



Original research

Sports-related brain injury in the general population: An epidemiological study



Alice Theadom^{a,*}, Nicola J. Starkey^b, Tony Dowell^c, Patria A. Hume^d, Michael Kahan^e, Kathryn McPherson^f, Valery Feigin^a, on behalf of the BIONIC Research Group¹

^a National Institute for Stroke and Applied Neuroscience, Faculty of Health and Environmental Science, Auckland University of Technology, New Zealand

^b School of Psychology, University of Waikato, New Zealand

^c Primary Health Care and General Practice, Wellington School of Medicine and Health Sciences, University of Otago, New Zealand

^d Sports Performance Research Institute New Zealand, Faculty of Health and Environmental Studies, Auckland University of Technology, New Zealand

^e Waikato Occupational Service Ltd., New Zealand

^f Person Centred Research Centre, Faculty of Health and Environmental Studies, Auckland University of Technology, New Zealand

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ABSTRACT

Objectives: To determine the incidence, nature and severity of all sports-related brain injuries in the general population.

Design: Population-based epidemiological incidence study.

Methods: Data on all traumatic brain injury events sustained during a sports-related activity were extracted from a dataset of all new traumatic brain injury cases (both fatal and non-fatal), identified over a one-year period in the Hamilton and Waikato districts of New Zealand. Prospective and retrospective case ascertainment methods from multiple sources were used. All age groups and levels of traumatic brain injury severity were included. Details of the registering injuries and recurrent injuries sustained over the subsequent year were obtained through medical/accident records and assessment interviews with participants.

Results: Of 1369 incident traumatic brain injury cases, 291 were identified as being sustained during a sports-related activity (21% of all traumatic brain injuries) equating to an incidence rate of 170 per 100,000 of the general population. Recurrent injuries occurred more frequently in adults (11%) than children (5%). Of the sports-related injuries 46% were classified as mild with a high risk of complications. Injuries were most frequently sustained during rugby, cycling and equestrian activities. It was revealed that up to 19% of traumatic brain injuries were not recorded in medical notes.

Conclusions: Given the high incidence of new and recurrent traumatic brain injury and the high risk of complications following injury, further sport specific injury prevention strategies are urgently needed to reduce the impact of traumatic brain injury and facilitate safer engagement in sports activities. The high levels of 'missed' traumatic brain injuries, highlights the importance in raising awareness of traumatic brain injury during sports-related activity in the general population.

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1. Introduction

The physical, social and psychological benefits of engaging in sports-related activities are well documented,¹ however, participation in sports-related activities can place individuals at increased risk of injury.² Injury to the brain as the result of a high acceleration, multiple or rotational impact to the head in the context of sport is common, with previous studies revealing that up to 15% of all traumatic brain injuries (TBIs) are sustained during sports-related activities.³ In the USA, 1.6–2.3 million cases of sports-related head injury occur every year, with high associated direct and indirect costs (estimated to be US\$56 billion each year).⁴

* Corresponding author.

E-mail address: alice.theadom@aut.ac.nz (A. Theadom).

¹ BIONIC Research Group members: Valery Feigin (Chair and Principal Investigator), Suzanne Barker-Collo, Kathryn McPherson, Robert Kydd, P. Alan Barber, Varsha Parag, Paul Brown, Nicola Starkey, Anthony Dowell, Michael Kahan, Alice Theadom, Shanthi Ameratunga, Grant Christey, Kelly Jones, Amy Jones, Natalie Hardaker, Braden Te Ao. Alice Theadom was co-funded by ABI Rehabilitation Management during this study and Kath McPherson holds the Laura Fergusson Trust Chair.

The most recent consensus statement⁵ on concussion in sport highlights that the term concussion specifically refers to a low velocity shaking of the head. Many injuries sustained during sport can involve severe injury or a direct blow to the head, in addition to injuries sustained through shaking of the brain. All injuries where there is an injury sustained to the brain will be referred to as TBIs in this article to encompass the full spectrum of injuries that may occur within the sports context, rather than just concussion.

Although early management has improved enormously with more people now surviving acute injury, those who do survive a significant brain injury frequently experience persistent difficulties in physical, social, cognitive and emotional functioning.^{6–8} There is emerging evidence that there may also be long-term effects from sustaining even a mild TBI(s). For example, mild TBIs may pre-dispose individuals to early onset dementia and cognitive impairment,⁹ depression¹⁰ and neurodegenerative disease.¹¹ Sustaining multiple impacts to the head (recurrent TBI) can result in cumulative effects as the surviving brain cells from the initial injury become more vulnerable to further damage.¹²

Previous studies on the epidemiology of brain injuries sustained during sport have revealed that males and those under 18 years of age are at increased risk of sports-related TBI.^{3,13} Generally, the highest rates of TBIs occur in hockey, rugby, equestrian activities, cycling, winter sports and football.^{3,13,14} However, the findings of previous studies are limited as recruitment has been restricted to particular populations (such as school children or professional athletes) or specific sporting activities (such as football players). Studies examining sports-related injuries in the general population have also been limited as they have focused on hospital or emergency department records to identify TBI cases. This approach to case ascertainment can result in cases of mild TBI being missed as people may not wish to go to hospital or an emergency department (particularly if it may affect return to play), may not realise they have experienced a brain injury, or the TBI can be overshadowed by more severe injuries, such as broken bones, that require immediate treatment. Population-based studies utilising a range of sources of case ascertainment sources are needed to accurately capture the extent of sports-related TBI in the general population. It is also unclear if the greater risk of TBI experienced by people of Maori and Pasifika ethnicity (indigenous populations of New Zealand, NZ) identified in TBI incidence studies¹⁵ is also observed in sports-related TBIs.

