

# A prospective cohort study of injury in amateur and professional boxing

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*Br J Sports Med* 2006;40:670–674. doi: 10.1136/bjsm.2006.025924

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Accepted 6 June 2006  
Published Online First  
28 June 2006

**Background:** There is concern over the potential for a high incidence of injury in boxing. This is despite a lack of prospective data evaluating the risk for modern day participants. Updated, reliable data with a focus on potential exposure to injury for both amateur and, especially, professional boxers is required.

**Aim:** To determine the epidemiology of injury and exposure of amateur and professional boxers in Victoria, Australia.

**Methods:** A prospective cohort study with one year follow up was carried out over 2004–2005. Thirty three amateur and 14 active professional boxers registered with either Boxing Victoria Inc (amateurs) or the Professional Boxing and Combat Sports Board of Victoria (professionals) volunteered. Exposure at training and competition was measured, and any injuries sustained during this participation were recorded.

**Results:** Twenty one injuries were sustained by the cohort during the follow up period. Most were to the head region (71%; 95% confidence interval –3.7 to 89.4), with concussion being the most common (33%). An overall injury rate of 2.0 injuries per 1000 hours of boxing was calculated.

**Conclusion:** The high exposure experienced by the boxers (as a result of considerable training time) indicated that boxing has acute injury rates comparable to, and often lower than, those found in other contact and non-contact sports. Further, acute injuries during training appear to be less common and severe than those sustained in bouts.

Boxing is the physical skill of fighting with fists. It is believed to have originated as a sport around 800 BC,<sup>1</sup> with the first historical reference being an account from the 23rd Ancient Olympic Games in 688 BC.<sup>2</sup> The modern day sport has developed from rules and standards established since this time.

Boxing has two participation forms: professional and amateur. Each has its own rules, and analysis of the injuries in each is important, as different injury patterns may exist.<sup>3</sup> For both forms of boxing, a win is achieved by scoring more points than an opponent by delivering more blows to the designated scoring regions of the body (trunk and head), or by an opponent being unable to complete a bout.<sup>4</sup> Boxing is similar to other physical activities in that there is a presumed risk of injury through participation.

Based on previous literature, 27.1–93.4% of boxing injuries involve the head.<sup>3–9</sup> Most are minor, with lacerations and contusions being the most common.<sup>3–7–9–10</sup> There is no conclusive evidence in the scientific literature about the risk factors associated with the development of injuries in either professional or amateur boxers. This is mainly due to the retrospective nature of most boxing studies and the fact that retired rather than currently participating boxers have usually been studied.

Information on the incidence of acute injuries in professional boxing in particular is limited, with most studies concentrating on amateur competitors. Despite the knowledge that injuries during training can occur to boxers, there is a paucity of data pertaining to injuries sustained during these times.<sup>7–9–11</sup> This is especially so for sparring,<sup>12–14</sup> with only one study published so far.<sup>11</sup>

Current, valid, and reliable information about the risk of acute injury during boxing is required, and suitable means of reducing the risk of injury need to be developed and implemented.<sup>15</sup> The aim of this project was to prospectively collect data to describe the incidence of acute injury and

potential exposure to injury for amateur and professional boxers.

## METHODS

### Subjects and study design

A prospective cohort of active boxers in Victoria, Australia was recruited and followed on a monthly basis for 12 months. They had to be registered with either Boxing Victoria Inc (amateurs) or the Professional Boxing and Combat Sports Board of Victoria (professionals). All 59 registered professional boxers were invited to participate in the study either by responding to one of three mail outs or during a researcher visit to their training gym. Gym visits were used to recruit amateur boxers, with 37 amateurs invited to participate. Written informed consent from 34 amateur and 13 professional boxers was obtained. Details on professional boxers who did not respond were obtained from the official records of the Professional Boxing and Combat Sports Board of Victoria.

