Hand and Wrist Injuries in Elite Boxing: A Longitudinal Prospective Study (2005-2012) of the Great Britain Olympic Boxing Squad

Michael Loosemore¹, Joseph Lightfoot¹, Ian Gatt², Mike Hayton³,
and Chris Beardsley⁴

Abstract

Background: The purpose of this investigation was to explore prospectively the nature and duration of hand and wrist injuries in training and competition in the Great Britain (GB) amateur boxing squad between 2005 and 2012. **Methods:** Longitudinal prospective injury surveillance of the GB boxing squad was performed from 2005 to 2012. The location, region affected, description, and the duration of each injury were recorded by the team doctor and team physiotherapist. We recorded whether the injury occurred during competition or training and also whether it was a new or a recurrent injury. The injury rate during competition was calculated as the number of injuries per 1000 hours. **Results:** Finger carpometacarpal instability and finger metacarpophalangeal joint extensor hood and capsule sprain also known as “boxer’s knuckle” injuries were significantly more common than other injury diagnoses. The number of injuries during training or competition was similar, which is remarkable given the far greater number of training hours than competition hours performed. Injury rate for hand and wrist injuries in competition was 347 injuries per 1000 hours, while the estimated injury rate in training was <0.5 injuries per 1000 hours. **Conclusion:** Carpometacarpal instability and boxer’s knuckle were more common than any other kind of hand and wrist injury in this cohort of elite amateur boxers. The rate of hand and wrist injuries was higher in competition than in training. Our study highlights the importance of hand and wrist injury prevention in the competition environment.

Keywords: boxing, hand, wrist, injuries, sport

Introduction

The ability of man to make a fist suitable to fight may have been an evolutionary advantage.²² Humans are the only primate to be able to fold their fingers into their palms buttressed by the thenar and hypothenar eminences to make a club-like structure. The lack of movement at the second and third carpometacarpal joint stabilizes the kinetic chain when a punch is thrown.²² This natural ability may explain why boxing is such an ancient sport. Artistic depictions of boxing have been found from many civilizations of the ancient Middle East,^{18,32} and the sport was recorded as far back as 3000 BC.^{18,32} Many of these depictions portray the boxers using some form of wrapping, covering, or protection for the hands and wrists.¹⁸ Whether these coverings were to reduce or enhance the damage to the opponent or rather to reduce the risk of injury to the boxers’ hands is unclear.

Injuries during both amateur and professional boxing have been documented in many previous investigations,^{2-4,16,25,33,35,36}

but most attention has been paid to head and neurodegenerative injuries and conditions as a result of boxing.¹⁵ A recent 5-year prospective investigation of injuries in elite amateur boxing showed that injuries to the hand region were in fact the most frequent and also led to the most time lost from training and competition.¹⁶ In a sport in which high forces are transmitted through the clenched fist and wrist^{11,30,31,34} in striking an opponent, injury to the hand and wrist is to be expected. The exact nature, location, and description of the injuries that

¹University College London, UK

²English Institute of Sport, Sheffield, UK

³Wrightington Hospital, Lancashire, UK

⁴Strength and Conditioning Research Limited, London, UK

Corresponding Author:

Michael Loosemore, Institute of Sport Exercise and Health, University College London, First Floor, 170 Tottenham Court Road, London W1T 7HA, UK.

Email: mike.loosemore@eis2win.co.uk

boxers incur to the hand is therefore of some particular interest and requires further investigation.

It was therefore the purpose of this investigation to analyze 8 years of prospectively gathered longitudinal hand injury data from the Great Britain (GB) boxing squad in both training and competition to report the exact nature, location, and description of the injuries that these elite amateur boxers incurred between 2005 and 2012.

Methods

The participants included all male boxers on the GB boxing squad at any time between January 1, 2005, and December 31, 2012. The data were released by GB boxing. Ninety-eight boxers (aged 24.7 ± 3.8 years) were members of the GB boxing squad during the relevant period. There were boxers in each weight category from 48 kg (light flyweight) to above 91 kg (super heavyweight). The mean duration that each boxer was a member of the squad was 28.5 ± 19.8 months, and the duration of membership ranged from 6 to 78 months. The total number of boxer-years in the relevant period was 232.8 years.

Data relating to the number of minutes spent competing during this period were gathered for each athlete individually from their personal boxing card, which contains their full bout history. No data were recorded for the number of minutes spent in training in the same period, but the time spent training was estimated from athlete training schedules provided by the boxing coaches from their own records. These records were very detailed, so an accurate estimation was possible. The amount of time that the boxers spent punching in training was estimated from a sample training month.