A population-based TBI incidence study using prospective and retrospective methods to identify cases via multiple sources in NZ revealed that the TBI incidence rate was higher than previous estimates (overall incidence rate of 790 per 100,000 of the general population).¹⁶ The sequence of injury prevention model¹⁷ emphasises that describing the nature and extent of the injury problem is a critical component to design, implement and evaluate injury prevention strategies. Given the drive to encourage adults and children to engage in sport as part of maintaining a healthy lifestyle, it is important that general population are able to do so in the safest way possible. To provide an evidence base for the design and implementation of sports-related injury prevention strategies, a population-based incidence study of sports-related TBIs in the general population is needed.¹⁶ Therefore the purpose of this study is to report on the incidence, nature and severity of sports-related brain injury from a population-based TBI incidence dataset using multiple case ascertainment approaches.

2. Methods

Ethical approval was obtained from the Northern Y Regional Ethics Committee of NZ (NTY/09/09/095). This study formed a component of a population-based incidence study that identified all TBI

events that occurred in a one-year period (1st March 2010–28th February 2011) in the Hamilton and Waikato districts in the central North Island of New Zealand (Total Population 173,214, including 20% Maori and 2% Pasifika).¹⁸ To be eligible for inclusion, identified TBI cases were required to have been primarily resident in the study area for the past 12-months. Cases included people across all ages and encompassed the full spectrum of injury severity (including fatal and non-fatal injuries). The methodology of the parent epidemiological study¹⁹ (and full incidence findings)¹⁶ are described elsewhere. In brief, all new cases of TBI that occurred in the study region were identified using a capture–recapture approach. Prospective and retrospective searches of hospital, coroners, ambulance, general practitioner (GP) or other clinical records (e.g., physiotherapy) were conducted. Searches also included school and sports club accident records, national health-care databases (Accident Compensation Corporation and New Zealand Health Information Service) and local prison records. Self-referrals and referrals from community services were also accepted. As many cases of TBI go unrecognised, all people who experienced an accident resulting in an injury to the upper half of their body were contacted and screened to identify if a TBI had been sustained.

A TBI was defined in accordance with the World Health Organisation (WHO) criteria as *an acute brain injury resulting from mechanical energy to the head from external physical forces*.²⁰ Symptoms needed to be related to the TBI and not be due to drugs/alcohol or medications, nor caused by other injuries/treatments (e.g., systemic injuries, facial injuries), or other problems (e.g., psychological trauma, co-existing medical conditions). TBI severity was classified using the Glasgow Coma Scale (GCS): mild TBI as GCS 13–15 and/or Post Traumatic Amnesia (PTA) <24 h; moderate TBI–GCS 9–12 and/or PTA 1–6 days; and severe TBI–GCS 8 or less and/or PTA 7 or more days.^{21,22} If GCS and PTA severities differed, the more severe category was assigned. If no information on PTA was available, severity was based on the worst GCS score.

Details of the injury were obtained from medical records and through an interview assessment with the participant (where possible) to ascertain if the injury met the study criteria for TBI (reviewed by a panel of clinicians). If it was unclear if the case met the inclusion criteria they were excluded. Information on recurrent TBIs was collected from interviews with participants over 12 months following the initial injury and via medical/accident records. As the majority (over 95%) of injuries were mild, they were sub-classified using Servadei et al.²³ criteria. This criteria classifies mild TBI into three categories according to their risk of intracranial lesions; low-risk, medium-risk and high-risk mild TBI based on the presence of clinical signs (e.g., vomiting), risk factors (e.g., pre-trauma epilepsy) and neurological deficits (e.g., impaired vision/speech). These criteria aim to identify patients who require neuroimaging and further medical treatment to prevent onset of subsequent complications.

Based on the incidence data from the parent study of 1369 cases,¹⁶ data were extracted on all TBI events that were reported to have been sustained during a sports-related activity. For the purposes of this study, sports-related activities were defined as 'participation in a specified activity for the purpose of competition or pleasure involving physical exertion and skill,²⁴ that may follow rules or require the use of specific equipment (such as a ball) to complete'. Physical activities that were not deemed to meet this definition included walking, gardening or playing on playground equipment. Additionally, injuries sustained whilst cycling to a destination (cycling as a means of transportation) were also not included as the primary purpose was for transportation rather than competition or pleasure.

Incidence rates were calculated per 100,000 of the general population using NZ census data for the study region. The profile of TBIs is presented by age, gender, nature and severity of injury and

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