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Boxing injuries by anatomical location: a systematic review

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Abstract. Background. Boxing is commonly associated with injury in the head region. However, injury to the head region encapsulates a wide range of injury types, ranging from facial lacerations to concussion. It is therefore unclear whether a high incidence of injury to the head region is also reflective of a high incidence of concussions or cerebral injury. Additionally, given the historic focus on head injury concussions in boxing, the proportions of injury that are associated with the upper extremity, lower extremity and trunk are unclear. Aim. The objective of this review was to assess the proportion of injuries that occur in each anatomical location during either boxing competition or training, as reported in observational studies performed in both professional and amateur boxers. Method. A systematic review was performed according to preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines of all observational studies of either professional or amateur boxing athletes that reported the proportion of injury by anatomical location as a result of either boxing competition or training. The PubMed database was systematically searched. Results. Fifteen eligible articles were identified, describing 5.020 injuries. Four studies were prospective cohort trials and the remainder were cross-sectional studies. There was substantial between-study variability in the proportion of injuries reported across all regions. The head region appeared to be injured most often (range: 9 – 96%), followed by the upper extremity (range: 2 – 55%). However, concussion accounted for far fewer injuries than the head region overall. Conclusion. Studies report substantial variability regarding the proportion of injuries sustained across different regions of the body in boxing. This variability may have arisen for several reasons, including a lack of consistency in respect of injury definitions, boxing conditions (type of headgear worn), and whether the athletes were amateur or professional.
Key words: *boxing, sports injury, head injury, concussion.*

Introduction

Boxing is commonly associated with injury in the head region. The literature supports this viewpoint, with many studies reporting a large proportion of injuries in this region (1-10). It is less clear whether this high incidence of injury in the head region is reflective of a similarly high incidence of concussions or cerebral injury.

While some studies have reported both a large number of injuries in the head region and also a great many concussions (6-8), other studies reporting large numbers of injuries in the head region have identified no concussions whatsoever (1, 4).

The reasons for this high degree of variability between studies is currently unclear. Given the historic focus on head injury concussions in boxing, the proportions of injury that are associated with the upper extremity, lower extremity and trunk are less well known. Since the incidence of injuries by anatomical location is most often reported by reference to a proportion of total injuries, variability in respect of injuries in the head region has important ramifications for injuries in the other anatomical locations.

Therefore, it was the purpose of this systematic review to assess the proportion of injuries that occur in each anatomical location during either boxing competition or training, as reported in observational studies of boxing injuries across all anatomical locations in both professional and amateur boxers.

Material and Method

This review was conducted in accordance with the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines for systematic reviews (11).

The PubMed peer-reviewed database was systematically searched from the first available record for observational studies of either professional or amateur boxing athletes that reported the proportion of injury across all anatomical locations as a result of either boxing competition or training. The search terms were (1) boxing AND (2) injury OR injuries, subject to a date limit of 31 July 2015 and a requirement for studies to be performed in humans.
No other key terms, Boolean operators or limits were used. In addition to this database search, the reference lists of obtained full-texts were examined to identify studies that may have been missed by the database searches. Following the initial database searches, duplicates were removed to form an initial summary list. The abstracts of articles on this list were screened and potentially relevant articles identified. The full texts of these studies were obtained. Contact was not made with any of the authors in order to identify other potentially relevant articles. After reviewing the full texts of all those articles obtained and assessing them for eligibility in line with the inclusion and exclusion criteria, non-eligible articles were excluded, leaving only those to be included in the systematic review.
The inclusion criteria were: (1) an observational study design, (2) a population of boxing athletes, (3) record provided of injuries by anatomical location, (4) and any publication date. The exclusion criteria were: (1) non-English language article, (2) duplicates, (3), injuries reported that did not occur in either boxing competition or boxing training, (4) injuries not reported across whole body.
After finalizing the studies for incorporation into the review, data were extracted from each study by a single author. The data extracted were tabulated in rows on a spreadsheet using Microsoft Excel (Microsoft Corp., Redmond, WA), with each row containing a single trial.
The data extracted included the title, main author, study design, duration, training status of the population (amateur or professional), type of activity (training, competition, or both), number of subjects, total number of injuries, number of injuries in major anatomical region (head, upper extremity, lower extremity, trunk and other), specific anatomical location within the head region (face and scalp, nose, eye and eyebrow, mouth, jaw, ear, throat/neck, cerebral/neural /concussion, and non-specified), specific anatomical location within the upper extremity region (hand, shoulder, thumb, fingers, wrist, elbow, forearm, upper arm, clavicle), specific anatomical location within the lower extremity (knee, ankle, thigh, lower limb, foot, hip or groin, toes, non-specified), specific anatomical location within the trunk and other region (lumbo-pelvic, chest and ribs, neck, thorax, abdomen, other spine, non-specified or other).
Risk of bias of individual studies was not assessed as no statistical information was extracted from the individual studies that would permit any such analysis to be performed. Additionally, no assessment of study quality was performed.
The outcomes considered in this systematic review were (1) the proportion of injuries in each major region, and (2) the proportion of injuries in each anatomical location within each major region. These outcomes were calculated as percentages using the data extracted from each study and reported as ranges.