### Data collection

After recruitment, boxers completed a self reported survey detailing basic characteristics. Training data were recorded by the trainers using a daily log. This collection was completed for an initial block period of six months, and then for a one week period out of every month for the remaining six months. Information recorded included presence or absence at each session, whether sparring was undertaken, and whether an injury was sustained. Each trainer was personally trained by one of the authors (TZ), and written guidelines were provided to ensure standardised data collection. At the beginning of the study, trainers provided general information on activities undertaken during training, including specific activities completed and time period for each activity. This was used to estimate the exposure time in training for each boxer throughout the study period. A single researcher

**Table 1** Comparison of professional boxers enrolled in the cohort study with non-responders (n = 59)

	In study (n = 14)	Non-responders (n = 45)	95%CI or p value
Male (%)*	92.9	100.0	-0.6 to 14.9
Age (years)	32.2 (24.9–37.7)	30.0 (21.0–40.3)	0.1
Weight (kg)†	78.8 (52.0–106.6)	75.1 (60.0–165.0)	0.7
Number of fights in 2004 (for those who fought)	2.2 (1.0–4.0)	2.7 (1.0–7.0)	0.5
Number of fights in 2004 (for all registered)	1.4 (0.0–4.0)	0.9 (0.0–7.0)	0.3

Values are mean (range) unless indicated otherwise.

\*The number of female boxers was too small to complete a valid  $\chi^2$  test.

†Determined by weight in last fight before data collection beginning for all boxers with previous fights, otherwise self reported.

attended no less than three training sessions for each boxer to validate the training data.

Exposure during competition was recorded by a single researcher at all bouts over the 12 month period. Information recorded at bouts included number of scheduled and completed rounds, the fight result, and any injuries sustained. All fight details were confirmed with the respective boxing boards.

The injury definition used was any physical damage that occurred to the head, neck, arms, or trunk during any boxing related activity which met any of the following criteria: (a) it was brought to the attention of a fight doctor; (b) it prevented the continuation of a fight/training/sparring session; (c) it required medical treatment (either self or professionally administered). Injury data were collected on a standardised, validated assessment tool designed specifically for boxing during a previous study.<sup>3</sup> Injury data were collected by the trainers during training and by the fight doctors during competition. Ethical approval for this project was obtained from the Standing Committee on Ethics in Research Involving Humans at Monash University.

### Analysis

All data were coded before double entry into the Statistical Package for the Social Sciences (SPSS) version 12.0 for analysis. Descriptive statistics and 95% confidence intervals are reported for injury details. Significant differences between professional boxers were determined by  $\chi^2$  and *t* tests. Training and sparring exposure was estimated by extrapolating the number of sessions per month for the first six months to the entire 12-month period. Time spent in training and/or sparring was estimated by multiplying the number of sessions attended by the time period provided by each trainer for their usual training/sparring session. Time in competition was determined by multiplying the number of rounds completed during the fight, by the number of minutes per round. Injury rates were calculated on the basis of exposure time per 1000 hours of training, competition, and boxing participation, overall and per 100 fights.

## RESULTS

### Response rate

Forty seven boxers volunteered to participate in the study. Although a definite population from which to determine response rates was difficult to establish (as participants can register and de-register at any time), an estimated response rate of 19% for amateurs and 25% for professionals was obtained.

The initial six month intensive training data were obtained for all boxers. One amateur turned professional after data collection had begun, and all data collected for this boxer were included in the professional data. Two professionals retired during the study time frame and another changed trainer after eight months, with data collection ceasing at these points.

### Participants

Over 90% of the study participants were male, with three female amateurs and one female professional. The boxers had a mean age of 25.9 years (15.1–37.1): 23.7 years (15.1–37.1) for the amateurs and 31.8 years (24.6–36.3) for the professionals. Table 1 shows an analysis of basic information on professional boxers enrolled in the study and those who were not. No significant differences in sex, age, weight, or mean number of fights per boxer per year existed. Such information was not available for the amateurs.

### Boxing exposure

#### Competition exposure

Most of the cohort did not participate in any competitive bouts over the 12 month period. A total of 56 fights were participated in by 18 boxers. Nine professionals had at least one fight (mean 2.7; range 1.0–5.0), and nine amateurs had at least one fight (mean 3.6; range 1.0–10.0).

#### Training exposure

The length of the training sessions depended on the trainer. Sessions without sparring lasted 63–118 minutes. Sessions with sparring lasted 75–130 minutes. During the six month

**Table 2** Total boxing exposure (in hours) during the 12 month follow up period

	Combined (n = 47)	Amateur (n = 33)	Professionals (n = 14)
Training with sparring*	6378.1	4701.3	1676.9
Training without sparring*	4332.3	3067.1	1265.1
Bouts	10.7	3.3	7.4
Total	10721.1	7771.7	2949.4

\*Estimate based on extrapolation of six month intensive follow up.

