OPEN ACCESS

Sport-related major trauma incidence in young people and adults in England and Wales: a national registry-based study

Madeleine Davies ,[1,2] Tom Lawrence,[3,4] Antoinette Edwards,[4] Carly McKay,[2,5] Fiona E Lecky,[4,6] Keith A Stokes,[2,7] Sean Williams[2]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/ip-2023-044887).

[1]Institute of Sport, Exercise and Health, UCL, London, UK
[2]Department for Health, University of Bath, Bath, UK
[3]National Institute for Health and Care Excellence, London, UK
[4]Division of Population Health, Trauma Audit and Research Network, The University of Manchester, Manchester, UK
[5]Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, University of Nottingham, Nottingham, UK
[6]Centre for Urgent and Emergency Care Research, University of Sheffield School of Health and Related Research, Sheffield, UK
[7]Rugby Football Union, London, UK

Correspondence to
Dr Sean Williams, Department for Health, University of Bath, Bath, UK; sw356@bath.ac.uk

Received 3 March 2023
Accepted 24 August 2023
Published Online First 24 October 2023

Check for updates

To cite: Davies M, Lawrence T, Edwards A, *et al*. *Inj Prev* 2024;**30**:1–8.

ABSTRACT

Objectives Data on sport and physical activity (PA) injury risk can guide intervention and prevention efforts. However, there are limited national-level data, and no estimates for England or Wales. This study sought to estimate sport and PA-related major trauma incidence in England and Wales.

Methods Nationwide, hospital registry-based cohort study between January 2012 and December 2017. Following Trauma Audit and Research Network Registry Research Committee approval, data were extracted in April 2018 for people ≥16 years of age, admitted following sport or PA-related injury in England and Wales. The population-based Active Lives Survey was used to estimate national sport and PA participation (ie, running, cycling, fitness activities). The cumulative injury incidence rate was estimated for each activity. Injury severity was described by Injury Severity Score (ISS) >15.

Results 11 702 trauma incidents occurred (mean age 41.2±16.2 years, 59.0% male), with an ISS >15 for 28.0% of cases, and 1.3% were fatal. The overall annual injury incidence rate was 5.40 injuries per 100 000 participants. The incidence rate was higher in men (6.44 per 100 000) than women (3.34 per 100 000), and for sporting activities (9.88 per 100 000) than cycling (2.81 per 100 000), fitness (0.21 per 100 000) or walking (0.03 per 100 000). The highest annual incidence rate activities were motorsports (532.31 per 100 000), equestrian (235.28 per 100 000) and gliding (190.81 per 100 000).

Conclusion Injury incidence was higher in motorsports, equestrian activity and gliding. Targeted prevention in high-risk activities may reduce admissions and their associated burden, facilitating safer sport and PA participation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prior to this study, there were no national data on sport and physical activity (PA)-related trauma risks in the UK to inform prevention or reduction initiatives.

WHAT THIS STUDY ADDS

⇒ Injury incidence data are presented for 61 sporting and physical activities. The national trauma incidence across all sport and PA in England and Wales was 5.4 injuries per 100 000 participants. The incidence was higher for male (6.4 injuries per 100 000 participants) than female participants (3.3 per 100 000 participants). Motorsport, equestrian and gliding activities had the highest annual injury incidence rate.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Comparatively at-risk groups have been identified, which can be targeted with injury reduction initiatives. This study also takes steps towards establishing the feasibility of a national register for serious sporting injuries, as recommended in the UK governmental Duty of Care in Sport Review.

INTRODUCTION

Sporting activities and physical activities (PA) have health benefits, including lowering morbidity and mortality risks, improving pain, quality of life and mental health.[1–4] However, there is also an innate risk of injury. This central risk[5] can result in removal from activity and limit further participation, but can also predispose participants to disability,[6 7] and have financial consequences for individuals and society.[8] The financial sequelae of injury warrant international investment in preventative measures to reduce immediate and chronic societal burden.[9]

A major trauma and mortality rate of 12.2 per 100 000 participants has been identified in Australia (2847 injuries over 10 years to 2015), with an 8% increase in non-fatal trauma, notably equestrian activity, motorsports and cycling.[10] A national study in the Netherlands found that sports injury emergency department episodes had the third highest annual direct healthcare cost (€168 million), after home/leisure (€1334 million) and traffic injuries (€373 million).[9] In the context of nationalised, publicly funded healthcare such as the UK National Health Service (NHS), characterising injuries and identifying mechanism has clinical service implications, for reducing resource consumption, and facilitating PA health benefits with fewer detriments.

High-quality population-level data need to support prevention policies.[11] However, there are limited national sport-related data sources, and no such data in England and Wales. This limits prevention opportunities,[11] and the burden reduction of largely characterisable and preventable injuries. Since the 2012 introduction of regional trauma networks, and establishment of major trauma centres (regional specialist hospitals for trauma care provision) to provide increased specialised care for trauma patients in England,[12] the Trauma Audit and Research Network (TARN) Registry has underpinned service evaluations, comparative patient outcome, characteristics and mortality to support more consistent and evidence-based major trauma care.[13–16] Metrics include Injury Severity Score (ISS), an individual's person-level summary of injury, commonly used to define major trauma (>15).[17]

This Registry also provides an opportunity to establish the number of severe sport and PA injuries nationally, and alongside population-based national participation data such as Sport England's Active Lives Survey (ALS), to derive injury incidence nationally and identify reduction opportunities.

Therefore, this study's objectives were:

- To identify NHS-treated sport-related or PA-related adult major trauma injuries in England and Wales between 2012 and 2017.
- To determine the cumulative incidence rate of adult major trauma injury in activities with highest national participation.
- To describe the cumulative incidence rate of adult major trauma injury annually from 2012 to 2017.
- To determine the proportion of fatal sport-related adult major trauma injuries, and the proportion classified with an ISS >15.