Results

Search results. After following the search process, 15 articles were finally identified as being eligible for review (1-10, 12-16). Four of these articles (Porter and O'Brien, 1996 (8), Zazryn et al. 2006 (9), Siewe et al. 2015 (15), Loosemore et al. 2015 (16)) were prospective cohort trials and the remainder were cross-sectional studies and therefore retrospective by design.

A total of 5.020 injuries were reported across all 15 studies. Substantial variability between studies was observed in respect of the time period studied (from 8 days to 15 years), the status of the boxers (amateur, elite amateur, and professional), injury definitions, descriptions of the individual injury locations, and the details provided regarding the nature of the injury.

Injuries by region. Overall, the most common injury region in boxing appeared to be the head, accounting for the greater part of injuries by region (range: 9 – 96%) (Table I).
The range of results was large, with some studies reporting almost exclusively head injuries (2, 3, 6) and other studies reporting relatively few (1, 13, 16). This high level of variability was reflected in the proportions of injuries in the other regions, as follows: upper extremity range: 2 – 55%, lower extremity range: 0 – 24%; and trunk and other injury range: 0 – 16%.

These differences were partly explained by amateur or professional status. In professionals, the large majority of all injuries was routinely sustained in the head region (range: 74 – 96%), with a small minority in the upper extremity (range: 0 – 22%) and virtually none in the lower extremity region (range: 0 – 2%) and trunk/other region (range: 2 – 5%). In contrast, in amateurs, while the proportions were still weighted towards the head (range: 9 – 75%) there was a greater proportion in the upper extremity region (range: 14 – 55%), as well as in the lower extremity region (range: 4 – 24%) and trunk/other region (range: 0 – 16%).

Table I. Injuries by region

Study	Trial type	Training status	Training or competition	Period (years)	Total	Head	Upper extremity	Lower extremity	Trunk and other
Timm et al, 1993	R	Am	T&C	15	1,219	28%	36%	22%	14%
Zazryn et al, 2003	R	Pr	C	16	107	90%	7%	-	3%
Zazryn et al, 2009	R	Pr	C	8.5	214	86%	8%	1%	5%
Bledsoe et al, 2005	R	Pr	C	1.5	191	74%	22%	2%	2%
Bianco et al, 2005	R	Am	C	1.75	20	75%	20%	5%	-
Welch et al, 1986	R	Am (army)	T	2	294	48%	46%	4%	2%
Jordan&Campbell, 1989	R	Pr	C	2	376	93%	2%	-	4%
Jordan et al, 1990	R	Am	C	10	447	27%	33%	24%	16%
Estwanik et al, 1984	R	Am	C	8	52	48%	44%	4%	4%
McCown, 1959	R	Pr	C	7	1,089	96%	4%	0%	-
Oelman et al, 1983	R	Am (army)	T	12	437	68%	14%	5%	14%
Porter&O'Brien, 1996	P	Am	C	0.41	64	72%	23%	5%	-
Zazryn et al. 2006	P	Am&Pr	T&C	1	21	71%	24%	-	5%
Siewe et al. 2015	P	Am	T&C	1	192	46%	24%	16%	14%
Loosemore et al. 2015	P	Am	T&C	5	297	9%	55%	22%	13%
Total / range					5,020	9 – 96%	2 – 55%	0 - 24%	0 - 16%

**R= Retrospective; P= Prospective; Am= Amateur; Pr= Professional; T=Training; C=Competition*

Head Injury. The most common injury location in boxing within the head region appeared to be the face/scalp, being reported to account for a large proportion of injuries by anatomical location (range: 0 – 96%), albeit with great variability between studies (Table II). Concussions were also often found to comprise a large proportion of head injuries (range: 0 – 75%), again with great variability between studies. It is noteworthy that one third of the studies reported no concussions or neural/cerebral injury of any kind (1, 4, 10, 12, 14). The variability between studies was not entirely explained by amateur or professional status, as face and scalp injuries appeared to be the most common location of injury within the head region in both amateur (range: 0 – 93%) and professional (range: 12 – 96%) cohorts.

