Shoulder Injuries in Boxing. A systematic Review.

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Abstract

Background: High injury rates are to be expected in combat sports. Although case reports and epidemiological studies have documented shoulder injuries in boxers, numbers differ and there is currently no systematic review reporting injury prevalence.

Purpose: The aim of this study was to offer an analysis of existing studies documenting shoulder injuries in boxing. Additionally, we wanted to evaluate, if chronic shoulder pathologies seen in former boxers, originate from acute injuries or result from chronic overuse syndromes.

Study Design: Systematic Review

Methods: We performed a systematic database research according to the PRISMA guidelines on PubMed, Scopus and Google Scholar for the keywords “boxing”, “injury” and “shoulder” or their respective synonyms. Any epidemiological cohort- and cross-sectional studies on boxing, that documented shoulder injuries and were published in German or English language up to January 2020, were included. Statistical analysis including individual and overall proportion with 95% Clopper-Pearson confidence intervals was performed to determine shoulder injury rates for amateur and professional cohorts separately.

Results: Methodological quality was assessed using the STROBE statement and a modified Downs&Black's checklist. 13 studies were included, 10 of which met the criteria for statistical analyses. The heterogeneity in study design and cohort characteristics did not allow for detailed quantitative analysis. Overall, shoulder injuries occurred almost twice as often in amateur athletes than in professionals (overall proportion [95% CI]: amateur athletes: 9% [6%; 12%], professionals: 4% [2%; 8%]).

Conclusion: No study investigating the long-term effects of boxing on shoulder pathologies was identified. Although specific information on injury type is mostly missing, the few studies addressing it report shoulder dislocations, strains, tendonitis, or chronic impingement syndromes. Unlike head trauma, shoulder injuries do not necessarily lead to cessation of fight, therefore at the ringside gross underreporting of shoulder pathologies must be taken into consideration.

Background

Epidemiology

In combat sports, high injury rates are to be anticipated. However, reported rates have led to extensive discussion whether to abort boxing as an Olympic discipline. The problem being not only injury rates, but rather injury severity. Although safety regulations have been modified(1, 2) and numbers of severe injuries have been dropping accordingly, many experts still consider boxing to be unsafe. During the Summer Olympic games 2008 boxing was among the disciplines with the highest risk of incurring injury, together with soccer, taekwondo, hockey, handball and weightlifting accumulating 15% of detected injuries(3).

Whether athletes are competing in professional or amateur boxing affects the risk of injury. Olympic-style boxing with standardised rules and bouts organised by sports associations (as the AIBA, the official international boxing association) is commonly referred to as “amateur boxing”(4). In “professional boxing” athletes fight in regulated, sanctioned bouts for a predefined prize. Differences apart from monetary income include gear, bout design, scoring system and especially length of bouts. Most studies on boxing injuries clearly define whether they work with cohorts of amateur or professional boxers.

Data on boxing injuries is rather limited, but most of the conducted studies indicate that injury rates in boxing are comparable to or even lower than those reported in other contact sports like Australian football, professional rugby and soccer(5). Out of all the reported injuries, the clear majority are injuries to the head in professional boxing, while in amateur boxing injuries to the upper extremity also make up a large proportion(6).

Although several case reports and epidemiological studies have documented shoulder injuries in boxers, reported numbers vary and there is currently no systematic review reporting injury prevalence.

Objectives

The aim of this study was to offer an analysis of all existing studies documenting shoulder injuries in amateur and professional boxing. Given the broad qualitative range of studies, we put a special focus on critical appraisal of all included studies for methodological quality and risk of bias. Based on the results, we wanted to evaluate tendencies of whether chronic shoulder pathologies which can be seen in patients who have had a career in boxing, originate from acute injuries or are a result of chronic overuse syndromes.

Methods

Eligibility criteria and search strategy:

We planned and conducted the study as presented in the Cochrane Handbook(7) and adapted the guidelines for a review on observational studies. Our results are presented according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines(8).

The literature search was primarily conducted in June 2018 by a single author searching PubMed, Scopus and Google Scholar for the keywords “boxing”, “injury” and “shoulder” or their synonyms respectively (the search algorithm is presented in the appendix section). The literature search was then repeated in January 2020 to look for novel studies fulfilling the inclusion criteria. We included all studies reporting shoulder injuries in cohorts of boxers in English or German language. Exclusion criteria were defined as cohorts of kickboxing, case reports, letters to the editor and systematic reviews concerning different research questions. The study selection process is displayed in figure 1.

After removing duplicates, all studies with full-texts available were assessed for eligibility criteria and reference lists were checked to identify additional studies. We contacted 6 authors and asked them to provide full texts, but no answer was received. Full-text assessment of 31 articles led to exclusion of 18 articles, leaving 13 articles to be included in the final analysis.

Data extraction and assessment of methodological quality:

One author obtained the following data for each study and entered them manually into an Excel spread sheet: cohort characteristics (amateur or professional), included author(s), year of publication, study design, data collection period, demographics (age, number of athletes), definition of injury, main statistical approach, findings (prevalence). The data sheet was checked by a second author and disagreements were solved by consensus.

Methodological quality was assessed for each study using the STROBE(9) statement and the results were documented in a spreadsheet by one author. Another author checked these results in a second appraisal. Additionally a modified Downs&Black’s(10) checklist was applied to all included studies, as this tool has been assessed as one of the few available methods to test non-randomized controlled trials for risk of bias(11) (as the tool was designed for intervention studies, the term “intervention” was considered as “exposure” in our analysis whenever possible).

Statistical analysis:

Due to high heterogeneity in study design, data collection methods and formats of injury reporting, performing a meta-analysis of the presented data was very difficult. Also, many studies lacked information on the statistical measures applied, or did not present all the information needed (i.e. confidence intervals).

Quantitative variables are summarized as mean and standard deviation (SD) if not stated otherwise. Qualitative variables are reported as absolute and relative frequency (%).

