

Standardized Post-Bout Ringside Concussion Screening in Combat Sports: Systematic Evidence Review and Development of the RACE1 Ringside Acute Concussion Examination

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Instrument. The RACE1 Ringside Acute Concussion Examination card deck (edition 4) is shown in Figure 10 and reproduced in full in Appendix C for evaluation and comment. The RACE1 cards are intended to give the ringside clinician structured guidance after the bout. They do not supersede the authority, clinical judgment or decisions of the ringside physician or any other licensed ringside clinician, and they do not replace the rules or medical requirements of the governing body. The deck has not been validated and is not a clearance tool.

Scope and disclaimer. The analysis and conclusions are those of the author and do not represent the Alabama Athletic Commission as a whole. Rule text is quoted with source and currency information; current text should be confirmed before formal reliance.

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Standardized Post-Bout Ringside Concussion Screening in Combat Sports: Systematic Evidence Review and Development of the RACE1 Ringside Acute Concussion Examination

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Abstract

Context: The objective was a standardized post-bout ringside concussion protocol for combat sports regardless of rule set: professional boxing, mixed martial arts (MMA), bare-knuckle boxing, kickboxing, Toughman contests, amateur MMA and amateur boxing. Amateur boxing was the model for its stricter rules (mandatory post-bout examination, Sport Concussion Assessment Tool after a knockout or head-blow stoppage, tiered restrictions).

Evidence Acquisition: PubMed/MEDLINE, Consensus, Scholar Gateway, Wiley Scholar Gateway, SciSpace, alphaXiv and ClinicalTrials.gov were searched on September 30, 2026, without limits, plus citation searching. One reviewer screened and extracted; the author verified a 10% sample. Synthesis followed the Synthesis Without Meta-analysis guideline.

Study Design: Clinical review (systematic search with synthesis without meta-analysis) and instrument description.

Level of Evidence: Level 3.

Results: Of 2,250 records, 2,063 were screened and 214 core records were included (53 amateur); 137 rested on the abstract. Of 33 primary studies judged on full text, 16 were at high risk of bias. No amateur study measured the accuracy or reliability of any ringside item; nothing was pooled. Diagnosed concussion was recorded infrequently with incompatible denominators, stoppage could not substitute for diagnosis, and an abstract reported evolving cognitive slowing after 2 of 160 bouts in boxers not suspected at ringside. In other sports, single components were mostly specific, with limited sensitivity. Amateur evidence for every screening item was SORT Level 3. RACE1 is an 18-card post-bout screen, compared with a pre-bout baseline where possible, scored out of 20, with 3 provisional dispositions.

Conclusions: A multidomain post-bout screen can standardize ringside findings, but a normal screen cannot exclude concussion. RACE1 is used only after the bout and never clears an athlete or permits same-day return. Evidence is mainly from amateur boxing; RACE1 has not been evaluated in any sport.

Strength-of-Recommendation Taxonomy (SORT): After the bout, any sign, symptom or examination deficit precludes a "no deficit detected" result; absence of signs does not exclude concussion (B). Use brief items from several domains, never one domain alone (B). Transport any boxer with a red flag to a pre-identified trauma center with computed tomography and neurosurgical cover (C). A normal screen is not clearance (C).

Keywords: boxing; concussion; sideline assessment; combat sports; ringside physician; mixed martial arts

1. Introduction

Concussion in amateur and Olympic-style boxing has to be recognized at ringside, within minutes of a knockout (KO), a referee stoppage or the final bell, by a physician who often cannot rely on the overt signs that make recognition easier in other settings. Loss of consciousness accompanies only about 10% of sport-related concussions,⁵⁰ and in a systematic review of team sports

most individual observable signs had sensitivity below 50%.¹⁰⁸ The 5th international consensus statement noted that most sport-related concussions occur without LOC or frank neurological signs.⁷⁸ Self-report is an unreliable safeguard: about 21% of professional boxers and mixed martial arts (MMA) fighters in one survey said they had concealed head-injury symptoms from medical providers,⁸ and the American Medical Society for Sports Medicine (AMSSM) estimated in its abstract that as many as 50% of concussions go unreported.⁵⁰ Amateur data point the same way. In an amateur tournament in which every boxer was screened clinically by a ringside physician, an abstract reported evolving cognitive slowing typical of concussion after 2 bouts (1.3% of 160 bouts) in boxers who had not been suspected of concussion.⁸¹

The ringside examination is also confounded by the injuries of the sport. Laceration or abrasion made up 41.1% of injuries at 3 Olympic Games,⁷³ epistaxis occurred in 68 of 1,446 Brazilian amateur bouts,⁷ and the Association of Ringside Physicians (ARP) noted that eye injuries alone can produce diplopia, photophobia, reduced acuity and pupil changes,⁵⁷ all of which overlap with concussion findings. Exertion degrades balance scores for about 20 minutes in other sports,⁶ and a boxer examined immediately after the final bell is maximally exerted.