Table II. Boxing head injuries by location

Study	Total injuries	Face and scalp	Nose	Eye and eyebrow	Mouth	Jaw	Ear	Throat/ neck	Cerebral/ neural/ concussion	Non-specified
Timm et al. 1993	344	42%	21%	13%	9%	8%	6%	1%	-	-
Zazryn et al. 2003	96	26%	-	51%	-	2%	-	-	21%	-
Zazryn et al. 2009	184	12%	4%	63%	3%	2%	2%	1%	14%	-
Bledsoe et al. 2005	142	68%	7%	19%	1%	2%	2%	-	-	-
Bianco et al. 2005	15	93%	-	7%	-	-	-	-	-	-
Welch et al. 1986	142	-	80%	-	-	4%	-	-	15%	-
Jordan&Campbell, 1989	351	19%	1%	4%	-	1%	0%	-	75%	-
Jordan et al. 1990	121	7%	28%	19%	11%	6%	4%	-	26%	-
Estwanik et al. 1984	25	56%	12%	12%	8%	-	12%	-	-	-
McCown, 1959	1,049	96%	2%	2%	-	0%	-	-	-	-
Oelman et al. 1983	296	34%	-	-	-	-	-	-	62%	4%
Porter&O'Brien, 1996	46	9%	11%	7%	-	-	2%	-	72%	-
Zazryn et al. 2006	15	-	27%	27%	-	-	-	-	47%	-
Siewe et al. 2015	88	7%	25%	39%	13%	5%	2%	1%	9%	-
Loosemore et al. 2015	28	7%	7%	4%	7%	-	4%	36%	18%	18%
Total/range	2.942	7–96%	0–80%	0 - 63%	0 – 13%	0–8%	012%	0 – 36%	0 – 75%	0 – 18%

Upper Extremity Injury. The most common injury location in boxing within the major category of the upper extremity appeared to be the hand, accounting for the largest proportion of injuries by anatomical location (range: 7 – 100%), albeit with great variability between studies (Table III). It is noteworthy that all 15 studies found some instance of hand injury and 6 studies reported that hand injury comprised >75% of upper extremity injuries (2-4, 6, 10, 14). This variability was partially explained by amateur versus professional status, as hand, shoulder and wrist injuries all appeared to be substantially more common in amateur (ranges: 7 – 100%; 13 – 49%; 9 – 49%) than professional (range: 79 – 89%: 6 – 14%; 0 – 0%) cohorts.

Table III. Boxing upper extremity injuries by location

Study	Total number of injuries	Hand	Shoulder	Thumb	Fingers	Wrist	Elbow	Forearm	Upper arm	Clavicle
Timm et al. 1993	441	24%	20%	14%	13%	10%	10%	4%	4%	2%
Zazryn et al. 2003	8	88%	-	-	-	-	-	-	13%	-
Zazryn et al. 2009	17	87%	6%	-	-	-	-	-	6%	-
Bledsoe et al. 2005	42	79%	14%	-	-	-	7%	-	-	-
Bianco et al. 2005	4	100%	-	-	-	-	-	-	-	-
Welch et al. 1986	134	7%	49%	10%	5%	19%	10%	-	-	-
Jordan& Campbell, 1989	9	89%	11%	-	-	-	-	-	-	-
Jordan et al. 1990	147	24%	22%	12%	18%	9%	11%	2%	3%	-
Estwanik et al. 1984	23	57%	-	30%	-	9%	-	-	-	4%
McCown, 1959	39	82%	10%	-	8%	-	-	-	-	-
Oelman et al. 1983	59	47%	-	-	-	-	-	8%	2%	42%
Porter& O'Brien, 1996	15	53%	-	13%	-	20%	13%	-	-	-
Zazryn et al. 2006	5	20%	20%	-	-	20%	20%	-	20%	-
Siewe et al. 2015	47	11%	19%	-	4%	49%	2%	4%	11%	-
Loosemore et al. 2015	164	42%	13%	-	-	19%	14%	1%	12%	-
Total / range	1,154	7–100%	0-49%	0-30%	0–18%	0-20%	0–20%	0–8%	0–20%	0–42%

Lower Extremity Injury. The most common injury locations in boxing within the major category of the lower extremity appeared to be the ankle and thigh, which each were found to account for the largest proportion of injuries by anatomical location (range: 0 – 100%), albeit with substantial variability between studies (Table IV). The total number of injuries in this category was very low in comparison with the head and the upper extremity.