Results of injury prevalence are depicted separately for amateur and professional cohorts of boxing, as major discrepancies in injury patterns have been found(6). The individual and overall proportion with 95% Clopper-Pearson confidence limits were calculated and the results were visualized in a forest-plot (R-package meta, R-functions metaprop and forest). The calculation of the overall proportion is based on a generalized linear mixed model. Three studies were not included in the statistical tests due to low methodological quality scores and risk of bias scores(12–14) (see Fig. 2). Also, only verifiable numbers were included in statistical analysis, i.e. in the case of Porter et al.(15), competition and training data were reported but it is not clear whether the cohorts were mixed. Therefore, only the number of training injuries detected by injury questionnaires were included in further data analysis.

Statistical analyses were conducted with R 3.6.0 and IBM SPSS Statistics Version 25.

Results

Study Characteristics:

In 13 included studies we detected three different study designs: Retrospective cross-sectional study(12–14, 16–18) (n = 6), retrospective case-control study(19) (n = 1), prospective cohort studies(5, 6, 15, 20–22) (n = 6).

Furthermore, given the differences in rules, bout design and injury prevalence, dividing the studies in cohorts of amateur(6, 12, 13, 15, 16, 20) (n = 6) and professional(14, 17–19, 21, 22) (n = 6) boxers (with one study presenting results for both cohorts(5)) seemed reasonable.

Sample sizes ranged from 16 to 11,173 included athletes (median = 105), with 5 studies(5, 6, 20–22) including small samples of < 100 athletes, 4 studies(15, 17–19) including medium samples of 100-1,000 athletes and two studies(13, 14) including > 1,000 athletes. Most of the included studies displayed cohorts of male boxers with 4 studies including only males(6, 20–22), 3 studies with at least 90% males(5, 17, 19), one study including 70% males(18), one study including only females(13), and 3 studies not giving any gender characteristics(12, 14, 16) (considering however, that these studies have been published before 2000 and females have not been allowed at the Olympic games until 2012, it can be assumed that most cohorts were male). One study reported on a mixed cohort of different combat sports with boxing as a subgroup(22), while the rest of the included study cohorts were boxers only.

In terms of injury definition, the majority of studies(6, 15, 18, 21, 22) (n = 5) used “time loss” (events preventing the athletes from competing or training) as their main criteria, and 2 studies(12, 17) required “medical attention” (athletes sought out a physician or hospital) as their definition for injury. One study(5) used a combination of both definitions, and in 5 cases(13, 14, 16, 19, 20) injury was not defined. Data collection periods ranged from 2 months to 14.5 years (median = 8 months for prospective studies and median = 84 months for retrospective studies). Seven studies collected combined data on injuries sustained in competition and training(5, 6, 15, 18, 20–22), 3 studies presented only competition data(13, 17, 19) and 3 studies gave no information on this part(12, 14, 16).

Further details on study characteristics can be found in Tables 1 and 2.

Table 1
Study characteristics for amateur cohorts

Author	Journal	Study design	Data collection method	Data collection period	Statistics	N	Gender	Age (mean)	DoI
Oelman 1983(12)	J R Arm Med Corps	RCS	Screening of hospital admissions	12 years	descriptive analysis	5700	?	22,12	MA
Timm 1993(16)	J Athl Train	RCS	retrospective analysis of standard medical report forms used by the per- manent and voluntary staff at the USOTC	14.5 years	χ^2 tests	?	?	?	?
Porter 1996(15)	Clin J Sport Med	PCS	Injuries recorded during competition + self reported injuries during training	5 months	descriptive analysis	281	?	?	TL
Zazryn 2006(5)	Br J Sports Med	PCS	Self reported survey initially and assessment tool used by trainers and fight doctors assessment tool	12 months	χ^2 and t tests	33	3 F 30 M	23,7	TL + MA
Bianco 2009(13)	Br J Sports Med	RCS	Medical examinations at bouts before and after competition	6 years	?	2800	100% F	?	?
Oke 2012(20)	Glo Adv Res J of Med and Med Sci	PCS	Injury documentation during training camp by medical team	4 months	descriptive analysis	29	100% M	22.50 ± 2.72	?
Loosemore 2015(6)	Br J Sports Med	PCS	prospective recording by GB medical team using a modified Orchard Sports Injury Classification System	5 years	χ^2-tests, Z-scores and multiple regression analysis	66	100% M	22.0 ± 2.5	TL

Abbreviations:

RCS = retrospective cohort study, RCS = retrospective cross-sectional study, PCS = prospective cohort study, RCCS = retrospective case control study; DoI = definition of injury, MA = medical attention, TL = time loss; ? = information not given; M = males, F = females

Table 2
Study characteristics for professional cohorts

Author	Journal	Study design	Data collection method	Data collection period	Statistics	N	Gender	Age (mean)	DoI
McCown 1959(14)	Am J Surg	RCS	Injuries detected by the Commission and Medical Advisory Board	7 years	?	11173	?	?	?
Bledsoe 2005(19)	Southern Med J	RCCS	Clinical report of the physician at ringside	1.5 years	Logistic regression analysis for risk of injury calculation	688	92.2% M	?	?
Zazryn 2006(5)	Br J Sports Med	PCS	Self reported survey initially and assessment tool used by trainers and fight doctors	12 months	χ^2 and t tests	14	F: 1 M: 14	31,8	TL + MA
Zazryn 2009(17)[16]	Clin J Sports Med	RCS	fight statistics database	8.5 years	descriptive analysis, univariate and multi-variate logistic regressions	545	98,3% M 9 F 536 M	27.9 (range 18.1–43.6)	MA
Siewe 2014(21)	Orthopedics and Biomechanics	PCS	questionnaire once a month	1 year	χ^{2-}test, descriptive analysis	44	100% M	20.2 ± 7.86	TL
Noh 2015(22)	J Phys Ther Sci	PCS	Injury questionnaire filled out by athletes under the supervision of a re- searcher	2 months	Student's t-test, χ^2 test and Fisher's exact test	16	100% M	19.4 ± 0.3	TL
Kumar 2015(18)	IOSR J Sports Phys Ed	RCS	modified nordic musculoskelettal questionnaire	1 year	descriptive analysis	105	73 M 32 F	M: 16.26 ± 3.13; F: 18.38 ± 4.69	TL

