The risk of chronic traumatic brain injury in professional boxing: change in exposure variables over the past century

H Clausen, P McCrory, V Anderson

Objective: To determine if boxing exposure has changed over time and hence if current professional boxers are at the same risk of developing chronic traumatic brain injury (CTBI) as historical controls.

Design: Literature review of published studies and analysis of data of active professional boxers.

Subjects: Professional boxers in the United Kingdom and Australia.

Main outcome measures: Boxing history and participation in sparring and professional bouts.

Results: Since the 1930s, the average duration of a professional boxer’s career has dropped from 19 years to five years, and the mean number of career bouts has reduced from 336 to 13. This is despite no significant decline in participation rates from 1931 until 2002.

Conclusions: The incidence of boxing-related CTBI will diminish in the current era of professional boxing because of the reduction in exposure to repetitive head trauma and increased medical monitoring of boxers, with preparticipation medical and neuroimaging assessments resulting in the detection of early and potentially pre-symptomatic cases of CTBI.

Professional boxing is associated with a risk of chronic neurological injury. The development of chronic neurological symptoms in this setting was originally referred to as the punch drunk syndrome. This terminology has evolved over time and the entity is now termed chronic traumatic brain injury (CTBI).

Although approximately one third of cases of CTBI are progressive, the clinical evidence does not support the concept that this condition goes through a predictable and sequential series of stages. Rather, it is a constellation of symptoms affecting the pyramidal, cerebellar, and extrapyramidal domains. Cognitive impairment becomes the major neurological feature in the later stages of the condition. Neuropsychiatric and behavioural symptoms occur variably throughout the course of the disease.

Amateur boxers also show definite neurophysiological and neuroimaging evidence of CTBI. This, however, occurs at a lower incidence than in professional boxers. The difference is presumably because of less exposure to repetitive head trauma, through shorter bouts, and the mandatory use of protective headgear.

There are few prospective studies of this condition that enable an epidemiological estimate of the prevalence of chronic boxing related neurological injury in either amateur or professional boxing. Many of the epidemiological studies in this area are retrospective or are case series studying specific radiological or pathological changes in retired boxers. As a result, all of these published studies suffer from major methodological flaws.

The best estimate of the prevalence of boxing related CTBI is the prospective study of Roberts in 1969, who randomly sampled 250 retired boxers from a total of 16 781 UK boxers registered between 1929 and 1955. All boxers were traced, and 224 were formally studied (16 died, nine emigrated, and one refused). In 37 (17%), lesions of the nervous system were detected using clinical examination, limited neuropsychological assessment, and the radiological techniques of that era, such as pneumoencephalography.

It is important to note that boxing in that era was unlike boxing today for a number of reasons. The striking feature is the difference in exposure. Boxers’ careers in the 1930s to 1950s generally lasted 10–20 years, started in childhood, and often included more than 1000 professional fights. Many boxers after retirement from the professional ranks become professional sparring partners or tent/booth boxers, having up to 30–40 unsupervised bouts a day. Typically boxers had long amateur careers before turning professional. Fighters were not matched by skill or weight, had no medical supervision, and fought with 6 oz gloves. There was less willingness by ring officials to stop bouts when a boxer was overmatched, as well as longer bout duration (up to 40 rounds of two minutes). Furthermore there was no mandatory exclusion after a knockout or head injury. Because of the depression in the 1930s, financial reasons kept many boxers competing for long periods despite the documented onset of neurological symptoms.

The major risk factor cited for CTBI is prolonged exposure to repeated concussive and subconcussive head impact. Hence boxers with long professional careers or boxers with limited defensive skills who repeatedly sustained heavy blows were said to be at the greatest risk of developing this condition. More recent studies suggest that there may be an additional risk factor, the ApoE-ε4 genotype. It is proposed that the presence of these two risk factors together—exposure and ApoE-ε4 genotype—may be multiplicative rather than additive in terms of CTBI risk.