METHODS

Study design and setting

Registry-based cohort study of adults and young people (≥16 years), with severe injuries treated in NHS hospitals in England and Wales, from January 2012 to December 2017. The TARN Registry receives data from hospitals for patients who: (1) stay in hospital for ≥3 days, (2) become fatalities after admission or (3) have high dependency care admission.[18] All major trauma units and hospitals are members, with Health Research Authority approval for data collection without patient consent, in the absence of an individual national data opt-out.

Registry data include admission date and time, incident date, location and description, intent, sex, date of birth, ISS,[19] length of stay, length of stay in critical care, outcome at discharge and readmission. The categorical 'intent' field describes the rationale (ie, sport, non-intentional, intentional or self-harm). Outcome at discharge includes death after reaching hospital. Readmission is defined as ≤30 days of and related to the initial incident. Ethnicity data were not available.

Hospital-level case attainment is measured against Hospital Episode Statistics.

Patient and public involvement

Patients or the public were involved in the design, conduct and dissemination plans through active involvement in the project's steering group. Categorisation for cases, definitions, study progress and outputs were all discussed, and decisions made jointly, informed by patient perspectives.

Defining sport-related trauma cases

Injuries meeting the inclusion criteria, occurring in 'sport' (intent field) or including sporting phraseology in injury description (online supplemental file 1) were extracted.[18] Sporting injuries were defined as occurring in bowling, gymnastics, or team, roller, adventure, racket, water, leisure, combat or winter sports. PA definition included occurring during running, gym attendance, fitness or exercise classes, cycling or walking. Key sporting phrases were identified with Sport England, the study steering group and a literature review.

Sport and PA exposure: ALS

ALS contacts households to examine sporting involvement, habits and spectatorship. Predetermined target responses per local authority are set throughout the survey year for national generalisability.[19,20] Only people aged ≥16 are included, with children's data collected elsewhere. There were 376 382 respondents to ALS in Year 2 (Y2; 2016/2017) and Year 3 (Y3; 2017/2018) surveys, with an 18.9% response rate in Y2 and Y3.[19,20]

Before ALS, the Active People Survey collected sports participation data in England. However, this landline telephone survey ran largely unchanged between its introduction in 2005 and 2015, thus becoming increasingly outdated and less generalisable. In discussion with Sport England, the second and third years of the new ALS were decided to be the most reliable national sporting exposure.

Variables

Using Stata V.13.1 and V.16.1 SE (StataCorp, Texas), data were checked for accuracy and outliers. Queries regarding the definition of sports participation and sporting exposure were identified during data checking and escalated to a quarterly steering group for discussion and collaborative decision-making.

Data cleaning and management

A sporting indicator variable was generated for each activity. Key phrases, likely typographic errors, alternate spelling or common derivations (ie, 'rugby', 'playing ruby', 'rygby') were identified. The *foreach* command was used to flag potential cases. Cases were reviewed, and any non-sport-related cases (eg, 'attended *Rugby* St Cross' hospital) excluded. The list of non-cases (ie, 'attended *Rugby* St Cross', 'way back from watching rugby') was reviewed again.

Cases with unclear sporting contexts (ie, tackled by a sibling at home; struck by hockey stick; triathlon inclusion as 'leg' of activity or overarching activity; moving goals and posts) were escalated for collective steering group decision-making on inclusion (n=61). This included one example (ie, struck by hockey stick) bought for every scenario it may happen (ie, struck by hockey stick, cricket bat, tennis racket). Cases with no evidence of sporting involvement, or alcohol consumption but no sporting mechanism (ie, 'fell over clothes *horse*', 'on *Boxing* Day'), were identified, a non-sports indicator generated using the string match (*strmatch*) command, and then reviewed. Incidents with special characters were excluded separately with the string position command *strpos*. Incidents occurring during rehabilitation of another injury ('rehab', 'physio class', 'physio exercises') were excluded. Data for prespecified sports were extracted, and remaining uncategorised cases reviewed. This case-by-case review process resulted in either: (1) the incident categorised as non-sport for exclusion, (2) the extraction terms being revised and rerun or (3) a novel sporting category generated. All exclusion cases were then reviewed again.

Defining person-time at risk

Twice-monthly sports participation data from ALS Y2 and Y3 formed the 'person-time at risk' denominator across the study period. Respondents were asked about their broad activity participation (i.e., walking, cycling, dance, fitness or sporting activities) and selected each individual sport or activity they participated in from a list of 77 activities (online supplemental file 2). The ALS sampling strategy extrapolates responses to a population level using Office for National Statistics (ONS) data. The number of sports participants at risk was derived from an ONS-weighted Y2 and Y3 ALS participation estimate, to produce a population-weighted mean Y2-Y3 estimate, for England and Wales.

Participation data were derived for:

- Any twice-monthly (28 days) participation.
- Twice-monthly broad activity participation (walking, cycling, creative or artistic dance, fitness activities, sporting activities).
- Each of 84 individually collected specific activities (online supplemental file 1).

Injury data could not be consistently differentiated between PA or travel incidents for walking and cycling. Therefore, broad activity groupings of (1) any walking or (2) any cycling in ALS (including commuting, off-road cycling or tricycles) were used. It is acknowledged that this may increase the denominator data. However, commuting trauma cases would be collected for walking or cycling injuries as for sport.

Statistical methods

Descriptive statistics were estimated for demographic, incident, location type, treatment and derived sporting activity fields. Any trauma cases or participation data, either overall or by sex which reported a count of less than 5, were suppressed for the purpose of disclosure control. The crude cumulative incidence proportion for specific activities was estimated by dividing the total number of injuries by the sum of annual population-weighted participation data. Not every activity corresponded to a broad activity grouping in ALS (ie, motorsport was not included in sporting or fitness activities in ALS). All cases are presented for their specific activity.