Existing tools do not fit this setting well. The Sport Concussion Assessment Tool 6 (SCAT6) is the reference multimodal sideline instrument, but it requires at least 10 to 15 minutes, its Maddocks questions are team-sport items (venue, half, last scorer), and its authors state that it should not be used by itself to make or exclude the diagnosis.^{35,91} The Concussion Recognition Tool 6 (CRT6) is designed for lay recognition, and its developers acknowledged little systematic research on the utility of the CRT tools.³³ Amateur federation rules require post-bout examinations and contain bout-specific orientation questions, but they specify no brief standardized screen to be applied to every boxer after every bout.^{112,115} The ARP consensus called for evaluating winners as well as losers and repeating the evaluation in a quieter setting,⁸⁵ which presupposes a structured examination that can be repeated and compared.

The objective of this work was to create a standardized post-bout ringside concussion protocol for combat sports regardless of the rule set, that is, for professional boxing, MMA, bare-knuckle boxing, kickboxing, Toughman contests, amateur MMA and amateur boxing. The author chose amateur boxing as the model because its concussion rules and medical requirements are more stringent. World Boxing requires a post-bout examination of all boxers and the latest SCAT after a KO or a stoppage for head blows,¹¹⁵ and USA Boxing requires post-bout examinations and tiers its minimum restrictions by the presence and duration of loss of consciousness.^{112,113} The review examined, component by component, the published evidence for the content, sequence and decision rules of a standardized post-bout ringside screen for suspected concussion. Its core evidence is amateur and Olympic-style boxing, with professional boxing and other combat sports retained as context. This article also describes the resulting instrument, the RACE1 Ringside Acute Concussion Examination, an 18-card deck reconciled against that evidence. RACE1 records standardized findings to assist the ringside physician; it does not diagnose or exclude concussion and never clears an athlete. It is used only after the bout has ended, against a pre-bout baseline of the same items where possible. It is not calibrated for use while a bout or any active combat is in progress, is never used between rounds, and is never used to determine return to participation the same day or during active competition. Whether to stop a bout remains the ringside physician's in-competition decision, made under the governing body's rules and separate from RACE1. RACE1 has not been evaluated in any sport. This preprint is released to seek co-authors and initial peer review, so that the evidence, the instrument and the methods can be examined before validation studies begin.

2. Methods

2.1 Protocol and Registration

The review was not registered. The question, eligibility criteria, components and analysis plan were fixed in a written protocol before searching, and every subsequent step was documented in dated records: a search log, screening log, extraction log and workbook, pooling feasibility report, retrieval report, evidence synthesis, project review report and an author decision record of 23 decisions (Supplementary Files S1 to S6). Departures from the planned protocol are listed in Table 10. Reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement for the search, selection, risk-of-bias and synthesis items and the SWiM guideline for the synthesis.

The review question was: in amateur and Olympic-style boxing, what published evidence informs the content, sequence and decision rules of a standardized ringside screen for suspected concussion? Evidence was mapped to 9 components that

correspond to the RACE1 cards and were kept separate throughout: 0, background and incidence (all cards); 1, observable signs and red flags (Cards 2 and 3); 2, orientation and memory (Cards 4B, 6, 7 and 15); 3, oculomotor and pupil findings (Cards 8 and 9); 4, motor and balance (Cards 10 to 14); 5, speech and comprehension (Cards 16 and 17); 6, symptom self-report and its limits (Card 4C); 7, confounding injuries and factors (Card 5); and 8, disposition and return to participation (Card 18).

2.2 Eligibility Criteria

The population was amateur and Olympic-style boxers, including youth, junior, novice, collegiate, national and elite boxers, evaluated at ringside after a knockdown, a stoppage, the end of a bout, or at the request of the referee or ringside physician. Records were classed at screening as IA (amateur or Olympic-style boxing specific), IB (professional boxing or another combat sport, retained as context), IG (consensus statement, position statement, guideline or governing-body rule document), IR (systematic or scoping review or meta-analysis) or IC (other-sport, military or clinical evidence bearing on a single screening component, retained as a context set). Classes IA, IB, IG and IR and eligible registry records formed the core evidence set. The IC context set was not synthesized as a class; individual IC or other-sport findings were drawn on only where a component lacked boxing evidence, and never in place of an amateur finding.

