replacement surgery after sports injury: A population-level analysis

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ABSTRACT

Objectives: To quantify the likelihood of hip replacement (HR) surgery at a population level up to 15 years after sports injury.
Design: Cohort study.
Settings: Public and private hospitals in the state of Victoria, Australia.
Participants: The cohort was established by linking administrative datasets capturing all hospital admissions and emergency department (ED) presentations. All sports injury presentations from 2000 to 2005 and HR admissions from 2000 to 2015 were identified using ICD-10-AM codes.
Main outcome measures: Time to HR (number of days from sports injury admission to HR admission).
Results: Over the study period there were 64,750 sports injuries (including 815 hip or thigh musculoskeletal injuries) that resulted in ED presentation or hospitalisation, and 368 HR procedures. Compared to all other sports injuries, having a hip or thigh injury tripled the hazard of subsequent HR in multivariate analysis (hazard ratio 3.07, 95%CI 2.00–4.72). Of the main hip or thigh injury types, femoral fractures (hazard ratio 3.08, 95%CI 1.77–5.36) and hip dislocations (hazard ratio 5.64, 95%CI 2.34–13.58) were significantly associated with HR.
Conclusion: Sports-related hip or thigh musculoskeletal injury is associated with a significantly higher likelihood of HR within 15 years. Effective injury prevention and appropriate post-injury management are needed to curtail this population burden.

1. Introduction

Osteoarthritis (OA) of the knee has long been recognised as a downstream consequence of knee injury (Lohmander et al., 2007; Roos, 2005), with injuries commonly sustained during sport. Our recent population-based research showed that having a sports-related knee injury more than doubled the likelihood of knee replacement surgery within 15 years, compared to all other sports injuries (Ackerman, Bohensky, & Kemp, 2019). The link between sports injury and hip replacement (HR) for OA is not as clear. An early case-control study from the United Kingdom found that prior hip injury was an independent risk factor for hip OA (Cooper et al., 1998) and longitudinal research from Finland reported the risk of developing hip OA was 5 times higher for people who had sustained any previous musculoskeletal injury (Juhakoski et al., 2009). With regard to sports-related injuries, a review of systematic reviews concluded there was moderate to strong evidence that high-intensity sporting activity is a risk factor for hip OA (Bierma-Zeinstra & Koes, 2007), although this could relate to repetitive joint loading as well as acute injury. A more recent systematic review reported that elite-level impact sport participation was associated with a 1.8–8.7 times increased odds of hip OA (variably defined as radiographic OA or progression to HR surgery), when compared with matched controls (Vigdorchik et al., 2016).

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However, the contribution of sports injury to HR risk was not specifically investigated.

While elite or professional athletes represent a unique group in which to examine sports injuries and their sequelae (given training volume and regular competitive participation), these findings may not be generalisable to the broader community where recreational or amateur sport participation is more common. To better understand the burden of HR after sports injury, a population-based approach is required. This is particularly important as lower limb sports-related injury rates are rising in the general community, with implications for future OA burden (Finch, Kemp, & Clapperton, 2015). The present study aimed to:

- quantify the likelihood of HR 10–15 years after sports-related hip or thigh injury, compared to other types of sports injuries; and
- estimate the cost burden of HR surgery after sports-related injury at a state level.

2. Methods

A population-based cohort study for the state of Victoria, Australia (population size 6.4 million (Australian Bureau of Statistics, 2017)) was undertaken using data linkage of two key administrative data sources maintained by the Victorian Government Department of Health. The Victorian Admitted Episodes Dataset (VAED) includes all public and private hospital episode data, including day procedures. The Victorian Emergency Minimum Dataset (VEMD) captures emergency department (ED) presentations to all Victorian public hospitals. All Australians have access to publicly-funded healthcare in public hospitals, while private hospitals are accessible to privately-insured individuals and those who can pay for private care.

De-identified data were obtained for people aged ≥18 years who had an ED presentation or hospitalisation involving a sports-related injury in a Victorian hospital between 1 January 2000 and 31 December 2005. Hospitalisation data included public and private hospital admissions. All subsequent hospital admissions coded to an orthopaedic specialty were obtained for each patient up to 30 June 2015. Informed consent was not applicable to this study as no participant recruitment was involved and only de-identified data were used.