The annual crude cumulative incidence rate was derived by dividing the number of injuries per specific activity by the annual population-weighted participation per sport. Annual incidence rate for all sport or activity participation, that is, any participation in one or more sport or PA activities twice in the last 28 days, was derived per year. This was also derived for broad activity groupings, and then for each individual sport or activity in ALS. The proportion of ISS >15 injuries was derived,[17] and the proportion fatal once reaching hospital. Cumulative injury incidence rate was reported per 100 000 participants/year, unless otherwise stated (ie, for specific year). Poisson CIs assessed the influence of injury risk factors (sex) on injury incidence. Incidence figures were produced in RStudio (1.2.1335). Subgroups of the number and proportion of injuries by sex for each age group were undertaken as sensitivity analyses.

RESULTS

Sport and PA-related severe sports injury: 2012–2017

Data for 18 343 incidents were received, of which 'sport' as the only search field would have captured 73.6% of cases (table 1). After excluding paediatric (≤16 years, n=2191), rehabilitation (n=5), non-sports incidents (n=2549), incidents with no description (n=164) and incidents with sporting terminology but not occurring in sport (n=1732), there were 11 702 incidents between January 2012 and December 2017. Most cases were men (n=6909; 59.0%), with a mean age of 41.2 (16.2) years. The highest reported age category was 45–54 (21.3%), followed by 16–24 (21.2%). The mean length of stay was 9.4 days, 3278 incidents (28.0%) were ISS >15 and 148 (1.3%) were fatal (table 1).

Table 1 Participant characteristics for those with eligible Trauma Audit and Research Network (TARN) Registry incidents, and reporting twice-monthly sports participation in Sport England's Active Lives Survey

	TARN incident participants (n=11 702)	Active Lives Survey Year 2 and Year 3 respondents with twice-monthly participation (n=376 382)	
		Respondents (n)	
Age (years)			
Mean age (SD) - years	41.2 (16.2)	373 174	–
Categories (%)			
16–24	2476 (21.2)		23 629 (6.3)
25–34	2225 (19.0)		46 933 (12.6)
35–44	1984 (17.0)		58 508 (15.7)
45–54	2489 (21.3)		64 132 (17.2)
55–64	1654 (14.1)		71 397 (19.1)
65–74	630 (5.4)		71 446 (19.1)
75–84	205 (1.8)		29 700 (8.0)
85+	39 (0.33)		7429 (2.0)
Male sex (%)	6909 (59.0)		166 086 (44.2)
Ethnicity (%)	–	362 510	
White British			313 419 (86.5)
White other			19 860 (5.5)
South Asian			14 959 (4.1)
Black			5490 (1.5)
Chinese			1952 (0.5)
Mixed			4080 (1.1)
Other ethnic group			2750 (0.8)
Major trauma centre treated, n (%)	5812 (49.7)	–	–
Mode of arrival (n=8657)		–	
Helicopter	1334 (15.4%)		–
Ambulance	6164 (71.2%)		
Car/personal vehicle	625 (7.2%)		
Aircraft	21 (0.2%)		
Walking	114 (1.3%)		
Ambulance and helicopter	142 (1.6%)		
Not applicable	195 (2.3%)		
With police, by ambulance car or other	62 (0.7%)		
Intent (n=11 702)			
Alleged assault	29 (0.2%)		
Intent inconclusive	18 (0.2%)		
Non-intentional	2999 (25.6%)		
Sport	8608 (73.6%)		
Suspected high-risk behaviour or self-harm	48 (0.4%)		
Radiograph	8862 (75.7%)	–	–
CT scan	7869 (67.2%)	–	–
Length of stay (days)	9.4 (16.2)	–	–
Readmission	476 (4.1%)	–	–
Injury Severity Score >15	3278 (28.0%)	–	–
Death	148 (1.3%)	–	–

Data are reported as n (%) unless otherwise indicated.

Table 2 The number of cases, length of stay and proportion of Injury Severity Score >15 for Trauma Audit and Research Network (TARN) Registry injuries by broad activity

	TARN cases (n)			Length of stay	Injury Severity Score >15	Overall injury incidence (per 100 000 participants/year)	Male injury incidence (per 100 000 participants/year)	Female injury incidence (per 100 000 participants/year)
	Overall	Male	Female	Days (SD)	n (%)			
All adults physically active (aged 16+)	11 702	6909	4793	9.4 (16.2)	3278 (28.0)	5.39 (5.29 to 5.49)	6.44 (6.29 to 6.59)	3.34 (3.25 to 3.44)
Broad activity cases (n=11 208)								
Sporting activities	9623	5209	4414	9.3 (15.9)	2671 (27.8)	9.88 (9.68 to 10.08)	9.36 (9.11 to 9.62	10.56 (10.25 to 10.88)
Cycling*	1339	559	86	9.9 (16.7)	206 (31.9)	2.81 (2.66 to 2.96)	4.04 (3.82 to 4.27)	0.71 (0.60 to 0.85)
Fitness activities	177	85	92	9.5 (9.1)	40 (22.6)	0.21 (0.18 to 0.24)	0.23 (0.19 to 0.28)	0.20 (0.16 to 0.25)
Walking*	49	32	17	12.4 (11.9)	23 (46.9)	0.03 (0.02 to 0.04)	0.04 (0.03 to 0.06)	0.02 (0.01 to 0.03)
Creative or artistic dance	20	†	†	12.4 (16.7)	2 (10.0)	0.35 (0.23 to 0.54)	†	†

Results are ordered by case number.
*Walking and cycling are separated into the following activity groups in the Active Lives Survey: (1) walking for leisure and (2) walking for travel; and (1) cycling for leisure and sport and (2) cycling for travel. We are unable to correctly classify TARN incidents by these descriptions, and therefore they are not reported separately.
†Cells for which less than 5 cases have been suppressed for disclosure control.