Abbreviations:

RCS = retrospective cohort study, RCS = retrospective cross-sectional study, PCS = prospective cohort study, RCCS = retrospective case control study; DoI = definition of injury, MA = medical attention, TL = time loss; ? = information not given; M = males, F = females

Quality Assessment:

Given that publication dates of all included studies ranged from 1959 to 2015, a wide range of methodological quality was to be expected. High variability in study design and risk of bias led to considerable problems in applying quality assessment tools. Applying one tool and rating the included studies accordingly was deemed insufficient to guarantee that all methodological aspects were weighted in accordance with the underlying study design and methodology. Out of all the items assessed in the

STROBE statement, we therefore chose to depict a sample of key quality features below to be considered in the further assessment of study outcomes. All further details and ratings concerning the quality assessment can be found in table 8 in the appendix section.

Participants:

Eligibility criteria for patient inclusion and the selection were present in most of the included studies, 11 studies(5, 6, 13, 15–22) therefore fulfill this criterion in its most basic form. Two older studies give no information on patient selection at all(12, 14). One study, which reports on injury prevalence in a cohort of boxers, is missing a total number of participants(16). Another study(22) is offering relative numbers that are not adding up in their tables. Also, only 3 studies(6, 15, 21) offered information on how drop-outs were handled (however, one needs to bear in mind that drop-out rates have a bigger impact on outcomes in prospective cohort studies than they have on retrospective cross-sectional studies).

Variables:

"Injury", being the variable which all the included studies claim to assess, needs to be defined a priori. Therefore, all the studies having failed to include a definition of injury(13, 14, 16, 19, 20) were graded as not having fulfilled this criterion. Four studies used a questionnaire to gather information on injury prevalence(5, 15, 21, 22), one study however failed to report their response rate(22). Response rates will be discussed in the results section for each study, respectively.

Reported risk of bias:

A detailed description on detected bias is following in the "risk of bias" section. However, in the course of quality assessment, it also needs to be stated that authors addressed possible bias in only 4/13 included studies(5, 16–18).

Statistical analyses:

To report injury numbers and display them correctly, authors ought to define how they reached those numbers and what kind of calculations they used. Correct display of all calculated measures (including CI and SDs) is the basis for further evaluation and pooling of data. Four studies(12–15) give no information on the statistical measures they used, and only 3 studies give confidence intervals for the injury numbers(5) or statistical models(17, 19) presented. Two studies offer standard error values(15) or standard deviation, median and range(21) for exposure rates, but not for injury data. Two studies presented Chi-square tests with p-values(16) and/or Z scores(6) to compare injury locations.

Population characteristics:

Basic demographic information for the included sample is presented in the majority of included studies(5, 6, 15, 17–22), with one study also including technical information and medical history(13). However, 3 studies give no description of study participants except that they were boxers (12, 14, 16). Following basic demographic characteristics, information on exposure is highly relevant, especially in all the longitudinal cohort studies included. However, only 3 studies(5, 6, 21) offered information on training or competition exposure within this period.

Numerous potential confounders can be identified, some of which are discussed in 8/13 studies(5, 6, 12, 15–17, 19, 21). Most of these confounders concern injury prevalence (i.e. age, bouts/year, preexisting injury, sparring vs. bouts, protection gear), sometimes also study design, injury documenting measures and population are discussed as influencing factors.

Generalizability:

Generalizability is discussed only in 5 studies(5, 6, 12, 13, 16) and is considered high for 7 studies(5, 6, 15–17, 19, 21), and low for the rest, given the missing information on study participants (“population at risk”), exposure and possible confounders.

Risk of Bias:

Risk of bias sometimes correlates with the general quality of the study but is also a factor that affects analysis of outcomes on its own. Specific bias that readers need to be aware of are for example detection bias in those studies that do not declare a definition of injury(13, 15, 16, 19, 20), confounding bias in all included studies which mix training and competition data(12, 14, 16, 18, 20, 22) or recall bias in all retrospective studies relying on the participants’ memory(13, 18, 22).

Risk of bias was assessed using a modified Downs&Black’s questionnaire[9]. Applying the same questionnaire for all included studies again proved difficult. According to study design, different biases need to be addressed and not every item in the questionnaire works for every study. Items 8, 14, 15, 19 and 21–24 were not used at all, as they can be applied for intervention studies only. As some of the items (items 9, 11, 12, 16, 17 and 26) could only be applied for prospective longitudinal studies, risk of bias assessment will be presented separately for retrospective and prospective studies (see Tables 3 and 4).

Table 3
Risk of bias assessment for prospective studies

Item	1	2	3	4	5	6	7	9	10	11	12	13	16	17	18	20	25	26	27	total
Porter 1996(15)	1	1	1	1	1	1	1	1	0*	1	0	1	1	1	1	1	1	1	1	17
Zazryn 2006(5)	1	1	1	1	1	1	1	1	0*	1	1	1	1	1	1	1	1	1	0	17
Oke 2012(20)	1	1	1	1	0	1	1	0	0	0	1	1	1	1	1	0	1	0	0	12
Siewe 2014(21)	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	16
Loosemore 2015(6)	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	15
Noh 2015(22)	1	1	1	0	0	0	1	0	1	1	0	1	1	1	1	1	1	0	0	12