Within the VAED, sports-related injuries were identified using International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modifications (ICD-10-AM) activity and injury codes, similar to previous methods (Ackerman, Bohensky, & Kemp, 2019); (Finch et al., 2015). Prior to 2002, the activity code used for sports was Y930. From 2002 onwards, the activity codes for sports were in the range U50-U71. All patients were required to have a principal diagnosis code in the range of S00 to T98 to indicate an injury had occurred. Sports injuries were also identified within the VEMD according to ICD-10-AM codes using the activity field code for sport (activity code = S). Codes in the VAED and VEMD are assigned by trained clinical coders with audits conducted regularly to ensure coding accuracy. The VAED records up to 40 diagnostic codes per admission and the VEMD records 3 diagnostic codes per episode. Patients with planned follow-up visits to EDs were excluded from further analyses ($n = 581$ episodes), to avoid injury double-counting.

Three data linkages were undertaken for this study. Person-level linkage was undertaken between the VEMD and VAED to identify ED presentations that were followed by a hospital admission. Person-level linkage was also undertaken to longitudinally link episodes over time and identify subsequent orthopaedic admissions. To preserve patient privacy, linkages involving person-level data were undertaken by the Victorian Government Department of Health using a stepwise deterministic linkage process based on personal identifiers (Victorian Department of Health). The de-identified linked dataset was provided to the researchers for analysis. Patients' statistical local area codes were mapped to available Socio-Economic Indexes for Areas (SEIFA) and Accessibility/Remoteness Index of Australia (ARIA) datasets by the researchers to approximate socioeconomic status and residential remoteness. This mapping used a deterministic linkage process based on statistical local area codes.

Patient and injury characteristics (age group, sex, length of hospital stay, patient insurance type) were generated from VAED variables (Supplementary file) and ED length of stay was generated from VEMD variables. The bodily region of injury was generated using either dataset, depending where the patient presented. Socioeconomic status at the time of injury was approximated using SEIFA Index of Relative Socio-economic Disadvantage quantiles (Australian Bureau of Statistics, 2006). The ARIA Index was used to assess remoteness of each patient's residence (The University of Adelaide). Statistical local areas that could not be mapped to the SEIFA or ARIA datasets due to missing values (1% of cases for each dataset) were imputed to the median value or metropolitan regions, respectively.

The primary outcome of interest was time to HR (including hemiarthroplasty, hip resurfacing, unilateral total hip replacement, and bilateral total hip replacement procedures, as classified by ICD-10-AM procedure codes) during the follow-up period. Relevant procedure codes (Supplementary file) were used to identify these surgeries in hospital admission episodes. Time to HR was calculated as the number of days from sports injury admission to HR admission. The first HR was used where patients had multiple HR procedures over the follow-up period.

All statistical analyses were performed using Stata version 14.2 (College Station, Texas, USA). Descriptive analysis was used to summarise demographic and sports injury characteristics. Age group, sex, and patient insurance type were treated as categorical variables, while time to HR admission, and cost data were treated as continuous variables. Sports injuries were classified by bodily region for analysis, according to ICD-10-AM codes (Supplementary file). A Cox proportional hazards model was used to calculate hazard ratios and 95% confidence intervals (95%CI) for time to HR admission, with adjustment for patient-level risk factors. The proportional hazards assumption was tested on the basis of Schoenfeld residuals after fitting the Cox proportional hazards model. There was no evidence that this assumption had been violated. A time-varying model was not used as the hazard ratio did not vary with time. Clinically-relevant risk factors that may predispose individuals to HR (for example, age group and sex) were included in the multivariate analyses. The largest category was used as the reference group for all variables. To account for patients who had multiple sport-related injuries over the study period, all analyses were clustered on patient identifier using a Huber-White sandwich estimator of variance, which is a method of robust variance estimation in Stata that is used for cluster-correlated data (Williams, 2000). Patients without a linked HR episode were censored as at the end of the follow-up period (30 June 2015).