Sport and PA exposure

Most ALS respondents were active twice monthly (77.2% and 77.5% for ALS Y2 and Y3). When weighted by population estimates, this resulted in 77.3% active twice in 28 days (online supplemental file 3). Participation was highest in walking (59.1%), sport (34.7%) and fitness activities (29.7%). By individual activity, participation was highest in running (15.3%), fitness classes (14.3%) and gym sessions (12.8%). This equated to a 6-year total population at risk of 42.9 million for running, 40.2 million for fitness classes and 35.8 million for gym sessions (online supplemental file 2). Full participation data are provided (online supplemental files 2–4).

Injury incidence and incidence by participation rankings

Overall injury incidence

With 11 702 trauma incidents, and 77.3% of the population active twice monthly, there was a cumulative injury incidence of 5.4 injuries per 100 000 participants/year. The overall cumulative incidence for male participants was 6.4 injuries per 100 000 participants/year, and 3.3 injuries per 100 000 for female participants/year (table 2). The incidence was highest for 16–24 year-olds (6.25 injuries per 100 000 participants/year), followed by 45–54 year-olds (figure 1).

By age group, the proportion of injuries was higher for men at all age groups aside from or those aged 55–64 years and 85+, where female participants accounted for 55.1% and 53.8% of trauma cases, respectively (figure 2).

Injury frequency and incidence by broad activity

The number of cases was highest for equestrian activity (n=4303), followed by cycling (n=1339), football (n=876), motorsports (n=597) and rugby (n=490). Injury severity was highest in boxing (71.6%), followed by abseiling (55.6%), surfing sports (51.1%) and gliding sports (online supplemental file 5).

Of the 95.8% of incidents which corresponded to a broad activity grouping, 9623 (85.9%) were in sport, followed by 1339 in cycling (11.9%). The incidence was highest for sporting activities (9.9 injuries per 100 000 participants/year).

Incidence of injury by national participation

Participation was highest in running, with an injury incidence of 0.70 per 100 000 participants/years (table 3). Of high participation sports, football had the highest injury incidence (6.56 per 100 000 participants/year).

Incidence of injury for specific activities

Motorsports had the highest incidence, with 532.3 injuries per 100 000 participants/year. This was followed by equestrian-related sports, with 235.3 injuries per 100 000 participants/year. The third highest sporting activity was gliding, paragliding or

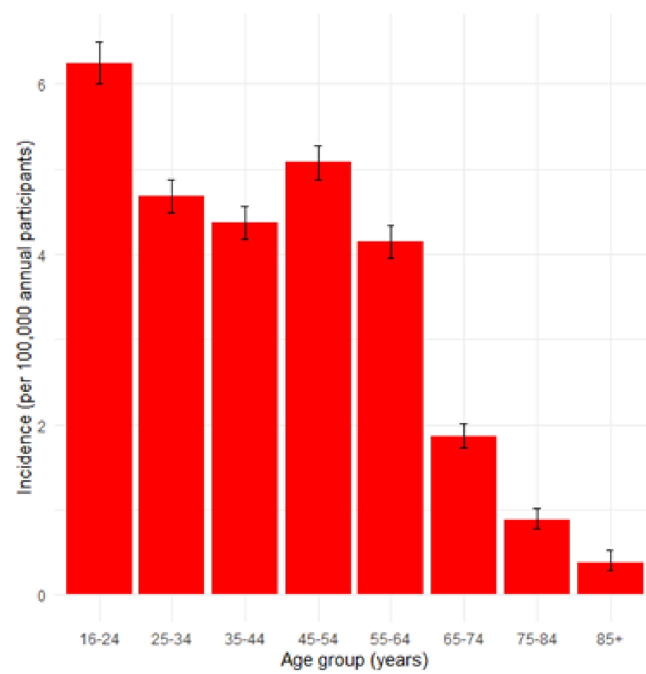

Figure 1 The overall annual incidence of severe sport-related injury (per 100 000 participants) by age group across the study period. Error bars represent 95% CIs.

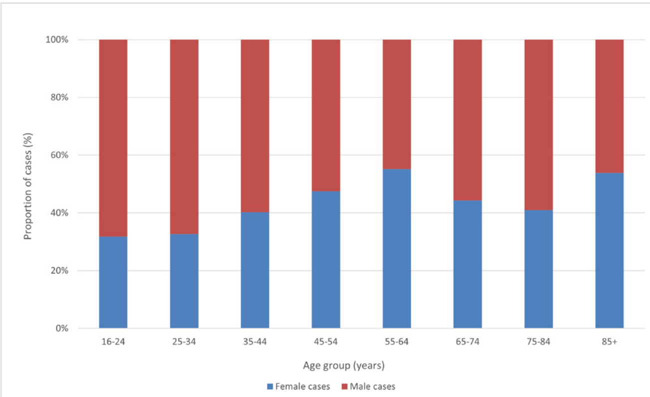

Figure 2 The proportion of severe sport-related injury cases, by age group and sex.

hang gliding, with 190.8 injuries per 100 000 participants/year (table 4). All sledding, luge and tobogganing incidents ranked 10th. However, excluding any incidents with 'hill' or 'park' (ie, discounting unorganised, seasonal recreation), this category was 14th (table 4). Full incidence data for all activities have been provided (online supplemental file 5).

Annual cumulative injury incidence over time

The injury incidence appeared to increase over time (table 5), with the highest incidence in 2015, but data from 2016 and 2017 remaining higher than the incidences seen for 2012–2014. Sporting activities consistently had the highest incidence (7.75 per 100 000 participants (95% CI 7.33 to 8.20) in 2012 and 10.83 (95% CI 10.34 to 11.34) in 2017), followed by cycling (1.87 (95% CI 1.59 to 2.20) in 2012 and 2.92 (95% CI 2.57 to 3.32) in 2017). In sporting activities, there were an additional 3.08 injuries per 100 000 participants/year in 2017, compared with 2012, and injuries in fitness activities were more than twice the incidence in 2012 by 2017 (table 5).