**Table 3** Comparison of injury rates per 1000 hours of participation in published studies of different sports

Sport	Reported injury rate per 1000 hours of participation		
	Training	Competition	Training and competition
Boxing			
This study			
Combined	0.6	1124.1	2.0
Amateur*	0.5	1221.4	1.0
Professional†	1.7	1081.1	4.4
Amateur	22.1 <sup>17</sup>	920.0 <sup>9</sup>	–
Contact sports			
Australian football‡			
Elite/subelite	–	62.0–96.0 <sup>17–19</sup>	–
Amateur/community	5.8–6.5 <sup>15 16</sup>	20.5–52.8 <sup>15 16</sup>	12.1–27.2 <sup>15 16 20</sup>
Professional rugby league¶	0.3–0.5 <sup>21</sup>	44.9–157.7 <sup>17 21 22</sup>	4.1–8.5 <sup>21</sup>
Professional rugby union§	–	53.0 <sup>17</sup>	–
Professional rugby**	–	–	7.1 <sup>23</sup>
Professional soccer††	2.9 <sup>24</sup>	35.3 <sup>24</sup>	6.2 <sup>24</sup>
Amateur ice hockey‡‡	0.6 <sup>25</sup>	4.6–6.0 <sup>25</sup>	–
Non-contact sports			
Community field hockey¶¶	–	–	15.2 <sup>20</sup>
Community basketball§§	–	–	13.6 <sup>20</sup>
Community netball***	–	–	11.3 <sup>20</sup>
Elite, subelite gymnastics	3.3 <sup>26</sup>	–	–

\*Two participants, maximum bout time of eight minutes = 0.3 hours of exposure per bout.

†Two participants, maximum bout time of 36 minutes = 1.2 hours of exposure per bout.

‡36 participants, game time of 120 minutes = 72 hours of exposure per game.

¶26 participants, game time of 80 minutes = 34.7 hours of exposure per game.

§30 participants, game time of 80 minutes = 40 hours of exposure per game.

\*\*Rugby not further specified.

††22 participants, game time of 90 minutes = 33 hours of exposure per game.

‡‡Only concussions reported: 12 participants, game time of 60 minutes = 12 hours of exposure per game.

¶¶22 participants, game time of 70 minutes = 25.7 hours of exposure per game.

§§10 participants, game time of 40 minutes = 6.7 hours of exposure per game.

\*\*\*14 participants, game time of 60 minutes = 14 hours of exposure per game.

intensive training data collection, the cohort participated in an estimated total of 5549.5 hours of training. A total of 4120 training sessions were documented, with 2366 including sparring. These data were extrapolated to calculate training times for the 12 month period. The total boxing participation for the 12 month period was estimated to be 10 721.1 hours (table 2).

### Injury data

A total of 21 injuries were reported over the 12 months. These 21 injuries occurred to 17 different boxers, with three professionals sustaining two injuries each. Most injuries were sustained by male boxers ( $n = 20$ , 95%), with most occurring during competition (57%) compared with training (43%; 95% confidence interval –57.5 to 28.9). Over 70% of injuries were to the head (71%, 95% confidence interval –3.7 to 89.4), with almost half of the injuries to this region being concussions (47%). Other common sites of injury were the eyebrow and nose (19% each). After concussion (33%), open wounds/lacerations/cuts (29%) and fractures (19%) were the second and third most common injuries.

### Injuries in training

Of the four amateur training injuries, three occurred during sparring. The two upper extremity injuries (upper arm and elbow) were strains, with the remaining two being a suspected rib fracture and an eyebrow laceration. The two upper extremity injuries resulted from punching, and the two other injuries resulted from being punched.

Three of the five training injuries sustained by professionals were to the head (two eyebrow lacerations and one concussion). These three injuries were all sustained during sparring when the participant was punched. The other two injuries were reported as aggravations of existing injuries;

one of these was an inflammation of the shoulder and the remaining injury was a wrist sprain.

### Injuries in competition

Of the 12 injuries sustained by the cohort during competition, 92% were to the head. The four amateur competition injuries included two blood noses, one fractured nose, and one concussion. All occurred as a result of the boxer being punched. Two of the fights in which these injuries occurred were stopped by the referee as a result of the injury. These fights were losses for the injured boxers. Of the other two fights resulting in injury, both were completed with the result decided by points (for one win and one loss).