To further quantify the burden of HR following sport-related injury, the direct costs of surgery (including average costs for operating theatre, imaging, allied health, prostheses, and pharmaceuticals) were estimated. Hospital admission costs were estimated from the perspective of the Australian healthcare system. For these analyses, Australian refined diagnosis-related groups codes (AR-DRG) were extracted for each surgical episode from the VAED. Relevant AR-DRG cost weights for public and private hospitals were obtained from the most recent version of the National Hospital Cost Data Collection (Round 18, 2012-13 and Round 13 was used for AR-DRG code I04Z, which was discontinued after 2009) (Independent Hospital Pricing Authority, 2010; Independent Hospital Pricing Authority; PWC. National, 2017). To obtain a current price for each procedure, the national efficient price for 2017-18 was used, as published by the Independent Hospital Pricing Authority (Independent Hospital Pricing Authority, 2016). All costs are reported in Australian dollars (1 AUD = 0.60 GBP).

3. Results

From 2000 to 2005, there were 64,750 sports-related injuries for 57,560 people (including 815 hip or thigh musculoskeletal injuries for 779 people) that resulted in ED presentation or hospitalisation. As shown in Table 1, most sports injuries were sustained by people aged 20–29 years (representing 49% of all injuries) and those aged 30–39 years (23%). Sports injuries were more common among males (77% of all injuries). Most of the cohort resided in highly accessible (metropolitan areas) and all quantiles of socioeconomic status were represented (Table 1).

Overall, sports injuries resulted in 28,097 hospitalisations over the study period. Table 1 presents a summary of bodily injury regions. The most commonly injured regions were the knee, lower leg, ankle and foot (comprising 36% of all presentations), shoulder, arm or hand (33% of all presentations), and the head or face (18%). Hip and thigh musculoskeletal injuries represented 1% of all sports injury presentations, and were predominantly femoral fractures ($n = 410$, 50% of all hip and thigh injuries) or soft tissue injuries ($n = 187$, 23%). Unspecified hip injuries ($n = 106$, 13%), hip dislocations ($n = 76$, 9%) and multiple injuries affecting the hip ($n = 36$, 4%) were less common. Hip and thigh neurovascular injuries were infrequent among the cohort ($n = 284$, <1% of all presentations).

A total of 368 HR procedures were performed for the cohort between 2000 and 2015 (Table 2). Of these, 42 procedures were performed for the hip and thigh injury group (5.4% of this group) and 326 were performed for people who had sustained sports injuries affecting other bodily regions (0.57% of the ‘other injury group’). Overall, 75% of HR procedures were unilateral total arthroplasties, while 16% involved hemiarthroplasty. Only a small proportion were bilateral total HR procedures (7%). The majority of HRs were performed for males ($n = 258$, 70%). HR was more common among people aged 40 years and over (Table 2) and privately-insured patients (67%). Most patients receiving HR (82%) had a recorded primary diagnosis at HR admission (based on ICD-10-AM codes) that was consistent with hip OA, such as primary coxarthrosis or post-traumatic coxarthrosis (Table 2). A small number of patients who received HR had a diagnosis of unspecified osteonecrosis (5%).

The median time from sports injury to HR admission was 5.3

Table 1
Demographic and injury admission characteristics for the sports-injured cohort.