An injury was defined as any musculoskeletal condition that prevented the boxer from participating in either training or competition for more than 24 hours.⁷ Injuries were coded using a modified Orchard Sports Injury Classification System (version 10),²⁷ which recorded the location of injury, the bodily region affected by the injury, description of the injury, duration (number of days injured) of each injury, participation when injury occurred (training or competition), and whether the injury was new or recurrent. Recurrence of an old injury was defined as the repeated report of an injury with the same code as the previous injury. Injuries were recorded prospectively by the GB medical team, which consisted of a senior physiotherapist with experience in hand injuries (I.G.) and the team doctor (M.L.). The injuries were also examined by a consultant hand surgeon (M.H.) in the more serious cases requiring surgery.

Statistical Methods

All athlete demographics (age and weight classification), participation (training or competition), and injury information (diagnosis, location, type, duration, and whether

recurring or non-recurring) was entered into an Excel spreadsheet (Microsoft, Seattle, Washington). All statistical tests and analysis were performed using R.²⁸ Chi-square tests were performed to identify significant differences in respect of the numbers of injuries incurred in different athlete, participation, or injury categories. The z scores were calculated to identify the individual differences. The Shapiro-Wilks test was used to assess normality of data. For normally distributed data, 1-way analysis of variance was used to assess the effects of injury type or diagnosis on the duration of injury. Where these data were not normally distributed data, the non-parametric Kruskal-Wallis test was used. Paired t test or Dunn test was used for post hoc analysis (with the Bonferroni correction for multiple comparisons) as appropriate. Significance was accepted at $P < 0.05$.

Results

Time Spent in Competition and Training

Across all athletes, there were 218.8 hours of competition during the period of the study. The average number of minutes spent competing by each athlete in total during their membership of the squad was 133.9 ± 123.5 minutes, which is a mean of 56.4 minutes of competition per boxer per year. In contrast, the number of training hours performed by each athletes during their membership of the squad was estimated at between 900 and 1200 hours per year, which leads to an estimate across all athletes of between 210 000 and 280 000 hours of training, and an estimated average of hours spent training by each athlete in total during their membership of the squad of between 2100 and 2900 hours. Consequently, each athlete spent approximately 1000 times more hours training than competing. Estimates of training hours were based on programmed rather than actual attended training sessions during which athletes were members of the squad. On an average day training time consists of 30-minute endurance run, 1 hour of resistance work, and 1.5 hours of boxing gym work. Boxing gym work consists of shadow boxing, hitting pads held by a coach, hitting bags of various weights, technical sparring when various techniques are practiced, and open sparring, which is like a competition bout. From a 1-month sample of the squad in training, it was calculated that the average time spent punching was 766 minutes per boxer per year; a boxer on the GB squad will spend approximately 13 times longer punching in training than in competition. The injury rate in training where punches are thrown was 30 injuries per 1000 hours.

Overview of Hand and Wrist Injuries

During the 8-year period, there were 172 hand and wrist injuries, of which 84 occurred at the hand and 88 occurred at the wrist. Of these injuries, there were significantly more new (78%) than recurrent (22%) injuries. A similar number

of hand and wrist injuries were sustained during training (44%) and during competition (56%). This lack of significant difference between injuries sustained during training and competition is remarkable given that training time is approximately 1000 times greater than competition time.

Analyzing hand and wrist injuries separately provides a similar picture. Of the 84 hand injuries, 65 (77%) were new and 19 (23%) recurrent, while out of the 88 wrist injuries, 69 (78%) were new and 19 (22%) recurrent. Of the 84 hand injuries, 41 (48%) occurred in competition and 43 (52%) in training, while out of the 88 wrist injuries, 36 (41%) occurred in competition and 52 (59%) occurred in training.

The injury rate for hand and wrist injuries combined during competition was 347 injuries per 1000 hours (hand = 183 injuries per 1000 hours; wrist = 165 injuries per 1000 hours), while injury rate for hand and wrist injuries combined during training was estimated at 0.34 to 0.45 injuries per 1000 hours (hand = 0.15-0.20 injuries per 1000 hours; wrist = 0.19-0.25 injuries per 1000 hours).