Of the eight injuries sustained by professional boxers in competition, seven occurred to the head (five concussions, one fractured nose, and one eyebrow laceration). All of these injuries occurred as a result of being punched. Two of these concussions were sustained by the one boxer. One other professional had multiple injury events during competition, with a fractured nose and a concussion reported. The only competition injury that was not to the head region was a fractured hand, which occurred during the action of punching an opponent. All five of the fights in which participants sustained a concussion were losses by technical knock-out (boxer is defenceless or has an apparent brain injury) or knock-out (boxer is disabled after a blow or series of blows for at least 10 seconds). The two boxers who sustained the fractures both won their fights on points, whereas the boxer who had the eyebrow laceration lost on points.

### Injury rates

An overall injury rate of 44.7 injuries per 100 boxers was calculated. With exposure taken into account, an overall injury rate of 2.0 injuries per 1000 hours of participation was

**Table 4** Comparison of injury rates per 100 fights in published studies of different combat sports

Sport	Reported injury rate per 100 fights
Boxing (this study)	
Combined	37.5, 25.0*, 12.5†
Amateur	25.0, 15.6*, 3.1†
Professional	33.3, 29.2*, 20.8†
Boxing	
Amateur	15.5, <sup>6</sup> 22.8 <sup>9</sup>
Shotokan karate	9.0 <sup>27</sup>
Tae kwon do	4.1 <sup>28</sup> ‡, 10.0 <sup>29</sup> ‡

\*Reported on head injuries only.

†Reported on concussions only.

‡Reported on head and neck injuries in 6–16 year olds only.

calculated. The number of injuries occurring during competition was much greater, with a rate of 1081.1–1221.4 injuries per 1000 bout hours calculated. For training only, an injury rate of 0.5–1.7 injuries per 1000 hours was obtained. Table 3 displays the injury rates per 1000 hours of participation (training, competition, and combined time) for this study compared with other contact and non-contact sports.

When injury rates were determined on the basis of number of fights only (table 4), injuries occurred in one quarter of amateur fights and one third of professional fights (overall injury rate of 37.5 per 100 fights).

## DISCUSSION

This study confirms the belief in sports medicine that it is the intensity of the activity rather than the exposure time alone that is ultimately important in determining risk. Exposure has long been considered a risk factor for injury development in boxing.<sup>12</sup> However, this research is the first to have collected exposure data for both training and competition in both professional and amateur boxers. The results indicate that exposure to boxing over a 12 month period, especially in training, is high. Although training accounted for 99.9% of participation time, only 42.9% of injuries were sustained during these sessions. Further, the severity of the injuries sustained during training appear to be less, with strains and sprains more common, as opposed to the concussions reported during competition.

The injury results of this study are consistent with previous literature with regard to the common sites (head)<sup>3–5,9</sup> and natures (concussion/lacerations)<sup>3–5,7–9,10</sup> of acute boxing injury. This indicates that the prospectively collected bout data often reported by boxing associations<sup>13</sup> may be accurate in broad injury profile. Further longer term research with larger samples focused on injuries in training and sparring are still needed however, as the injury profile for boxers at these times is still not clear.

Only two other studies of boxing, both using amateurs, have determined an injury rate per 1000 hours of participation. Porter and O'Brien<sup>9</sup> found an injury rate during amateur competition similar to the present study (920.0 and 1221.4 injuries per 1000 hours of competition respectively), whereas Welch *et al*<sup>7</sup> determined that, for military cadets (considered amateurs as no prize money is awarded), the injury rate during training was 22.1/1000 hours. This rate is much higher than that found in this study (0.5/1000 hours) for amateur training. This may be the result of participation in other high intensity exercise as a result of military training for cadets, which may have a cumulative effect on injury risk. No comparisons with this study exist for professional boxers.

The high injury rates during competition exposure indicate that, for every hour of bout participation, at least one injury is sustained. Although this indicates a high injury risk per hour,

extrapolation of the data from 10.7 actual hours of participation is not an accurate representation. At most, an amateur can have only eight minutes and a professional only 36 minutes of participation time in any one bout, so to extrapolate these minutes to such a rate is not necessarily a true portrayal of the injury risk in competition. Overall injuries sustained during training appear to occur at a low rate, whereas during competition the injury rate is very high. Given the small amount of time spent participating in competition (generally up to two bouts a year), the overall injury risk for boxers is quite low.

The average number of bouts participated in during this study was representative of that for the entire cohort of Victorian amateur and professional boxers for 2004. This indicates that the exposure measured during this study is what would be expected of Victorian boxers in any one year period. Given the small amount of bout participation and consequently exposure time for a current day boxer over their entire career,<sup>30</sup> a measure of injury based on time at risk, while useful for comparisons with other sports, is not useful in terms of tangible meaning within boxing circles.