Variable	Subsequent hip replacement		No hip replacement		Total
	n	%	*n*	(%)	*n*
Sport-related injury presentations[a]	368	0.6	64,382	99.4	64,750
Sex					
Female	110	0.8	14,615	99.3	14,725
Male	258	0.5	49,767	99.5	50,025
Age group at time of injury					
<20 years	4	0.1	7908	99.9	7912
20–29 years	32	0.1	31,463	99.9	31,495
30–39 years	65	0.4	14,865	99.6	14,930
40–49 years	94	1.5	6245	98.5	6339
50–59 years	76	3.4	2201	96.7	2277
60–69 years	56	6.2	856	93.9	912
≥70 years	41	4.6	844	95.4	885
Remoteness of residential location[b]					
Highly accessible	324	0.6	57,737	99.4	58,061
Accessible	39	0.7	5453	99.3	5492
Moderately accessible	5	0.5	1039	99.5	1044
Remote	0	0	64	100.0	64
Very remote	0	0	89	100.0	89
Socioeconomic status[c]					
Quantile 1 (most disadvantaged)	39	0.5	8483	99.5	8522
Quantile 2	45	0.6	8066	99.5	8111
Quantile 3	84	0.5	16,849	99.5	16,933
Quantile 4	101	0.6	17,241	99.4	17,342
Quantile 5 (least disadvantaged)	99	0.7	13,732	99.3	13,831
Injury region					
Hip/thigh (musculoskeletal)	42	5.2	773	94.9	815
Hip/thigh (neurovascular)	1	0.4	283	99.6	284
Abdomen/lower back/pelvis	13	0.8	1636	99.2	1649
Head/face	53	0.5	11,429	99.5	11,482
Neck/thorax	29	1.3	2294	98.8	2323
Shoulder/arm/hand	117	0.5	21,473	99.5	21,590
Knee/lower leg/ankle/foot	105	0.5	22,921	99.5	23,026
Unspecified/N/A	7	0.2	3170	99.8	3177
Multiple injuries	1	0.3	403	99.8	404
Hospital admission for injury	251	0.9	27,846	99.1	28,097

[a] Number of sport-related injuries resulting in emergency department presentation or hospitalisation; number of people with injuries = 57,560 (some had >1 sport-related injury presentation or hospitalisation over the period of interest).
[b] Based on the Accessibility/Remoteness Index of Australia (ARIA) using residential statistical local area.
[c] Based on SEIFA codes using residential statistical local area.

Table 2
Characteristics of patients receiving hip replacement.

Variable	Hip replacement patients ($n = 368$)	
	n	(%)
Sex		
Female	110	29.9
Male	258	70.1
Age group at HR admission		
<20 years	0	0.0
20–29 years	3	0.8
30–39 years	18	4.9
40–49 years	76	20.7
50–59 years	89	24.2
60–69 years	96	26.1
≥70 years	86	23.4
Patient type at HR admission		
Public	104	28.3
Private	248	67.4
Other	16	4.3
HR procedure type		
Unilateral total arthroplasty	277	75.3
Hemiarthroplasty of femur	59	16.0
Bilateral total arthroplasty	27	7.3
Excision arthroplasty of hip	5	1.4
Primary diagnosis[a] at HR admission		
Other primary coxarthrosis (M161)	294	79.9
Other primary diagnosis	47	12.8
Unspecified osteonecrosis, pelvic region and thigh (M8795)	17	4.6
Other post-traumatic coxarthrosis (M165)	7	1.9
Non-union of fracture [pseudoarthrosis], pelvic region and thigh (M8415)	3	0.8

HR: hip replacement.
[a] Codes shown are ICD-10-AM codes.

years (range 0.3–14.0 years) for patients with a previous hip or thigh injury, and 8.8 years (range 0.3–15.0 years) for those who sustained other injuries. For the hip and thigh injury group, the median time to HR was 3.7 years for those who had fractures and 7.3 years for those who had dislocations. The results of the Cox proportional hazards analysis are presented in Table 3. The

Table 3
Cox proportional hazards analysis of time to hip replacement.

Variable	Hazard ratio (95%CI)	
	Univariate analysis	Multivariate analysis[a]
Injury region		
All other body injury regions[b]	1.00 (reference[c])	1.00 (reference[c])
Hip/thigh (musculoskeletal)	10.56 (7.33–15.21)	3.07 (2.00–4.72)
Fracture	13.47 (8.40–21.60)	3.08 (1.77–5.36)
Multiple injuries	5.62 (0.80–39.40)	2.61 (0.39–17.28)
Soft tissue injuries	4.40 (1.63–11.86)	2.02 (0.74–5.54)
Dislocation hip injury	18.69 (8.74–39.97)	5.64 (2.34–13.58)
Unspecified injuries	5.89 (1.87–18.53)	2.55 (0.80–8.18)
Sex		
Male	1.00 (reference[c])	1.00 (reference[c])
Female	1.54 (1.21–1.95)	0.80 (0.63–1.02)
Age group at time of injury		
<20 years	0.50 (0.14–1.76)	0.50 (0.14–1.76)
20–29 years	1.00 (reference[c])	1.00 (reference[c])
30–39 years	4.50 (2.88–7.02)	4.48 (2.87–6.97)
40–49 years	15.76 (10.20–24.35)	15.56 (10.03–24.13)
50–59 years	35.81 (22.88–56.07)	34.09 (21.59–53.85)
60–69 years	67.68 (42.30–108.30)	59.89 (36.62–97.95)
≥70 years	49.43 (29.95–81.60)	38.35 (21.33–68.95)
Hospital length of stay (injury admission)	1.01 (1.01–1.02)	1.00 (0.97–1.02)
Patient insurance type (injury admission)		
Public	1.00 (reference[c])	1.00 (reference[c])
Private	1.30 (0.99–1.72)	1.00 (0.75–1.32)
Other	1.13 (0.63–2.03)	0.70 (0.39–1.27)
Emergency department presentation only	0.39 (0.30–0.51)	0.85 (0.63–1.13)