Diagnoses of Hand and Wrist Injuries

Of the 172 hand and wrist injuries that occurred, there were 4 injury diagnoses that together accounted for 64.9% of the injuries: finger carpometacarpal instability (21.6%), finger metacarpophalangeal joint extensor hood and capsule sprain also known as “boxer’s knuckle” (15.8%), thumb metacarpophalangeal joint ulnar collateral ligament first degree sprain also known as “skier’s thumb” (14.6%), and wrist sprains (13.5%). However, only the number of carpometacarpal instability (z score = 2.93) diagnoses were significantly greater than the numbers of other injury diagnoses. The numbers of each injury diagnosis and their proportion of all hand and wrist injuries are shown in Table 1.

Duration of Hand and Wrist Injuries

During the 8-year period, the total number of days lost to training was 7712 days, of which hand injuries accounted for 3083 days (40%) and wrist injuries accounted for 4622 days (60%). In Team GB boxers between 2005 and 2012, the median number of days lost per injury for hand and wrist injuries combined was 29.5 days (interquartile range [IQR], 14.0-56.0 days). The median number of days lost for hand injuries was 16.5 days (IQR, 10.0-47.3 days), and the median number of days lost for wrist injuries was 31.5 days (IQR, 16.5-74.0 days). The four injury diagnoses that lead to the longest total durations of time lost were carpometacarpal instability (2009 days), scapholunate instability (796 days), finger metacarpophalangeal joint sprain also known as “boxer’s knuckle” (762 days), and thumb ulnar collateral ligament first degree sprain also known as “skier’s thumb” (737 days). The mean and total durations of time lost to each injury by diagnosis are shown in Table 2.

Table 1. Diagnoses of Hand and Wrist Injuries in Team GB Boxers Between 2005 and 2012.

Nature of injury	Frequency	Proportion, %
Carpometacarpal instability	37	21.6
Extensor expansion tendon tear/rupture	6	3.5
Finger distal interphalangeal joint sprain	2	1.2
First metacarpal base fracture subluxation (Bennett fracture)	3	1.8
Hand abrasion	2	1.2
Hand contusion	2	1.2
Hand laceration	1	0.6
Intrinsic muscle strain	3	1.8
Middle phalangeal fracture of fingers	1	0.6
Other hand injury	5	2.9
Other metacarpal fracture	2	1.2
Finger metacarpophalangeal joint sprain	27	15.8
Other wrist injury	10	5.8
Proximal phalangeal fracture of fingers	3	1.8
Scapholunate dissociation	1	0.6
Scapholunate instability	4	2.3
Triangular fibrocartilage complex tear	8	4.7
Thumb ulnar collateral ligament (skier’s thumb)	25	14.6
Wrist capsulitis	1	0.6
Wrist contusion	3	1.8
Wrist extensor tendinopathy	3	1.8
Wrist sprain	23	13.5
Grand Total	172	100.0

Discussion

The hand and wrist have previously been identified as locations that have a high risk of injury in amateur boxers^{16,33} but not professional boxers.⁴ This investigation adds to our current understanding of hand and wrist injury in elite amateur boxers, by demonstrating that carpometacarpal instability and finger metacarpophalangeal joint extensor hood and capsule also known as “boxer’s knuckle” injuries were the most common injury diagnoses. The duration of time lost to scapholunate instability was greater than that of some other injury types. It was found that new injuries were more common than recurring injuries in this cohort of elite amateur boxers, while there was no difference between the number of injuries sustained during training or competition even though the boxers spent approximately 1000 times more hours in training (13 times more hours punching). Comparison of the injury rate for combined hand and wrist injuries: recorded in competition, 347 injuries per 1,000 hours, recorded in all training, <0.5 injuries per 1,000 hours and recorded in

Table 2. Total and Mean Duration of Hand and Wrist Injuries by Diagnosis in Team GB Boxers Between 2005 and 2012.

Nature of injury	n	Proportion of hand injuries (%)	Mean number of days	Total number of days	Proportion of total days (%)
Finger distal interphalangeal joint sprain	2	1.2	9.0	18	0.2
Finger metacarpophalangeal joint sprain	27	15.8	28.2	762	9.9
Extensor expansion tendon tear/rupture	6	3.5	109.7	658	8.5
Proximal phalangeal fracture of fingers	3	1.8	42.0	126	1.6
Middle phalangeal fracture of fingers	1	0.6	42.0	42	0.5
Other metacarpal fracture	2	1.2	49.5	99	1.3
First metacarpal base fracture (Bennett fracture)	3	1.8	89.3	268	3.5
Hand abrasion	2	1.2	4.5	9	0.0
Hand contusion	2	1.2	48.0	96	1.2
Hand laceration	1	0.6	7.0	7	0.1
Intrinsic muscle strain	3	1.8	20.0	60	0.8
Other hand injury	5	2.9	24.8	124	1.6
Scapholunate instability	5	2.9	172.4	862	11.2
Triangular fibrocartilage complex tear	8	4.7	42.5	340	4.4
Thumb ulnar collateral ligament sprain acute (skier's thumb)	25	14.6	30.8	752	9.8
Carpometacarpal instability	37	21.6	54.3	2009	26.1
Wrist capsulitis	1	0.6	31.0	31	0.4
Wrist contusion	3	1.8	28.3	85	1.1
Wrist extensor tendinopathy	3	1.8	64.3	193	2.5
Wrist sprain	23	13.5	28.3	650	8.4
Other wrist injury	10	5.8	52.1	521	6.8
Total	172	100.0	44.8	7712	100.0