A better measure is a rate based on the number of fights participated in or the number of boxers participating in fights. Results based on this information indicate that injuries occurred in about one quarter of all amateur and one third of all professional fights. This is similar to the results of studies of amateur boxing and other combat sports.<sup>6–9,27–29</sup> No data for professional boxers exist.

Two studies have reported injury rates in professionals, based on the number of injuries per 100 boxers.<sup>5,10</sup> The injury rates found in those studies (41.5 and 21.0 respectively) were lower than those found in this study (92.9/100 boxers). Both of these other studies were completed over a longer period of time, with a greater number of boxers which may have affected the results of this measure.

Injury rates based on time exposed have not been reported in many sports. When the injury rate in boxing per 1000 hours of training and competition participation are compared with data available for other contact sports, the results of this study indicate that the injury risk in boxing is lower than that calculated for amateur<sup>19</sup> and community level<sup>15,20</sup> Australian football, professional rugby,<sup>21,23</sup> and soccer.<sup>24</sup> Further, it is also lower than in the non-contact sports of community field hockey,<sup>20</sup> basketball,<sup>20</sup> netball,<sup>20</sup> and elite gymnastics.<sup>26</sup> Injury definitions in these studies were comparable to that used in the present study, although lower limb injuries could be included in the other studies. The acute injury rate for boxing participants therefore appears less than that for other sports (both contact and non-contact) with higher participation rates.

It should be noted that a number of limitations to this research exist. Firstly, a relatively small number of boxers were recruited. The potential impact of this on the ability to generalise to other boxers is acknowledged. However, characteristic and fight analysis comparing participants and non-participants in the study indicated no significant differences between the groups. Secondly, it was necessary to have different data collectors for training and competition. The potential effect of this on the results obtained is believed to be limited because of the training provided to all the data collectors and the small variations shown during validation of the data. The high level of involvement of trainers was necessary to ensure data could be collected at all venues at each training session, and although these data were self reported, agreement with the researcher was shown to be high (90%). The training data were extrapolated for six months of the study, although contact between researchers and trainers was maintained to allow changes in training patterns to be determined. During competition, the



### What is already known on this topic

- Injuries sustained during boxing bouts are well covered in the scientific literature
- However, most data come from retrospective studies, and injuries during training and sparring have often been neglected

### What this study adds

- This is the first study to prospectively collect data on exposure time and injury occurrence in a cohort of professional and amateur boxers
- It is also the first study to report injury rates based on time in both competition and training

researcher results were compared with the official results of the boxing associations, with 100% agreement obtained.

With regard to the injury reporting, there is a possibility of under-reporting during training times. However, as doctors were required to examine boxers before and directly after each fight, it is likely that no under-reporting during bouts occurred. Under-reporting during training may have occurred because of the combined issues of the injury definition and the culture of boxing. The injury definition was strict in its requirement of treatment or stopping participation for an injury to be included. Although this is a common way of reporting sports injuries, the culture in boxing is such that a boxer may continue participating after sustaining an injury. It has been widely considered an important research tool to use standardised injury definitions so sport comparisons can be made.<sup>31-32</sup> However, this study has shown that commonly used injury definitions may not be applicable to boxing.

This was the first study to prospectively follow up currently participating professional boxers for a 12 month period. Further, it is one of only nine cohort studies in boxing to have ever been published.<sup>33-40</sup> One of the major advantages of this type of prospective design is the ability to systematically and accurately collect exposure data in the cohort. The high levels of exposure experienced by the boxers indicated that boxing has acute injury rates comparable to, and often lower than, those found in studies of other sports. Boxers sustain considerably more injuries per hour of competition than per hour of training; however, the low level of competition exposure makes participation in the sport acceptable in terms of injury risk.

### ACKNOWLEDGEMENTS

The Professional Boxing and Combat Sports Board, Boxing Victoria Inc and their boxers, trainers, and promoters are thanked for their support and involvement throughout the study. In particular, Noel Sharpe and Dean Lappas are thanked for their continued assistance. TZ is funded by a National Health and Medical Research Council Public Health and a VicHealth postgraduate scholarship. Thanks to Professor Caroline Finch for her initial involvement in the conception of this project.

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Competing interests: none declared

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