CI: Confidence interval.
[a] Model adjusted for sex, age group, patient insurance type, and presentation type (emergency department presentation or hospital admission).
[b] Includes head/face injuries, neck/thorax injuries, abdomen/lower back/pelvis injuries, shoulder/arm/hand injuries, hip/thigh neurovascular injuries, knee/lower leg/ankle/foot injuries, unspecified injuries and multiple injuries.
[c] The largest category was used as the reference group for each variable.

unadjusted hazard ratio for HR was 10.56 (95% CI 7.33 to 15.21) for people with a hip or thigh musculoskeletal injury, compared to those with other injuries (comprising head/face injuries, neck/thorax injuries, shoulder/arm/hand injuries, abdomen/lower back/pelvis injuries, hip/thigh neurovascular injuries, knee/lower leg/ankle/foot injuries, unspecified injuries and multiple injuries). In a multivariate model, which adjusted for age group and other potential confounding factors, hip and thigh musculoskeletal injury remained significantly associated with an increased hazard of HR (hazard ratio 3.07, 95%CI 2.00 to 4.72). Patients aged 30–39 years, 40–49 years, 50–59 years, 60–69 years and ≥70 years were all more likely to have HR, compared to those aged 20–29 years, after adjusting for potential confounders (Table 3).

The likelihood of HR was also examined according to hip and thigh injury type, using all other body injury regions as the reference category (Table 3). In a multivariate model, femoral fractures and hip dislocation injuries were each associated with an increased hazard of HR. Multiple hip injuries, soft tissue injuries (including muscle, tendon and ligament injuries affecting the hip and thigh) and unspecified hip injuries were not significantly associated with an increased likelihood of HR in the multivariate analysis (Table 3).

The average (IQR) cost of HR surgery was $AUD28,566 ($20,753-$30,812) per admitted episode for the hip and thigh musculoskeletal injury subgroup and $AUD30,812 ($20,753-$30,812) per admitted episode for the other injury subgroup. The direct healthcare costs associated with HR for the overall sports-injured cohort were estimated at $AUD10,147,743. Direct healthcare costs for HR specifically for the hip and thigh musculoskeletal injury subgroup were estimated at $AUD1,154,634, representing 11% of the cost for the overall cohort.

4. Discussion

This study evaluated the population-level burden of HR in people who had previously sustained a sports-related injury and in particular, a sports-related hip or thigh musculoskeletal injury. On multivariate analysis, we found the hazard of HR for this subgroup was over three times higher than for all other sports injuries. This appears to be driven by sports-related fractures (which demonstrated a three-fold increased hazard) and dislocations (five-fold increased hazard). However, even after excluding these subgroups in a sensitivity analysis, musculoskeletal hip and thigh injury remained significantly associated with an increased likelihood of HR surgery. We also found that the average time to first HR admission following sports injury for the hip and thigh subgroup was relatively short (5 years). This may relate to the treatment of fractures but could also reflect pre-existing hip OA that was exacerbated by injury, as people aged 40 years or over had the highest likelihood of HR on multivariate analyses and it is well established that the prevalence of OA increases substantially with age (Australian Bureau of Statistics, 2015; Australian Bureau of Statistics, 2019).