* descriptive study, therefore unable to determine

Table 4
Risk of bias assessment for retrospective studies

Item	1	2	3	4	5	6	7	*9*	10	*11*	*12*	13	*16*	*17*	18	20	25	*26*	27	total
McCown 1959(14)	0	0	0	0	0	0	0	*0*	0*	*0*	*0*	1	*0*	*0*	0	0	0	*0*	1	2
Oelman 1983(12)	0	1	0	0	0	1	0	*0*	0*	*0*	*0*	1	*0*	*0*	1	0	0	*0*	1	5
Timm 1993(16)	1	1	0	0	0	1	0	*0*	1	*0*	*0*	1	*0*	*0*	1	1	0	*0*	0°	7
Bledsoe 2005(19)	1	1	1	1	0	1	1	*0*	1	*0*	*0*	1	*0*	*0*	1	0	1	*0*	0	10
Bianco 2009(13)	1	0	0	1	0	1	0	*0*	0*	*0*	*0*	1	*0*	*0*	1	0	0	*0*	1	6
Zazryn 2009(17)	1	1	1	1	1	1	1	*0*	0	*0*	*0*	1	*0*	*0*	1	1	1	*0*	1	12
Kumar 2015(18)	1	1	1	0	0	1	1	*0*	0*	*0*	*0*	1	*0*	*0*	1	1	0	*0*	0	8

* descriptive study, therefore unable to determine

° missing N, therefore unable to determine

Items not applicable for retrospective studies

By applying both STROBE quality assessment scores and Downs&Black's risk of bias scores, we evaluated methodological quality of all included studies to determine how to interpret the outcome findings and whether to integrate them into further analyses. Figure 2 shows a scatter plot of combined STROBE quality assessment scores and Downs&Black's risk of bias scores for all included studies.

In amateur cohorts (cohort 1) studies 1 (Oelman et al.(12)) and 5 (Bianco et al.(13)), and in professional cohorts (cohort 2) study 8 (McCown et al.(14)), can be easily identified as outliers, all three having an exceptionally low combined quality assessment score and risk of bias score with combined values of 15, 22 and 8 respectively compared to a mean combined score of 28 with a SD of 6.55 for all included studies (see Table 5 below). They were therefore not included in further statistical analyses.

Table 5
Descriptive statistics for STROBE quality assessment scores and Downs&Black's risk of bias scores

	N	Minimum	Maximum	Mean	SD
Combined	13	15	39	28.00	6.545
Downs&Black	13	5	17	11.46	4.095
STROBE	13	6	22	16.54	4.409

Data analysis (Outcome):

Professionals

Table 6 presents the extracted outcome data of all the included studies on professional athletes with a detailed description following below.

The overall proportion of shoulder injuries among all detected injuries in professional boxing cohorts was 4% [2%; 8%],with the absolute frequency of shoulder injuries ranging from 1 to 10 injuries in the individual studies (see Figure 3). The heterogeneity index I^2 was 69%.

Table 6
Outcome data for professional cohorts

Author	Data collection period	N	Competition exposure	Number of shoulder Injuries	%	Number of other Injuries	Injury rates
McCown 1959(14)	7 years	11173	not given	4 anterior shoulder dislocations	0.4	1010 lacerations or contusions	not given
Bledsoe 2005(19)	1.5 years	524 bouts, 688 boxers	not given	shoulder injuries: 6, shoulder and elbow: 1	3.59	195 injuries	17.1 per 100 boxing-matches or 3.4 per 100 boxer-rounds
Zazryn 2006(5)	12 months	14	mean 2.7; range 1.0–5.0	1 injury in training: shoulder inflammation	8.33	8 (comp.) 4 (training)	4.4/1000 h overall 1081,1/1000h (comp.) 1,7/1000h (training)
Zazryn 2009(17)[16]	8.5 years	545 boxers 907 bouts	not given	1 shoulder injury (strain)	0.47	214 injuries in total	23.6/100 fights:
Siewe 2014(21)	1 year	44	2.75 bouts per boxer/year	9 shoulder injuries (3 contusions, 3 strains, 2 impingement syndromes, 1 laceration)	4.69	192 injuries in total 67 in competition 125 in training	12.8/1000 h of training
Noh 2015(22)	2 months	16	not given	10 shoulder injuries	10.1	99 injuries in total	not given
Kumar 2015(18)	1 year	105	not given	3 shoulder injuries	6.25	48 injuries in total	1-year prevalence rate of 46%

As boxing dates back to 1904 as an Olympic sport, early medical records on injury epidemiology can be found within the literature. Already in 1959, McCown et al.(14) published data on boxing injuries in professional boxers, which they had gathered in the first seven years following implementation of the first Medical Advisory Board for boxing in the United States. Although details on cohort characteristics (age, competition exposure) and data collection methods (injury definition, injury recording), as well as information on statistical analyses are missing, their retrospective cross-sectional study included an astonishing sample of 11173 boxers. Besides, 1010 injuries to soft tissue resulting from trauma, 4 dislocations of the shoulder joint were mentioned.

In 2005, Bledsoe et al.(19) conducted an epidemiological study examining data from 524 professional boxing matches in the state of Nevada over a period of 1.5 years, using a retrospective case-control design including 688 participating boxers. The injured athletes were serving as cases and the healthy ones as controls. Although they obtained data on epidemiological characteristics (sex, age, weight) to perform injury risk calculations, no descriptive statistics on cohort characteristics (i.e. mean age) are offered. Injuries, as detected from the physician at ringside, are displayed in absolute and relative numbers with 6 injuries to the shoulder (3.16%) and 1 injury to the shoulder and elbow (0.53%) mentioned, without further specification on pathologies or injury definition.

In 2006, Zazryn et al.(5) published a prospective cohort study of 14 professional and 33 amateur boxers in Victoria, Australia, who were followed up monthly for a period of 12 months. Notably, the authors stated a response rate of 19% for amateurs and 25% for professionals. Providing a detailed description of data acquisition and cohort characteristics, they report an overall injury rate of 2.0 per 1000 hours of boxing (1.0/1000h in amateurs and 4.4/1000h in professionals). Being one of the few studies to differentiate between training and competition in their data analysis, they found injury rates to be a lot higher in bouts than in training (1081.1–1221.4 injuries per 1000 bout hours compared to 0.5–1.7 injuries per 1000 hours of training). While competition exposure is given as 2.7 bouts for professionals (range 1.0–5.0) and 3.6 bouts for amateurs (range 1.0–10.0), professionals are listed to have a higher total bout exposure in hours (7.4 for professionals and 3.3 for amateur athletes). Injury rates per 100 fights are also listed for amateurs and professionals separately (25 for amateurs compared to 33.3 for professionals). In professional athletes, they reported 5 shoulder injuries sustained in training, with one being listed as shoulder inflammation, but no shoulder injuries in amateurs.