Table IV. Boxing lower extremity injuries by location

Study	Total number of injuries	Knee	Ankle	Thigh	Lower limb	Foot	Hip or groin	Toes	Non-specified
Timm et al. 1993	267	29%	25%	15%	11%	9%	6%	4%	-
Zazryn et al. 2003	-	-	-	-	-	-	-	-	-
Zazryn et al. 2009	3	-	64%	-	36%	-	-	-	-
Bledsoe et al. 2005	3	-	67%	-	-	33%	-	-	-
Bianco et al. 2005	1	-	-	100%	-	-	-	-	-
Welch et al. 1986	12	25%	67%	8%	-	-	-	-	-
Jordan& Campbell, 1989	-	-	-	-	-	-	-	-	-
Jordan et al. 1990	107	34%	25%	6%	18%	11%	7%	-	-
Estwanik et al. 1984	2	50%	50%	-	-	-	-	-	-
McCown, 1959	1	-	100%	-	-	-	-	-	-
Oelman et al. 1983	21	48%	-	-	14%	-	-	-	38%
Porter&O'Brien, 1996	3	33%	33%	-	33%	-	-	-	-
Zazryn et al. 2006	-	-	-	-	-	-	-	-	-
Siewe et al. 2015	30	-	17%	47%	37%	-	-	-	-
Loosemore et al. 2015	65	15%	32%	18%	28%	6%	-	-	-
Total / range	515	0– 50%	0-00%	0-100%	0 – 36%	0 – 33%	0 – 7%	0 – 4%	0 – 38%

The variability was partially explained by amateur versus professional status, as knee injuries appeared to be substantially more common in amateur (range: 15 – 50%) than professional (range: 0 – 0%) cohorts while in contrast ankle injuries appeared to be substantially less common in amateur (range: 17 – 67%) than in professional (range: 64 – 100%) cohorts.

Trunk and Other Injury. The most common injury location in boxing within the major category of the trunk and other injury appeared to be the chest and ribs, which were found to account for most of injuries by anatomical location (range: 0 – 100%), albeit with substantial variability between studies (Table V). The total number of injuries in this major category was very low in comparison with the head and the upper extremity. The small number of injuries made it unclear whether any injury locations were more predominant in amateur or professional cohorts.

Table V. Boxing trunk and other injuries by location

Study	Total number of injuries	Lumbo-pelvic	Chest and ribs	Neck	Thorax	Abdomen	Other spine	Non-specified or other
Timm et al. 1993	167	29%	28%	25%	13%	6%	-	-
Zazryn et al. 2003	3	-	-	-	-	33%	-	67%
Zazryn et al. 2009	10	-	19%	-	-	19%	-	62%
Bledsoe et al. 2005	4	-	75%	-	-	25%	-	-
Bianco et al. 2005	-	-	-	-	-	-	-	-
Welch et al. 1986	6	-	17%	67%	-	17%	-	-
Jordan and Campbell, 1989	16	-	19%	-	-	44%	-	38%
Jordan et al. 1990	72	-	24%	-	-	1%	75%	-
Estwanik et al. 1984	2	50%	50%	-	-	-	-	-
McCown, 1959	-	-	-	-	-	-	-	-
Oelman et al. 1983	61	-	5%	-	-	-	28%	67%
Porter and O'Brien, 1996	-	-	-	-	-	-	-	-
Zazryn et al. 2006	1	-	100%	-	-	-	-	-
Siewe et al. 2015	27	56%	37%	-	-	4%	-	4%
Loosemore et al. 2015	40	55%	35%	-	-	10%	-	-
Total / range	409	0 – 56%	0 – 100%	0 – 67%	0 – 13%	0 – 44%	0 – 75%	0 – 67%

Discussion

This systematic review assessed the proportion of injuries that occur in each anatomical location during boxing competition or training, as reported in observational studies in both professional and amateur boxers. Our review found considerable variability between studies but broadly supports traditional assumptions about boxing that associate the sport with head injury. A large proportion (range: 9 – 96%) of injuries were found to occur in the head region, particularly in professional boxers, with many reports displaying greater proportions of head injury compared with the upper extremity (range: 2 – 55%), lower extremity (range: 0 – 24%) and trunk/other regions (range: 0 – 16%). Although injury in the head region appears to account for the largest proportion of boxing injuries, concussion appeared to account for a much smaller proportion. One third of the included studies reported no incidence of concussion or cerebral injury of any kind.