DISCUSSION

Principal findings

Between 2012 and 2017, there were 11 702 trauma injuries and an injury incidence of 5.4 per 100 000 participants/year. Male incidence (6.4 injuries/100 000) was higher than female incidence (3.3 injuries/100 000)/participants/year. Among sports with the highest participation, football had the highest injury incidence rate (6.56 injuries/100 000 participants/year (95% CI 6.14 to 7.01)), followed by golf (1.25/100 000 participants/year (95% CI 1.00 to 1.57)) and badminton (1.9%; 0.82/100 000 participants/year (95% CI 0.61 to 1.10)). For fitness activities, running had the highest participation (0.70 injuries per 100 000 participants/year (95% CI 0.63 to 0.78)), followed by fitness classes (0.10 per 100 000 participants/year (95% CI 0.08 to 0.14)) and gym sessions (0.23 per 100 000 participants/year (95% CI 0.18 to 0.28)). All fitness activities had a lower incidence than the overall sport and PA incidence. This is the first time comparable sport-specific national data have been described for England and Wales.

Interpretation and generalisability

Sporting activities had a higher injury incidence than cycling, walking, fitness or dance. A population-based survey in Finland similarly reported the injury incidence in 'commuting and lifestyle activities' (walking, rowing, gardening, home repair, cycling, hunting or fishing) as lower than in recreational and competitive sports.[21] The highest incidence activity was motorsports. In the UK, data from one regional trauma and spine unit identified an almost 500% increase in 5 years to 2015.[22 23] Motorsport's prominence in our study may indicate its consistently higher risk profile over recent years, and that this risk is not localised.

Equestrian-related injuries had the second highest incidence. An observational study in the USA reported one in five equestrians (21%) seriously injured during horse riding, a finding which in 2007 prompted calls for injury prevention attention, particularly for novices.[24] The high proportion of UK road-related equine incidents and risk factors such as passing distance and speed have been discussed.[25] These more mechanistic data

Table 3 The overall injury incidence and incidence by sex for the 15 highest participation sports and physical activities in individuals aged 16 and above

		Overall		Male		Female	
Activities	**Participation (%)**	**Cases**	**Incidence**	**Cases**	**Incidence**	**Cases**	**Incidence**
Walking	59.05	49	0.02 (0.02 to 0.03)	32	0.04 (0.03 to 0.06)	17	0.02 (0.01 to 0.03)
Cycling	16.98	1339	2.81 (2.67 to 2.97)	1215	4.04 (3.82 to 4.23)	124	0.71 (0.59 to 0.84)
Running	15.32	301	0.70 (0.63 to 0.78)	187	0.80 (0.70 to 0.93)	114	0.58 (0.48 to 0.69)
Fitness class	14.33	42	0.10 (0.08 to 0.14)	8	0.08 (0.04 to 0.15)	34	0.11 (0.08 to 0.16)
Gym session	12.76	81	0.23 (0.18 to 0.28)	40	0.21 (0.15 to 0.28)	41	0.25 (0.18 to 0.34)
Swimming	10.37	192	0.66 (0.57 to 0.76)	133	1.04 (0.88 to 1.24)	59	0.36 (0.28 to 0.47)
Exercise machines	8.59	27	0.11 (0.08 to 0.16)	17	0.13 (0.08 to 0.22)	10	0.09 (0.05 to 0.16)
Weights session	5.13	27	0.19 (0.13 to 0.27	20	0.23 (0.15 to 0.36)	7	0.12 (0.06 to 0.25)
Football	4.76	876	6.56 (6.14 to 7.01)	839	6.92 (6.47 to 7.41)	37	2.98 (2.16 to 4.12)
Golf	2.14	75	1.25 (1.00 to 1.57)	64	1.26 (0.99 to 1.61)	11	1.18 (0.65 to 2.13)
Badminton	1.92	44	0.82 (0.61 to 1.10)	20	0.61 (0.39 to 0.95)	24	1.13 (0.76 to 1.69)
Tennis	1.83	73	1.42 (1.13 to 1.79)	37	1.19 (0.86 to 1.65)	36	1.77 (1.27 to 2.45)
Boxing (includes boxing fitness classes)	1.65	74	1.59 (1.27 to 2.00)		*		*
Rowing (includes indoor rowing)	1.48		*		*		*
Table tennis	0.95	34	1.28 (0.91 to 1.79)	15	0.8 (0.48 to 1.32)	19	2.41 (1.53 to 3.77)

Please note the Active Lives Survey broad activity groupings of walking and cycling have been included for completeness.
*Result by sport or sex is not provided in the interests of non-disclosure (results are <5 cases).