While all of the other studies contain samples of mostly male athletes, Bianco et al.(13) reported on 2800 female amateur and professional boxers in Italy over a period of 6 years. While they give a lot of technical information and background on data acquisition, as well as prevalence for pathologies of the breast, urogenital tract and nervous system, further demographic information as well as injury rates are not listed. All listed injuries were detected in medical examinations after competition with 11 cases of contusion to the upper limb (hand, elbow, or shoulder) in amateurs, but none in professionals. Further specification on pathologies or injury definition are not given, also the data is limited to competition injuries. Therefore, there is no information on competition exposure.

Also in 2009, Zazryn et al.(17) analyzed 907 professional boxing bouts held in the past 8.5 years in the state of Victoria, including competition data only with injury being defined as “any injury reported to or by a ringside physician after bout participation”. In 545 athletes, they found 214 injuries and calculated an injury rate of 23.6 per 100 fights, or 60.7 per 100 when fights were stopped because of knockouts without further medical specification. Out of 17 upper extremity injuries, one shoulder injury was listed.

In a prospective cohort study published 2014, Siewe et al.(21) followed a sample of 44 professional athletes for one year with monthly questionnaires reporting injury occurrence (injury being defined as “an event causing interruption in training or competition”) with a response rate of 100%. They documented 67 competition injuries and 125 training injuries and found an overall injury rate of 12.8 per 1000 hours of boxing. On average, each boxer was found to compete in 2.75 bouts/year. Out of 47 upper extremity injuries, 9 shoulder injuries were documented with 3 contusions, 3 strains, 2 impingement syndromes and 1 laceration.

In a prospective cohort study, Noh et al.(22) followed 189 collegiate athletes of several combat sports, including judo, ssireum, wrestling, kendo, and taekwondo in addition to boxing (16 athletes) over a period of 2 months. They documented injuries using an injury questionnaire that was filled out by the athletes under the supervision of a group researcher and included information on injury type, location and mechanism/ surrounding factors. Injury is defined as bodily damage that interfered with competition or training. All athletes, except for one kendo fighter, experienced an injury during the observed time interval, but unfortunately no overall count of injuries per discipline or mean injury rate per athlete were described. The injury data were only presented in crosstabs of injury type and injury region with numbers not adding up correctly. When counting together all the listed boxing injuries within both categories, they sum up to 71 injuries categorized for injury types, in contrast to 99 injuries that can be counted when injuries are categorized in injury region. In addition to 13 head, 8 elbow, 16 wrist, 17 hands and fingers, 11 knee, 14 ankle, 1 toe, they also report 10 shoulder injuries in boxers, without further specification on injury mechanism or underlying pathology. This study focused more on comparison between combat sports, however absolute numbers of injuries are missing from tables and relative percentages are unclear, therefore making an injury rate comparison impossible.

Using the modified Nordic Musculoskeletal Injury Questionnaire, Kumar et al.(18) retrospectively collected data on injury rates within one year in 105 boxers, fighting at least at district level at different training sites in India. At a mean age of 16 for males and 18 for females, athletes in this study were younger than in any other study. Out of 48 injured athletes, 3 (6.25%) reported shoulder injuries that led to consultation of a doctor or physiotherapist. The study group also reported a higher rate of shoulder injuries in females than in males. However, the group size was clearly not balanced, and no information on statistical calculations was provided.

Amateurs:

In amateur boxing cohorts, the overall proportion of shoulder injuries among all detected injuries was 9% [6%; 12%] ,with the absolute frequency of shoulder injuries ranging from 0 to 86 injuries in the individual studies (see Figure 4). The heterogeneity index I^2 was equal to 52%.

Table 7 depicts outcome data for all included studies of amateur cohorts. A detailed description of studies is following below.

Table 7

Outcome data for amateur cohorts

Author	Data collection period	N	Competition exposure	Number of shoulder Injuries	%	Number of other Injuries	Injury rates
Oelman 1983(12)	12 years	5700 (calc.)	not given	9 cases of dislocated shoulders (15.3 % of upper extremity injuries)	2.06	437 injuries	1/ 9000 man hours of boxing (calc.)
Timm 1993(16)	14.5 years	not given	not given	86 shoulder injuries	7.05	1219 injuries	not given
Porter 1996(15)	5 months	281 (comp.) 147 (training)	not given	4 shoulder injuries during training, 0 during competition	4.3	93 injuries in total 64 (comp.) 29 (training)	920/1000h of comp. 0.7 /boxer/year (comp.) 0.69/boxer/year (training)
Zazryn 2006(5)	12 months	33	mean 3.6; range 1.0–10.0	0	-	4 training injuries 4 competition injuries	1.0/1000h overall 1221,4/1000h (comp.) 0.5/1000h (training)
Massi-miliano 2009(13)	6 years	2800	not given	11 injuries of upper limbs (hand, wrist and/or shoulder)	-	51 injuries	not given
Oke 2012(20)	4 months	29	not given	17 strain/tendonitis of the shoulder	15	113 in total	3.9/athlete
Loose-more 2015(6)	5 years	66	mean 96.6 min per participant (range 2-356min)	21 shoulder injuries, days lost: 21.2	7.07	297 injuries in total 88 (comp.) 209 (training)	828/1000h of comp. 7.4/athlete

In a retrospective cross-sectional study, Oelman et al.(12) screened hospital records for admittance of Army personnel with boxing injuries over a period of 12 years, and found 9 cases of shoulder dislocations out of 437 total injuries With an estimated total of 59 hours of boxing per year, the overall injury rate was calculated as 1 per 9,000 man-hours of boxing. But there is no further information on competition exposure or injury mechanism.