When considering studies reporting solely either amateur or professional boxers separately, the picture of injuries by location was different. In professionals, the large majority of all injuries was routinely sustained in the head region (range: 74 – 96%), with a small minority in the upper extremity (range: 0 – 22%) and virtually none in the lower extremity region (range: 0 – 2%) and trunk/other region (range: 2 – 5%). In contrast, in amateurs, while the proportion of injuries by location was still weighted towards the head (range: 9 – 75%) there was a greater proportion in the upper extremity region (range: 14 – 55%), as well as in the lower extremity region (range: 4 – 24%) and trunk/other region (range: 0 – 16%). It seems probable that such differences arise from a variety of factors that may protect the head to a greater extent in amateur boxers (stricter refereeing in relation to head injury and superior head and face protection from lacerations) and that may protect the hand to a greater extent in professional boxers (hand wrapping is less limited in professional boxing than in amateur boxing).

*Head injury***.** There was considerable variability in the proportion of injury to the head region (range: 9 – 96%) and in the components of the head region. In respect of the proportion of head injury comprised of facial lacerations, the difference in reported results was very large (range: 7 – 96%), with some studies reporting no face/scalp injuries(5, 9), others reporting a very small number of face/scalp injuries (3, 6, 8, 13, 16), and others reporting almost all head injuries in this subcategory (10, 14). This variability seems to be partly attributable to the absolute number of face/scalp injuries incurred, which is likely a function of whether headgear is worn (8) and which in turn is primarily a function of amateur status, as professionals do not wear headgear. It is noteworthy that the study resulting in the single greatest proportion of facial lacerations reported the earliest period of boxing (1952 – 1958) in which no kind of headgear was ever worn (10). Additionally, the variability between studies may also be attributable to the lack of consistency regarding the how face/scalp injuries are classified in relation to the other subcategories of nose, eye and eyebrow, mouth, jaw, ear, throat and neck. Jordan and Campbell (6) noted that attending physicians at boxing matches are less likely to record facial lacerations on injury forms unless they require sutures, which does indicate a lack of consistency.

In respect of the proportion of head injury comprised of concussions, the range of reported results was very large (range: 0 – 75%). There is some evidence to suggest that there may be some variability between studies in the way in which cerebral (concussion) injury is defined and consequently recorded, which may be partly responsible for these differences. This may be because the databases that are used in retrospective studies of boxing injury were not originally designed to be used for this purpose (3). Bledsoe (4) for example, drew data retrospectively regarding professional boxing matches in the state of Nevada from the Nevada State Athletic Commission. These data recorded no concussions in the injury reports, despite reporting that 51% of fights ended in either a technical knockout or knockout. Bledsoe (4) commented that injury significant enough to lead to knockout is doubtless evidence of damage and therefore that their data likely underestimate the incidence of concussion quite significantly. Other studies have explicitly noted that their definition of concussion was when a knockout occurred (6) or is particularly conservative (5) in that it records any sign of vertigo or nausea as cerebral injury. Nevertheless, in two recent prospective trials performed in amateur boxers (15, 16), there were only a small number of cases of concussion observed. Siewe (15) observed 8 cases in a 1-year period in 44 boxers while Loosemore (16) observed 5 cases in a 5-year period in 66 boxers. These findings may indicate that differences between amateur and professional status may be more important in relation to the incidence of concussion than the definition of concussion or the way in which it is recorded

Upper extremity injury. There was considerable variability in the proportion of injury to the head region and in the components of the upper extremity region (range: 2 – 46%). There was also a great deal of variability in the proportion of upper extremity injuries occurring in the hand (range: 7 – 100%). Some of this variability was explained by amateur versus professional status, as hand, shoulder and wrist injuries all appeared to be substantially more common in amateur (ranges: 7 – 100%; 13 – 49%; 9 – 49%) than professional (range: 79 – 89%: 6 – 14%; 0 – 0%) cohorts but it is unclear what mechanisms might underpin such differences, other than a greater amount of hand wrapping in professional boxers than in amateur boxers. Part of the variability could be caused by differences in the classifications of anatomical locations around the hand, such as the fingers, thumb, and wrist. Indeed, the range is somewhat reduced when considering the hand-wrist complex (i.e. hand, finger, thumb, and wrist subcategories) and in this case the hand-wrist complex accounts for the large majority of upper extremity injury, with a mean 74% (range: 40 – 100%) of injuries in the upper extremity. Nevertheless, a considerable amount of between-study variability remained that was not explained, which could have arisen due to various factors, including the training status of the populations, the boxing federation rules in which they boxed, or the proportions assigned to other injuries.