The vast majority of documented CTBI case reports relate to boxers who boxed in the era between 1900 and 1950. Given the evolution in diagnostic neuroimaging sensitivity, one would expect these more sensitive measures to detect much higher rates of CTBI than previous behavioural observations. Further, it is widely noted in the lay press that boxing is less popular as a spectator sport than 50 years ago, yet little is known of boxing participation rates in the current era. If participation in professional boxing is decreasing and the opportunities for head impact exposure is correspondingly reduced, then the risk of CTBI should be minimised. It is therefore hypothesised that current professional boxers will have a lower incidence of boxing related CTBI than their historical counterparts.
The aim of this paper is to determine if boxing exposure has changed over time and hence if current boxers are at the same risk of developing CTBI as historical controls.

METHODS

Relevant studies were identified by searching Medline, PreMedline, Cinahl, SPORTDiscus, Ausport, Austrom, Health & Society, PsychINFO, and the Cochrane database. The search terms used included boxing or boxing and injury or injuries and boxing and head injury or head injuries. The reference lists of identified studies were also searched for relevant studies. Epidemiological studies reported in languages other than English were included where translations were available. Review articles, expert discussion, and bibliographies of major sources were used to provide additional articles.

Australian boxing demographic data were derived from the Australian Boxing Records. This dataset has been compiled on an annual basis since 1996. The current edition provides a full history of all boxers registered and competing in Australia in the year 2002. Population figures for Australia in 2002 were obtained from the Australian Bureau of Statistics.

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maximum of 12 three minute rounds. This is the maximum number of rounds permitted worldwide today. Actual numbers of rounds per fight in current day boxing continues to vary, but presumably this variation occurs across countries.

**Boxing participation**

The total number of boxers who fought professionally in Australia in 2002 was 277. Of this number, 72% have had less than 11 bouts, 17% 12–25 bouts, 11% 25–50 bouts, and 0.7% more than 50 bouts. Not surprisingly, the two boxers with more than 50 bouts have had careers of 19 and 32 years.

Table 3 illustrates the comparisons for the relative historical boxing participation information where available from the United Kingdom and Australia. This is expressed as the number of registered professional boxers per 100,000 of the male population. Unfortunately, no accurate historical or current registration figures were available from the United States for comparison.

The figures in table 3 suggest that there has been no decline in participation rates from 1931 until 2002. The mean (SD) number of boxers over the entire period is 2.6 (0.4) per 100,000 of the male population.

**DISCUSSION**

Despite media perception that professional boxing is decreasing in popularity, our review of the available local and international data provides no support for the suggestion that relative participation in professional boxing has declined over the past 70 years. Comparison of registered boxers in the United Kingdom where there is long term documentation is expressed as the number of registered professional boxers per 100,000 of the male population. Unfortunately, no accurate historical or current registration figures were available from the United States for comparison.

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<table>
<thead>
<tr>
<th>Country/year</th>
<th>Male population</th>
<th>No registered boxers</th>
<th>Boxers per 100 000 male population</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK/1931</td>
<td>22 060 000</td>
<td>592</td>
<td>2.79</td>
</tr>
<tr>
<td>UK/1951</td>
<td>24 118 000</td>
<td>481</td>
<td>1.99</td>
</tr>
<tr>
<td>UK/2002</td>
<td>28 579 869</td>
<td>814</td>
<td>2.84</td>
</tr>
<tr>
<td>Australia/2002</td>
<td>9 908 963</td>
<td>277</td>
<td>2.79</td>
</tr>
</tbody>
</table>

**What is already known on this topic**

- Professional boxing is known to cause CTBI, and boxing exposure, as a surrogate for repetitive concussive injury, is considered to be a primary risk factor.
- The reported prevalence figures for CTBI are largely based on retrospective studies which have major methodological flaws or are drawn from populations in which exposure to the sport is anecdotal thought to be very different from today.

**What this study adds**

- Boxing exposure, as measured by bouts and length of career, has decreased significantly over the century.
- If this is assumed to be a primary risk factor, the incidence of boxing related CTBI should diminish in the current era, despite consistent participation rates.
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Competing interests: none declared

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COMMENTARY
One might expect that professional boxing is a dying art, but this is refuted by the findings of this paper. It is, however, encouraging to note the significant risk reduction in terms of exposure to head injury. This coupled with increased clinical, neuropsychological, radiological, and genetic monitoring and screening should, at least, have a significant effect on the incidence of chronic traumatic brain injury in this sport.

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