Timm et al.(16) performed a retrospective analysis of standard medical report forms used by the staff at the United States Olympic Training Center staff over a period of 14.5 years. Sadly, there are no numbers on total participants or group characteristics (i.e. age or competition expose), or definition of injury. It was noted that training was made up mostly of sparring with less competitive elements, and a total number of 1,219 injuries were reported including 86 shoulder injuries.

Porter at al.(15) prospectively gathered data on injuries sustained by a cohort of 281 amateur boxers in Ireland over a period of 5 months, including injuries recorded during competition and self-reported injuries during training. Defining injury as an event that would stop the athlete from competing or training, they found 4 shoulder injuries during training out of 29 injuries in total, and none during competition. Interestingly, shoulder injuries had the highest average number of missed training days (14.2), and all four mentioned shoulder injuries were reported to be of the "predominantly chronic impingement type related to repeated punching activities". After all participants, who did not send back their questionnaires, were excluded from the study, a response rate of 100% was assumed.

Oke et al.(20) assessed all injuries that were sustained by 29 amateur boxers during 4 months of training camp. With 113 injuries in total, an injury rate of 3.9 per boxer was calculated. 17 shoulder injuries were described and further classified as “strain/tendonitis”. Only one friendly international boxing competition seemed to have taken place during the study period, but there is no further specification on competition exposure. The authors differentiate between 69% of “acute on chronic injuries” and 31% of “chronic injuries”. However, there is no indication as to how these categories were defined. It is also not clear, whether all athletes finished the camp or if there were any dropouts.

Prospectively following all male boxers on the British boxing squad, Loosemore et al.(6) recorded any injuries (“any musculoskeletal condition that prevented the boxer from participating in either training or competition for > 24 h”) that occurred during a 5 year period using a modified Orchard Sports Injury Classification System. In total, 297 injuries were sustained by the 66 athletes included, with 70% occurring in training and 30% in competition. 21 shoulder injuries were reported with a mean time loss of 21.1 days. The overall occurrence of new injuries was found to be significantly higher than it was for recurring injuries.

Discussion

A thorough literature research showed that shoulder injuries in boxing are found twice as often in amateur cohorts than they are in professional boxers, but confidence intervals are overlapping. Due to major differences in study design, methodological quality, injury reporting, population characteristics, exposure rates and type of analysis, we were not able to perform any more specific statistical analyses. Addressing the wide range of shoulder injury rates among the included studies, finding an answer would only be possible if the majority of studies gave detailed descriptions on their study population, exposure rates, injury definition, injury location and statistical measures. Without these evaluations, generalizability is limited, and direct comparison is almost impossible. Therefore, all analyses of injury prevalence need to be done carefully and under the aspects mentioned above.

Most of the studies used injury data generated prospectively or retrospectively by analyzing all reported injuries within a predefined period of time. “Time-loss” or “medical attention” are definitions of injury that are widely used in sports medicine and are mostly accepted. The problem with both injury definitions is the significant risk of underreporting. Porter et al. [14], for example, reported that only 17% of all sustained injuries led to consultation of medical staff in boxers, which states the obvious problem with “medical attention” definitions. While many boxing fights are stopped when there is a KO (counting as a head injury in most of the included studies), underreporting of other injuries that do not necessarily terminate a boxing fight need to be kept in mind.

All the included studies focused on acute injuries sustained during competition or training. However, no study could be identified which reported on chronic injuries as a result of high-level sports exposure during a certain time of life. Already in 1993, Timm et al.(16) noted that long term effects of acute boxing injuries are not known and need to be studied. While there have been increased efforts to investigate long-term neurological effects of head injuries in boxing(23, 24), there is a complete lack of information on effects of other injuries.

A study by Owens et al.(25) depicts shoulder instability events (subluxations or dislocations) at a military academy over a period of time in several sports. The authors found boxing to be the sport with the highest number of instability events. Interestingly, a high proportion of these were non-contact injuries, mostly occurring during a missed punch. Even though very few of our included studies named the type of shoulder injury sustained, instability events might be very common. Another study by Murakami et al(26) summed up the MRI findings of patients with shoulder injuries after the Olympic games 2016. Most patients came from swimming, judo, boxing, gymnastics, volleyball and athletics (track and field). Within the 5 boxing athletes, evidence of an anterior shoulder dislocation, rotator cuff abnormalities, SLAP lesions or abnormalities of the biceps tendon were present. A case series of Özkan et al.(27) revealed different levels of chondropathy and pathologies of the glenoid labrum in 10 boxers with shoulder pain undergoing arthroscopy. Severity of intraarticular pathologies seemed to correlate with the years spent boxing. This observation can be confirmed by our own experience.

Several of our own patients with a history of boxing have presented with a combination of anterior internal impingement (SSC rupture), increased a.p. translation and PASTA/ Pulley lesions. Similar lesions have been found in patients with shoulder pain doing overhead sports and have been gathered under the term AIOS (acquired instability in the overstressed shoulder)(28). In theory, chronic microtraumata lead to structural damage of the shoulder joint, in turn leading to chronic instability even without any traumatic shoulder dislocations having occurred. While overhead athletes are known to have a high prevalence of shoulder pain which has been partly attributed to the pathomechanisms mentioned, and has been thoroughly studied in the last few years, there are only few studies investigating possible mechanisms for shoulder pain in contact sports athletes.

Limitations:

Considering our lack of human resources, with one researcher conducting the literature search and another one checking the results, potential misses of relevant literature are a main limitation of this study. Also, the adaptations we made in some of the research tools might have individualized our procedure, therefore making it less “systematic”. However, rather than analyzing randomized controlled trials, for which many instruments exist, it seemed most reasonable to use observational literature for our objectives. Given the huge variability within included studies, adapting the existing instruments to be able to analyze, compare and rate the existing literature seemed to be a necessary compromise.