Table 4 Annual participation, overall injury incidence and injury incidence for the 6-year study period by sex for the 15 highest overall incidence sports and physical activities for individuals aged 16 and over

Activities (6-year participation estimate)	Overall		Male		Female	
	Cases	Incidence	Cases	Incidence	Cases	Incidence
Motorsports (n=112 153)	597	532.31 (491.28 to 576.77)	555	506.30 (465.88 to 550.22)	42	*
Equestrian (n=1 828 913)	4303	235.28 (228.35 to 242.41)	768	292.79 (272.80 to 314.25)	3535	223.87 (216.61 to 231.37)
Gliding, paragliding or hang gliding (n=56 077)	107	190.81 (157.87 to 230.62)	97	*	10	*
Skateboarding (n=400 121)	168	41.99 (36.09 to 48.84)	148	48.10 (40.94 to 56.51)	20	19.69 (12.70 to 30.52)
Ice skating (n=355 983)	113	31.74 (26.40 to 38.17)	52	34.93 (26.62 to 45.84)	61	29.32 (22.81 to 37.68)
Rugby union and league (n=1 959 355)	490	25.01 (22.89 to 27.32)	462	28.14 (25.68 to 30.82)	28	8.88 (6.13 to 12.86)
Water-skiing (n=94 560)	21	22.21 (14.48 to 34.06)	15	*	6	*
Roller-skating, inline skating, rollerblading (n=266 885)	59	22.11 (17.13 to 28.53)	30	26.78 (18.72 to 38.30)	29	16.37 (11.38 to 23.56)
Snowsport (n=1 542 641)	339	21.98 (19.76 to 24.44)	221	23.71 (20.78 to 27.05)	14	2.30 (1.36 to 3.88)
Sledding, luge, tobogganing (all) (n=140 191)	28	19.97 (13.79 to 28.93)	13	*	15	14.95 (9.01 to 24.79)
Abseiling (n=56 077)	9	16.05 (8.35 to 30.85)		†		†
Gymnastics (including all trampolining) (n=1 830 547)	273	14.91 (13.25 to 16.47)	179	25.87 (18.72 to 38.30)	94	8.24 (6.73 to 10.08)
Climbing and bouldering (n=1 962 678)	288	14.67 (13.07 to 16.47)	227	17.44 (15.31 to 19.86)	61	9.25 (7.20 to 11.89)
Sledding, luge, tobogganing (excluding hills and parks) (n=140 191)	19	13.59 (8.67 to 21.30)	10	*	9	*
Obstacle course (eg, Tough Mudder) (n=99 827)	12	12.02 (6.83 to 21.17)		†		†

*Denominator data are not available in Active Lives Survey (ALS). This is predominantly due to insufficient data (ie, too few participant responses by sex) to report an ALS result.
†Result by sex is not provided in the interests of non-disclosure (results for one sex are <5 cases).

may be able to support intervention, given increased awareness of aetiology and national burden. The incidence was broadly similar between male and female equestrians (292.79 injuries per 100 000 participants/year (95% CI 272.80 to 314.25) for males and 223.87 injuries per 100 000 participants/year (95% CI 216.61 to 231.37) for females), despite there being a higher case load of female incidents (n=3535), which constitutes 73.8% of the female in cases in this dataset. This may be indicative of a clear intervention opportunity for a well-phenotyped group of female sports and leisure participants, which also constitutes a high clinical trauma burden.

The third highest incidence activity was gliding or paragliding. Previous research has sought to establish the rate of gliding incidents in the UK by comparing a survey of paraglider pilots to an incident database.[26] This study proposed risk factors of control or error decisions above equipment failure, however quantified participation as per 100 000 hours of flight time, which prevents comparison to this study's population methodology.[26] These three prominent activities together accounted for 5007 incidents (42.8% of cases), and therefore may be candidates for further prevention efforts.

The highest incidence age group was 16–24, followed by 45–54. A higher incidence for younger people emphasises the importance of injury management during the acute phase, as well as managing and mitigating longer term implications. Sensitivity analyses by sex demonstrated that the proportion of injuries was higher for males aside from two time points of 45–54 years and 85 years or more. Further investigation of the incident category responsible for this peak identified that almost half of the cases for the 45–54 age group were horse related. The proportion of injury by sex changing from predominantly male injuries (68.1%, 67.2% and 59.7% for 16–24, 25–34 and 35–44 years, respectively) to 55.1% female for 55–64 years of age and 53.8% for 85 years and older may be indicative of different life stages relating to the type of activity undertaken and relative risk of injury, encouraging individualised prevention approaches for at-risk groups.

Table 5 Incidence by year of admission for the five broad activity groupings for injuries in individuals aged 16 and over

Activity	Year of admission					
	2012	2013	2014	2015	2016	2017
Any activity (cases, n=11 586)	1504	1739	1927	2178	2096	2142
Any activity (incidence)	4.24 (4.03 to 4.46)	4.87 (4.65 to 5.10)	5.35 (5.12 to 5.60)	6.00 (5.76 to 6.26)	5.73 (5.49 to 5.98)	5.83 (5.58 to 6.08)
Broad activities						
Walking	0.04 (0.02 to 0.07)	0.03 (0.2 to 0.06)	0.04 (0.02 to 0.07)	0.02 (0.01 to 0.05)	0.04 (0.02 to 0.07)	0.01 (0.00 to 0.03)
Cycling	1.87 (1.59 to 2.20)	2.32 (2.01 to 2.68)	2.76 (2.42 to 3.15)	3.97 (3.39 to 4.24)	3.00 (2.65 to 3.41)	2.92 (2.57 to 3.32)
Creative or artistic dance	0.11 (0.02 to 0.76)	*	0.53 (0.22 to 1.26)	0.42 (0.16 to 1.11)	0.41 (0.16 to 1.10)	0.62 (0.28 to 1.37)
Fitness activities	0.13 (0.08 to 0.21)	0.12 (0.08 to 0.20)	0.22 (0.15 to 0.31)	0.24 (0.17 to 0.33)	0.26 (0.19 to 0.36)	0.28 (0.20 to 0.38)
Sporting activities	7.75 (7.33 to 8.20)	9.08 (8.62 to 9.56)	9.71 (9.24 to 10.21)	10.71 (10.22 to 11.22)	10.55 (10.07 to 11.06)	10.83 (10.34 to 11.34)

*No creative or artistic dance cases were reported in 2013.