To our knowledge, this is the first study to examine the relationship between previous sports-related hip injury and subsequent HR using a population-based data linkage approach. Hip and thigh injuries account for between 3% (Agel et al., 2007) and 15% (Walden, Hagglund, & Ekstrand, 2005) of sports injuries in soccer, one sport where these are commonly sustained. However, these are predominantly soft tissue strains, sprains, and contusions. In our study, hip and thigh musculoskeletal injuries represented over 1% of all sports injuries resulting in ED presentation or hospitalisation and of these, nearly one-quarter were soft tissue injuries. It is likely that other sports-related soft tissue injuries were managed within primary care (for example, by general practitioners, sports physicians and/or physiotherapists), rather than within the hospital system. We found that soft tissue injuries were not associated with an increased likelihood of HR. In contrast, femoral fractures and hip dislocations (comprising 50% and 9% of all hip and thigh injuries, respectively) were the only injury categories significantly associated with HR. We had no record of hip replacement being performed directly after a sports-related fracture, which suggests that these injuries were treated initially with internal fixation and later had a hip replacement performed. Traumatic hip and thigh injuries such as fractures and dislocations that require hospitalisation are relatively rare in sports, including soccer (Giza et al., 2004). It is increasingly recognised that many sports-related hip injuries are of gradual onset and recurrent in nature (Kemp et al., 2017). Such injuries are typically not captured in descriptive epidemiological studies of sports injuries (Toohey et al., 2017). This suggests that our study provides a very conservative estimate of HR outcomes following previous sports injury to the hip. Future population-based studies that can capture non-traumatic, gradual onset sports-related injuries will further augment our understanding of the risk of HR (and related economic burden) following hip injury. However, the establishment of a comprehensive national registry of sports injuries is essential if this goal is to be achieved.

It is well established that knee joint injury increases the risk of knee OA (Culvenor et al., 2015; Englund, Roos, & Lohmander, 2003), the primary reason for knee replacement surgery. The longer-term consequences of injury (including need for joint replacement surgery) are also important to examine, as these can have substantial personal and health system impacts. Our recent work revealed that sports-related knee injury more than doubled the hazard of having knee replacement surgery within a 15 year follow-up period (Ackerman, Bohensky, & Kemp, 2019). When considering the hip, structural deformities have been identified as key risk factors for OA development and need for HR. For example, people with hip dysplasia are at greater risk of developing hip OA (Jacobsen & Sonne-Holm, 2005), while those with cam-type morphology are up to 10 times more likely to require HR in later life (Agricola et al., 2013). Cam morphology refers to extra bone formation in the anterolateral femoral head-neck junction that may develop during adolescence in response to mechanical load (Agricola et al., 2014; Klij et al., 2018). Our study findings highlight the increased likelihood of HR following sports-related musculoskeletal injury. Our focus on sports-related injuries represents an advance over earlier studies examining HR outcomes after elite 'sports participation' in predominantly male cohorts (Vigdorchik et al., 2016) where the causal pathway to HR could be multifactorial. From a clinical perspective, our research is timely and relevant as state-level data indicate that the overall rate of sports injury is increasing, even after accounting for sports participation growth (Finch et al., 2015). Effective injury prevention programs, at all levels of sport, that are feasible and appealing to sporting teams and clubs will be critical (O'Brien, Donaldson, & Finch, 2016). Once an injury has been sustained, rehabilitation programs that prevent the progression of hip disease are essential to avoid an escalating hip OA and HR burden, although evidence of effectiveness is currently limited (Bennell et al., 2014; Kemp et al., 2018) and further research in this area is underway. The cost-effectiveness of such programs, particularly with consideration of downstream surgical expenditure, is also an area of interest. While it is difficult to compare costs between different health systems as funding models vary, we can compare our HR findings with direct healthcare costs for knee replacement surgery in the state of Victoria for the same time period (Ackerman, Bohensky, & Kemp, 2019). The cost burden was broadly comparable; direct costs for HR for the hip/thigh injury group totalled $AUD 1.15 million, compared to $AUD1.66 million relating to knee replacement for the knee injury subgroup (Ackerman, Bohensky, & Kemp, 2019).