training when punches are thrown, 30 injuries per 1000 hours. The reason for this marked difference in hand injuries in competition compared with training is not known. In training, the wraps are unrestricted, and hands are protected with high-density foam material wraps and tape and large 16 oz to 18 oz gloves. Furthermore, many of the punches thrown in training are not thrown at maximal effort, and not all the training is punching. Training also involves running and resistance work; however, the punching training (hitting bags and pads) is more intense with more punches thrown per minute than is a competition.

To wrap the hands under the boxing gloves in competition, originally 2.5 m of crepe bandage was allowed. In 2009 this was increased to a maximum of 4.5 m. The gloves used in competition were 10 oz (284 g) until 2013 when the weight was increased to 10 oz (284 g) for boxes up to 64 kg and 12 oz (340 g) gloves for the weights above this. Of note, there is no limitation on material wraps and tape allowed in professional boxing, and 10 oz (284 g) gloves are used.

Carpometacarpal Instability

Carpometacarpal instability was identified as being significantly more common than other injury diagnoses in this cohort of elite amateur boxers. This is perhaps unsurprising, as previous investigations have identified carpometacarpal

instability as being a common boxing injury.^{19,20} As a boxer tires, the wrist tends to collapse under load into flexion, which produces strain across the dorsum of the carpometacarpal joint. As there is little to no movement at the index and middle carpometacarpal joints, it is these joints that are loaded when a punch is thrown correctly.²² Instability at the carpometacarpal joint leads to irritation of the joint, pain, and joint laxity^{9,13} and eventually leads to periarticular hypertrophic bone formation, commonly known as carpal bossing.^{6,12,21} Carpometacarpal instability is thought to be best investigated using dynamic ultrasound, and the recovery from injury is commonly monitored by reference to grip strength and pain¹⁰ (Table 3). In addition to being more frequently occurring than other types of hand and wrist injury, the total duration of time lost to carpometacarpal instability injury was greater than the total duration of other injury types of injury. This is perhaps unsurprising as a previous investigation reported that the treatment for combined joint fusion for index and middle carpometacarpal instability in elite boxers displays an average recovery of 5 to 12 months.²⁴

Finger Metacarpophalangeal Sprain (Boxer's Knuckle)

Finger metacarpophalangeal sprain also known as "boxer's knuckle" injuries were identified as being more common

Table 3. History, Examination, and Investigations Used to Diagnose Carpometacarpal Instability and Boxer's Knuckle.

	History	Examination	Investigation
CMC instability	Pain at CMC joint on impact A feeling of instability at the CMC joint "My hand gives way" "My hand buckles"	Carpal bossing at the CMC joint (late sign) Pain on palpation of the CMC joint Laxity of second and third CMC joints on "piano key" testing	Plain radiograph—may show carpal bossing Further imaging often not needed if clinically unstable However Dynamic USS—may show instability at the second and third MCP joints MRI/MRA/3TMRI—may show the capsular (ligament defect)
Boxer's knuckle	Pain in the knuckle on impact Swollen "puffy" knuckle Difficulty in making a fist Occasionally pain on extension more than flexion Subluxing extensor tendons on flexion of the MCP joint.	Pain on palpation over either side of the extensor hood A defect "hole" may be felt in the indicating a potential tear of the extensor hood or capsule Occasional volar MCP joint pain knuckle Knuckle feels boggy Reduced flexion (not always especially with capsular tears) Extensor tendon subluxation on flexion; not always and can also be found in normal individuals	USS can show soft tissue edema and suggest a structural abnormality USS can show sagittal band tears and tendon subluxation MRI/MRA/3TMRI—will show extensor hood tears and capsular defect Note: Often USS and MRI can be difficult to interpret as the extensor hood is a very thin structure. Soft tissue edema however is generally a reliable indirect sign for deep structural damage and often an indication to surgically explore the area.