Noble (17) performed the only epidemiological study that has so far been carried out purely in relation to boxing hand injury, excepting case studies and case series. One hundred consecutive boxing injuries to the hand in 86 boxers were assessed. These boxers presented either post-match or in the office of the South African Boxing Board of Control. Noble reported that 23% of hand injuries involved tears of the ulnar collateral ligament of the metacarpophalangeal (MCP) joint of the thumb ("skier's thumb"), 10% involved carpometacarpal (CMC) joint injuries of the thumb ("Bennett's fracture and dislocation"), 12% involved damage to the second to fifth MCP joint soft tissues (also called "boxer's knuckle"), 12% involved inflammation of the second to fifth CMC joints, 12% involved subluxation of one or more metacarpal bases, and 8% involved metacarpal fractures of the second to fifth metacarpals, with the majority of these occurring in the fifth metacarpal ("boxer's fracture). Noble's findings are similar to those reported in the studies

included in this analysis. Skier's thumb was reported as representing a high proportion of upper extremity injuries by Estwanik et al. (12) (30%) and Porter and O'Brien (8) (13%). Boxer's knuckle was also reported as representing a high proportion of upper extremity injuries by Porter and O'Brien (8) (34%). Boxer's fracture and other metacarpal fractures were reported as being a high proportion of upper extremity injuries by Estwanik et al. (12) (9%), Porter and O'Brien (8) (1996) (13%) and Oelman et al. (7) (47%). These findings are similar to those reported in a clinical report performed by McDougall (18), which noted that common boxing hand injuries included boxer's knuckle, boxer's fracture and Bennett's fracture, and skier's thumb. In cases of boxer's knuckle, two case series indicate that this particular injury may affect the third metacarpal most often, followed by the fifth metacarpal (19, 20). However, the findings reported by McCown (10) indicate that it may be the second and third metacarpals that are most commonly affected.

Lower extremity and trunk injury. There was considerable variability in the proportion of injury to the lower extremity (range: 0 – 24%) and trunk/other regions (range: 0 – 16%). However, the number of injuries reported in the lower extremity and trunk/other regions were very low and our ability to analyze these data are very limited. However, it is interesting to note that Porter and O'Brien (8) (1996) observed that the lower-body injuries incurred in their trial were similar to overuse injuries typically found in long-distance runners. They speculated that such injuries may relate to the nature of boxing training, which often involves long-distance running, rather than actual boxing competition. Porter and O'Brien (8) (1996) noted a large difference in the proportion of lower extremity injury between training and competition (41% vs. 5%), which supports this observation. This may be related to the greater proportion of knee injuries in amateur (range: 15 – 50%) compared to professional boxers (range: 0 – 0%), insofar as amateur boxers may be less likely to follow professionally-guided strength and conditioning programs.

Limitations. There were several key limitations of this review. Firstly, the review was limited insofar as no quantitative analysis was performed of the reported results. Secondly, it was limited by the relative paucity of high-quality, relevant studies with large sample sizes (only 4 of the included studies were prospective cohort trials). Thirdly, the review was limited by the very large ranges observed in the reported proportions of injury by anatomical location. This heterogeneity between studies appears to have arisen for a variety of reasons, including the apparently very different definitions of certain key injuries, including concussion, which was defined in some studies as being equal to a knockout and not in others. A related limitation of this study in this respect was that this heterogeneity was not assessed formally by the use of statistical analysis. Therefore, the underlying factors that may have been responsible for the differences in reported outcomes were not definitively identified.

Conclusions

Boxing has historically most commonly been associated with head injury. This review supports this association to a certain degree, with many studies reporting a large proportion of injuries occurring in the head region (range: 9 – 96%), compared with the upper extremity (range: 2 – 55%), lower extremity (range: 0 – 24%) and trunk/other (range: 0 – 16%) regions. However, we found extremely marked between-study variability in the proportion of injuries reported in each region, which may have arisen for a variety of reasons, including a lack of consistency in respect of injury definitions, boxing conditions (type of headgear worn), and whether the athletes were amateur or professional. Although injury in the head region appears to account for the largest proportion of boxing injuries, concussion seems to account for a much smaller proportion because of the high incidence of facial

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