A key strength was our use of ED presentation and hospitalisation databases, enabling a spectrum of injury severities to be captured. We obtained linked data from the public and private hospital systems to ensure a comprehensive cohort and broad socioeconomic representation. In 2018, 59% of HR procedures in the state of Victoria (and 60% nationally) were performed in private hospitals (Australian Orthopaedic Association National Joint Replacement Registry, 2019). Our data support the preponderance of private arthroplasty procedures; 67% of HR procedures in this study were performed for privately-insured patients. To avoid missing HR outcomes in younger patients, we defined HR to include total hip replacement, hemiarthroplasty and resurfacing arthroplasty procedures. No resurfacing HR procedures were performed for the study cohort, although this is not surprising given the infrequent use of this type of surgery in Australia (less than 400 procedures are performed annually (Australian Orthopaedic Association National Joint Replacement Registry, 2019), with an approximate incidence of 1.5 procedures per 100,000 population in 2018). Consistent with previous methods, (Ackerman, Bohensky, & Kemp, 2019) our multivariate analyses clustered for individuals to account for multiple hospital admissions related to the same injury.

We also recognise the research limitations. Our study specifically focused on people who sustained a sports-related injury, using all non-hip/non-thigh injuries within the cohort as a comparator group. It is therefore not possible to directly compare our findings with HR risk among the general population. However, sports-injured individuals represent an important segment of the population (particularly given increasing sports participation rates (Eime et al., 2014)) and a relevant comparator group (activity levels are likely higher than for the general population), and our approach has clear implications for sports injury prevention. We also acknowledge that the VEMD dataset is restricted to ED presentations in 38 Victorian public hospitals (only 6 private hospitals in Victoria have EDs) and that systematic data on presentations to private ED units are not publically available. As such, our analyses probably underestimate the number of sporting injuries sustained in the state. A key limitation of current ICD-10 codes is the absence of laterality data (side of injury and side of surgery) and we understand this issue may be addressed in future coding iterations. Considering biological plausibility (and in the absence of population-level sports injury data that records the affected side), we assumed that HR surgery was performed on the same side that sustained the injury. Any error associated with this assumption is likely to be random and is not expected to introduce bias for the hip and thigh injury group compared to all other injuries. It is also possible that the sports injury led to altered biomechanics and degeneration of the contralateral hip, ultimately leading to HR surgery. We would contend that this is still an important downstream outcome from the initial injury, contributing to the overall burden of sports injuries. Sports injuries treated outside hospital settings were not included, as reliable injury data are not available for primary healthcare settings. However, patients treated in this way are likely to have sustained only minor injuries, as moderate to severe injuries would usually be referred for hospital-based assessment and management. Patients who moved interstate or died during the study period may have been lost to follow-up, although this should not have occurred differentially among subgroups and is therefore unlikely to introduce bias. We also acknowledge that there may be other confounders of hip disease requiring HR (such as lower limb alignment or hip joint morphology) that we were not able to account for in our analyses, given the data available. Finally, we examined short-to medium-term sports injury outcomes given currently available data; a longer follow-up period will enable additional HRs to be identified and this is an avenue for our future research.

5. Conclusion

Having a sports-related hip or thigh musculoskeletal injury tripled the likelihood of HR surgery within 15 years, compared to all other sports injuries. When examining injury types, femoral fractures and hip dislocations were each associated with an increased hazard of HR. For people who sustained a sports-related hip or thigh injury and progressed to HR, the duration from injury to surgery was relatively short. Effective, feasible injury prevention programs at all levels of sport may reduce this burden in the future, while timely rehabilitation of sports-related hip and thigh injuries (and ongoing monitoring) could provide opportunities for preventing the development and progression of symptomatic hip disease. Continued surveillance of population-level HR data will assist with evaluating the impacts of sports injury prevention and rehabilitation initiatives.

Ethical approval

Ethics approval was obtained from The University of Melbourne Human Research Ethics Committee (ID 1545763). Informed consent was not applicable to this study as no participant recruitment was involved and only de-identified data were used.

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Declaration of competing interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2019.10.008.

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