Note. CMC = carpometacarpal; USS = ultrasound scan; MCP = metacarpophalangeal; MRI = magnetic resonance imaging; MRA = magnetic resonance arthrograph; 3TMRI = 3 tesla magnetic resonance imaging.

than other types of hand and wrist injury in this cohort of elite amateur boxers (Table 3). The term "boxer's knuckle" was originally coined by Gladden in 1957,⁸ where it was used to refer to cases of damage to the extensor tendon hood mechanism, of which a proportion also involved damage to the underlying joint capsule. While some investigators and clinicians have continued to use this broad definition,²⁰ others have limited the term to cases where the joint capsule is damaged (with or without damage to the extensor tendon hood mechanism)^{14,23} and others refer only to damage to the extensor tendon hood mechanism.⁵

Boxer's knuckle is a swollen painful metacarpophalangeal joint with no fracture. It can encompass a tear of the sagittal band or extensor hood, damage to the joint capsule, synovitis of the joint, or even a combination of these injuries. Clinically, boxer's knuckle can present with a range of symptoms and signs ranging from a swollen, boggy joint to a finger that has reduced extension due to a rupture of the sagittal band or visible subluxation of the extensor tendon on flexion. Investigations including magnetic resonance imaging (MRI) or ultrasound scans may be useful for visualizing the nature of the damage to the extensor tendon mechanism,¹ but many reviewers either do not mention the need for imaging^{14,20} or consider it to be superfluous.⁵

Boxer's knuckle covers a range of diagnoses and may be treated either non-surgically or surgically, depending upon the severity of the injury,^{14,29} the extent of inflammation,²⁰ the demographic of the population injured,²⁰ and any demonstrable structural injury (ie, sagittal bands only or joint capsule only or both),²⁶ although the

literature is limited regarding the most effective treatments in each case.¹⁴

Some researchers always recommend performing surgical repair on the underlying joint capsule that has been damaged and suggest nonsurgical management for damage to the extensor tendon mechanism or hood.²⁶ In all cases, nonsurgical treatment typically involves immobilization for up to 8 weeks¹⁴ with either neighbor strapping for very minor injuries¹⁴ or a splint for those involving subluxation.^{14,29} In nonathletic populations, surgical treatment is usually only indicated in cases where nonsurgical treatment fails.¹⁴ While a similar procedure is often recommended for athletes,⁵ surgery is almost always considered essential for boxers because of the unique demands of the sport on the knuckles.^{17,20} Surgery in all cases can involve direct repair or grafts,^{14,17,20,29} depending on the extent and nature of the damage. In our experience, direct surgical repair of the torn extensor hood with the metacarpophalangeal joint in flexion yields the best results.¹⁷ In cases where the capsule is torn, an attempt is made to repair this structure in flexion. However, if a tension-free capsular repair is not possible, it is left as a defect to heal by secondary intention.

Limitations

A limitation of our investigation was inability to record accurate training hours in the relevant period. While we were able to report accurate injury rates of 347 injuries per 1000 hours for the hand and wrist in competition, our injury rates for training of <0.5 injuries per 1000 hours remain an

estimate based upon training schedules and diaries. It should also be noted that, unlike competition, training does not consist only of boxing but also includes running, resistance training, and hitting bags and pads. Even in sparring, the conditions are not the same as competition. A 1-month sample of the squads training was analyzed to estimate the time during training when punching takes place. Nevertheless, it is noteworthy that studies using reliable measurements have reported similar values for injuries overall.³⁵ In addition, our study was limited in that additional data were not collected that might have informed the reasons for why hand and wrist injuries were so common in competition and how they might have been prevented. Finally, our study was limited in that certain injuries were included within “other” classifications and were not provided with definitive diagnoses for the purposes of analysis.

Conclusion

In this cohort of elite amateur boxers, carpometacarpal instability and boxer’s knuckle injuries were the most common hand and wrist injury diagnoses. The rate of injury to the hand and wrist is approximately 1000 times greater in competition than it is in all training and approximately 13 times greater in competition than it is in punching training. Individuals involved in the care of boxers should therefore be aware of the frequency of their occurrence, the duration of recovery period, and the necessary treatments for these injuries. The governing body of international boxing should investigate ways of increasing hand protection in competition. Further research is required to fully understand the mechanism of injury occurring at the hand and wrist.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

As the data are anonymized, no informed consent was obtained.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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