Injury risks are increasing internationally.[27] In the Netherlands, the injury incidence of fitness injuries increased from 1.3 to 1.8 injuries per 1000 hours of participation between 2010 and 2014.[28] In Victoria, Australia, the annual rate of hospital-treated sports injury increased by 24% between 2004 and 2010,[7] with an incidence of sport-related major trauma or death of 12.2 per 100 000 participants/year.[10] This incidence in Victoria is higher than in our study; however, there were differences in the inclusion criteria for the Victorian State Trauma Registry which are: death after injury, an ISS >12 or intensive care unit admission for 24 hours.[10]

Strengths and limitations

Study strengths include national registry data, collected at the point of treatment and with ascertainment evaluation. As the first sporting analysis using this data source, the data extraction process involved extracting 'sport' incidents (intent field), but also identifying and extracting those featuring any of 62 keywords. This meticulous approach is a strength, as only 73.6% of our cases were captured with the intent field, suggesting that 26.5% cases would have been missed without this approach. However, this is time intensive and resulted in a vast amount of meta-data generation. This can also support improvements in future data recording and extraction.

ALS data covered the latter period of the study, but were agreed as the best available denominator. Data for 2 years were used to reduce any year-on-year variation. For sports where one may not participate twice a month all year (ie, obstacle courses such as Tough Mudder, motorsport, paragliding), a twice-monthly participation may overestimate incidence, compared with less seasonal or more organised sports. Limitations of the denominator data for this purpose also include response rate (18.9% in Y2) and data availability for lower participation sports, particularly by sex. The sampling strategy for ALS does, however, weight responses to population-level data representative of national demographics, which may improve generalisability outside of this sample, and mitigate response bias. These data are also the best available nationally, which governmental decision-making and sport funding is partly based on.

A limitation of TARN data for our study is its fatality definition. Other data sources were sought for all fatalities irrespective of admission, but there is currently no established reporting for this purpose. While all 'sport' mechanism cases and free-text sport-related cases were extracted, differentiation between activities for sport and travel in TARN was harder for some activities (walking or cycling) than for other sports where terminology is clearer. Where there is genuine competitive sports participation in branches of these activities (ie, BMX/off-road, road cycling, track cycling or hiking, fell walking, orienteering), establishing incidence through registries may not be the most reliable true estimate of severe injury. This differentiation difficulty lead us to use 'any' definition for participation and injury these categories (ie, 'any walking' and 'any cycling'), in order to describe a comparable incidence across all forms of sporting and physical activity. We acknowledge this may be of limited value to individual competitive sports in these areas to inform prevention initiatives. However, some of these (ie, BMX) can also be interrogated further within the category, which while not providing comparative incidence may support the identification of injury mechanism. Data were extracted in 2018 before the SARS-CoV-2 pandemic, and we cannot infer current incidence, or changes to sports participation or trauma presentation after pandemic. A final consideration while facilitating this research opportunity, representing severe clinical burden and ensuring reliable and consistent historic reporting, the severity of TARN inclusion criteria will exclude hospital episodes of 1–2 days, and any outpatient or brief inpatient interventions, which are relevant to fully identify the contribution of sports injury to patients and health services.

Most sport and recreation injuries may be considered preventable,[27] and major trauma is the third leading cause of avoidable mortality in the UK.[29] Modification to risk-taking behaviours, legislation, supervision and terrain may all provide opportunities to decrease these ~2000 annual incidents for patients, their families and the healthcare system. Multiple audits in emergency departments in the UK have highlighted these prominent sport-related injuries on a local level and demonstrate clinical eagerness to emphasise the burden of sports injury.[22 30–32] However, the sustained and higher incidence of sport-related major trauma in the UK in recent years is indicative of the absence of coordinated reduction efforts.

CONCLUSION

This study derived a national incidence for major trauma in sport and PA. The highest injury incidence was for sporting injuries, and individual activities of motorsports, equestrian, and gliding, paragliding or hang gliding. To date, there have been no coordinated efforts to reduce this participant, clinical and economic burden in England and Wales. Identifying these higher incidence activities and populations may provide intervention opportunities to reduce risk, and safeguard shorter and longer term participant and population health.

Contributors SW, KAS and CM conceived the study, which was designed by all authors. Data were acquired by TL, SW, MD and AE. MD and SW were responsible for analysing the data. KAS, CM, FEL and AE acted as scientific advisors. All authors contributed to managing the study and interpreting the data. MD drafted the manuscript, which was critically revised and approved for publication by all authors. MD acts as guarantor for this work, with full responsibility for the work, conduct and access to the study's data.

Funding This project was funded by the British Medical Association.

Disclaimer The funding body had no role in study design, data collection, analysis, or the development of this study.

Competing interests MD has received project funding from the British Medical Association, Rugby Football Union and the Rugby Football Union's Injured Players' Foundation. TL has previously been funded by TARN. AE receives funding from TARN and FL is part-funded by TARN. CM received funding from the British Medical Association (BMA) Scholarship Grant to initiate this work. CM also receives funding for other research projects from the Rugby Football Union, Rugby Football Union's Injured Players' Foundation and World Rugby. KS receives project funding from Premiership Rugby, the Rugby Football Union, Rugby Football Union's Injured Players Foundation, England and Wales Cricket Board, and the Racing Foundation. KS is employed by the Rugby Football Union.SW received funding from the British Medical Association (BMA) Scholarship Grant to initiate this work. SW also receives funding for other research projects from the Rugby Football Union, England and Wales Cricket Board, British Gymnastics and Premiership Rugby.

Patient and public involvement Patients with previous experience of sport-related trauma were members of the study steering group, responsible for contributing to its design, methodology, and decision-making.

Patient consent for publication Not applicable.