Because up to date no studies investigating the long-term effects of boxing on the shoulder joint could be identified, the question whether there is a proclaimed “boxing shoulder” could not be answered sufficiently. Further research, ideally high quality prospective longitudinal studies, will be needed to investigate this in detail.

Declarations

- # Ethics approval and consent to participate:

Not applicable

- # Consent for publication:

Not applicable

- # Availability of data and materials:

All data generated or analysed during this study are included in this published article [and its supplementary information files]

- # Competing interests:

The authors declare that they have no competing interests.

- ## Funding:

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- ## Authors' contributions:

CZ performed the literature research and data analysis and wrote the manuscript. RMK checked the extracted data and supervised the manuscript drafting process. IS performed the statistical analyses and prepared the figures. RB and RF proofread the manuscript. All authors read and approved the final manuscript.

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Not applicable

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Figures

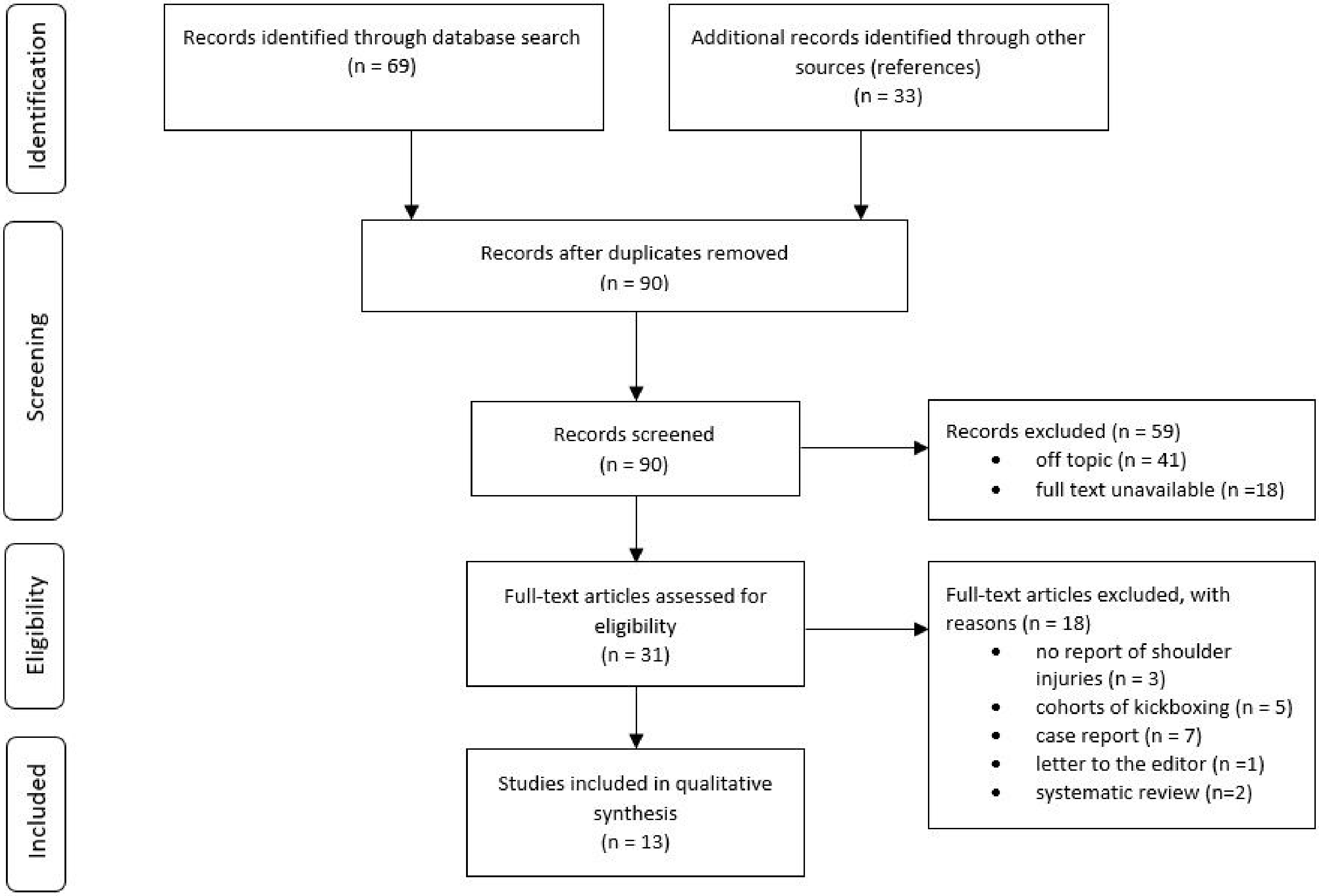

Figure 1

Flowchart study selection process

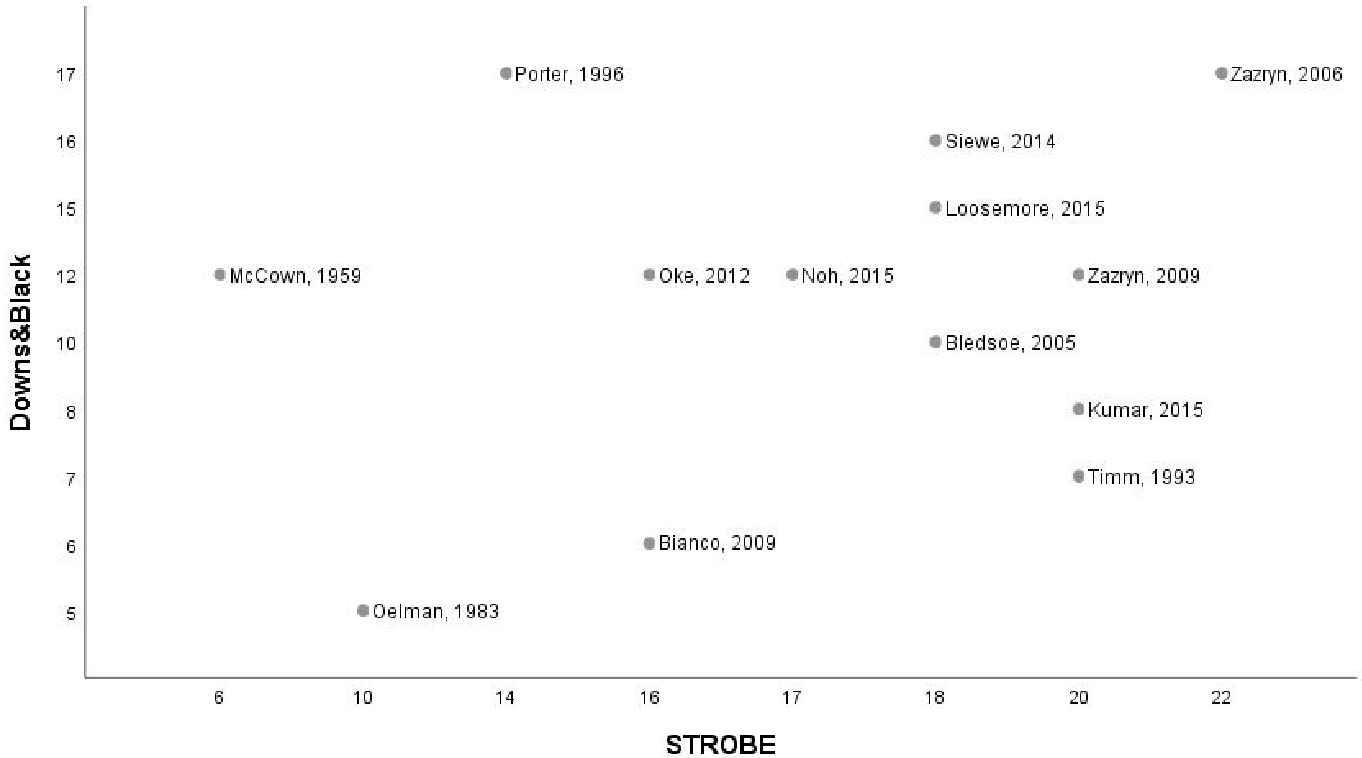

Figure 2

Scatter plot of STROBE quality assessment scores and Downs&Black's risk of bias scores

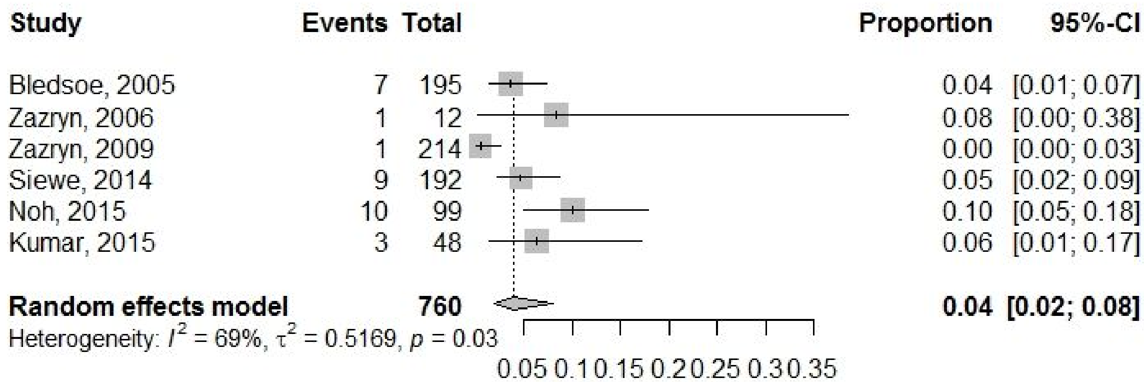

Figure 3

Shoulder injuries in proportion to all detected injuries in professional cohorts. The figure shows the proportion of shoulder injuries with 95% exact confidence intervals (Clopper-Pearson-Confidence intervals) as well as an estimate of the proportion of shoulder injuries for all studies also with 95% confidence intervall based on a random effects model.

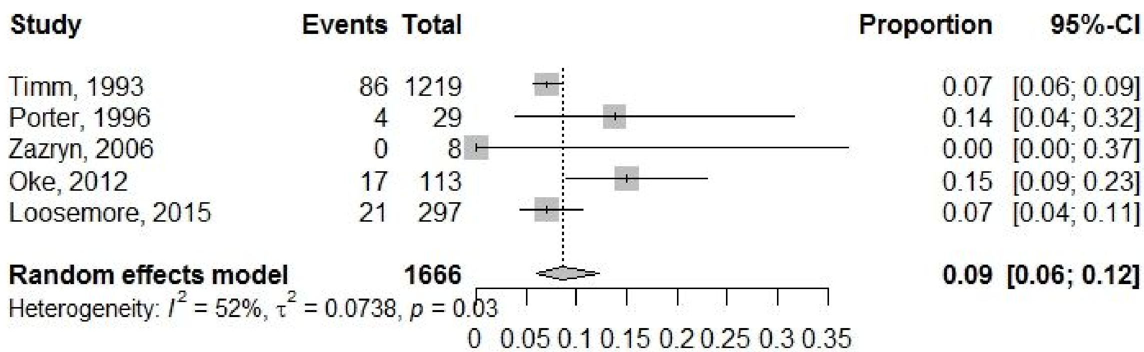

Figure 4

Shoulder injuries in proportion to all detected injuries in amateur cohorts. The figure shows the proportion of shoulder injuries with 95% exact confidence intervals (Clopper-Pearson-Confidence intervals) as well as an estimate of the proportion proportion of shoulder injuries for all studies also with 95% confidence intervall based on a random effects model.

Supplementary Files

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- Appendices.docx