Ethics approval Institutional research ethics approval was granted for this study by the University of Bath Research Ethics Committee for Health (EP 17/18 08) and the TARN Research Committee.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. No data were generated for this study. Active Lives Survey data are publicly available and retrievable from the Sport England website. Data used were obtained under agreement from the Trauma Audit and Research Network Registry and Sport England.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iD
Madeleine Davies http://orcid.org/0000-0002-6047-7340

REFERENCES

1 Wen CP, Wai JPM, Tsai MK, *et al*. Minimum amount of physical activity for reduced mortality and extended life expectancy: A prospective cohort study. *Lancet* 2011;378:1244–53.
2 Lavie CJ, Carbone S, Kachur S, *et al*. Effects of physical activity, exercise, and fitness on obesity-related morbidity and mortality. *Curr Sports Med Rep* 2019;18:292–8.
3 Geneen LJ, Moore RA, Clarke C, *et al*. Physical activity and exercise for chronic pain in adults: an overview of Cochrane reviews. *Cochrane Database Syst Rev* 2017;4:CD011279.
4 Goldberg JH, King AC. Physical activity and weight management across the LifeSpan. *Annu Rev Public Health* 2007;28:145–70.
5 Timpka T, Jacobsson J, Bickenbach J, *et al*. What is a sports injury? *Sports Med* 2014;44:423–8.
6 Davies M, Judge A, Stokes K, *et al*. Is Rugby playing load predictive of lower limb osteoarthritis in former International Rugby players? *Osteoarthr Cartil* 2016;24:S533–4.
7 Finch CF, Kemp JL, Clapperton AJ. The incidence and burden of hospital-treated sports-related injury in people aged 15+ years in Victoria, Australia, 2004-2010: A future epidemic of osteoarthritis. *Osteoarthr Cartil* 2015;23:1138–43.
8 Donaldson L, Li B, Cusimano MD. Economic burden of time lost due to injury in NHL hockey players. *Inj Prev* 2014;20:347–9.
9 Polinder S, Haagsma J, Panneman M, *et al*. The economic burden of injury: health care and productivity costs of injuries in the Netherlands. *Accid Anal Prev* 2016;93:92–100.
10 Ekegren CL, Beck B, Simpson PM, *et al*. Ten-year incidence of sport and recreation injuries resulting in major trauma or death in Victoria, Australia, 2005-2015. *Orthop J Sports Med* 2018;6:2325967118757502.
11 Finch CF. Getting sports injury prevention on to public health Agendas-addressing the shortfalls in current information sources. *Br J Sports Med* 2012;46:70–4.
12 McCullough AL, Haycock JC, Forward DP, *et al*. Major trauma networks in England. *Br J Anaesth* 2014;113:202–6.
13 Moran CG, Lecky F, Bouamra O, *et al*. Changing the system - major trauma patients and their outcomes in the NHS. *EClinicalMedicine* 2018;2–3:13–21.
14 Christensen MC, Ridley S, Lecky FE, *et al*. Outcomes and costs of blunt trauma in England and Wales. *Crit Care* 2008;12:R23.
15 Dixon JR, Lecky F, Bouamra O, *et al*. Age and the distribution of major injury across a national trauma system. *Age Ageing* 2020;49:218–26.
16 Edwards A, Hammond P, Evans E, *et al*. *Procedures Manual (England and Wales)*. Trauma Audit and Research Network, 2018: 10–1.
17 Baker SP, O'Neill B, Haddon W Jr, *et al*. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187–96.
18 Davies MAM, Lawrence T, Edwards A, *et al*. Serious sports-related injury in England and Wales from 2012-2017: a study protocol. *Inj Epidemiol* 2020;7:14.
19 Mori I. Year 2 Technical Report Ipsos MORI, . 2018Available: http://www.ipsos-mori.com/terms.http://www.ipsos-mori.com/terms
20 Sport England. *Active Lives Adult Survey 17/18 Report*. Sport England, 2019: 1–24.
21 Parkkari J, Kannus P, Natri A, *et al*. Active living and injury risk. *Int J Sports Med* 2004;25:209–16.
22 Singh R, Bhalla A, Ockendon M, *et al*. Spinal Motocross injuries in the United Kingdom. *Orthop J Sports Med* 2018;6:2325967117748644.
23 Fierro N, Inaba K, Aiolfi A, *et al*. Motocross versus Motorcycle injury patterns: A retrospective national trauma Databank analysis. *J Trauma Acute Care Surg* 2019;87:402–7.
24 Mayberry JC, Pearson TE, Wiger KJ, *et al*. Equestrian injury prevention efforts need more attention to novice riders. *J Trauma* 2007;62:735–9.
25 Pollard D, Grewar JD. Equestrian road safety in the United kingdom: factors associated with collisions and horse fatalities. *Animals* 2020;10:2403.
26 Wilkes M, Long G, Massey H, *et al*. Quantifying risk in air sports: flying activity and incident rates in Paragliding. *Wilderness Environ Med* 2022;33:66–74.
27 Tator CH. Risk of catastrophic injury in sports and recreation. *Sport in Society* 2011;14:1291–9.
28 Kemler E, Valkenberg H, Verhagen E. More people more active, but there is a counter site. novice athletes are at highest risk of injury in a large population-based retrospective cross-sectional study. *BMJ Open Sport Exerc Med* 2022;8:e001255.
29 Vassallo J, Fuller G, Smith JE. Relationship between the injury severity score and the need for life-saving interventions in trauma patients in the UK. *Emerg Med J* 2020;37:502–7.
30 Sandiford N, Buckle C, Alao U, *et al*. Injuries associated with recreational horse riding and changes over the last 20 years: a review. *JRSM Short Rep* 2013;4:2042533313476688.
31 Abdulkarim A, Juhdi A, Coffey P, *et al*. Equestrian injury presentations to a regional trauma centre in Ireland. *Emerg Med Int* 2018;2018:7394390.
32 Singh R, Chojnowski A, Hay S. Hand and wrist injuries related to Motocross injuries: 5 year series. *J Hand Surg Asian Pac Vol* 2019;24:60–4.