Eligible outcomes were diagnosed concussion or traumatic brain injury, acute neurological or neurocognitive findings after a bout or sparring, observable signs and red flags, symptom reports, KO and referee stoppage for head blows (RSC-H) or other stoppages, laceration, fracture and other confounding injuries, and stated stoppage, suspension, referral and return rules. These outcome families were never combined into one estimate, and stoppage was never treated as a surrogate for diagnosed concussion. Any study design was eligible, including case reports for red-flag and confounding-injury components. Exclusion codes at title and abstract were: E1, not concussion or acute head-injury assessment; E2, boxing as exercise therapy; E3, chronic outcomes only; E4, imaging, fluid biomarkers, neurophysiology or device-only measures not usable at ringside; E5, biomechanics or equipment engineering; E6, treatment, rehabilitation or subacute management beyond 72 hours; E7, non-sport population without a sideline-applicable tool; E8, animal or in vitro; E9, editorial, letter, commentary or conference abstract without data; E10, not English; E11, injury epidemiology without concussion recognition or assessment content; E12, general narrative review or textbook chapter; and E13, knowledge, attitude or reporting-intention study without assessment content. Full-text codes were FT1 to FT6 (no acute content; duplicate or superseded; no data; not retrievable with an insufficient abstract; out of scope; non-English full text).

2.3 Information Sources and Search Strategy

All searches were run on September 30, 2026, without date, language, species or article-type limits (Table 1). PubMed/MEDLINE was searched with 13 field-tagged Boolean topic queries (PM-1 to PM-12 and PM-8b) and 17 digital object identifier (DOI) look-up runs; a broad balance query (PM-8, 897 records) was run, judged too broad, not screened and replaced by PM-8b before screening. Consensus was searched with 12 natural-language queries (top 20 records each); Scholar Gateway and Wiley Scholar Gateway, which search the same Wiley Online Library full-text corpus, with 13 queries (20 passages each); SciSpace with 9 queries (10 records each); ClinicalTrials.gov with 2 queries; and alphaXiv with 2 queries, retained as context only because it indexes non-biomedical arXiv content. The medRxiv and bioRxiv search interface permits only date- and category-bounded listings, so preprint servers were effectively unsearched; 60 listed records were checked by title and none was relevant. The first 4 PubMed queries and the first 3 Consensus queries reproduced an earlier version of the search exactly. Every unique DOI from the semantic search platforms (311) was looked up in PubMed: 244 were PubMed-indexed, of which 111 had not been retrieved by the PubMed topic queries and were added to screening, and 67 were not indexed. The exact query strings, parameters and counts are given in Appendix A.

Other methods were backward citation searching of the included boxing studies, the combat-sport consensus statement and key reviews (47 new cited works); targeted searches at the analysis stage to test pooling feasibility (18 records); and retrieval of guideline, rule and society documents from publisher, repository and society sites, including the USA Boxing National Rule Book (effective January 1, 2025), the USA Boxing Medical Handbook for Ringside Physicians (revised May 15, 2026), the World Boxing Medical Handbook 2025 and the National Institute for Health and Care Excellence (NICE) head-injury guideline NG232.

2.4 Selection Process

PubMed metadata were retrieved for all 1,958 PubMed-indexed records; 2 records returned no metadata on repeated calls and were removed. Records from the semantic search platforms were de-duplicated by DOI or normalized title, merged with PubMed records where their DOI resolved to a retrieved PMID (133), and compared with the PubMed set by title (6 further duplicates); 1 arXiv record duplicated a Consensus record. Screening was performed by a single reviewer working to the written criteria, on title and then on abstract for uncertain records (243 PubMed records were carried to abstract review). No automation tool was used to exclude records. For the core set, full text was requested through PubMed Central for every record with a PubMed Central identifier, each retrieved text was read against a written protocol, and a single rule was applied: a record whose full text or abstract confirmed the component content tagged at screening was retained, with abstract-only status recorded where only the abstract was available; a record with neither text nor abstract was a report not retrieved; and exclusion at full text required a code. After full-text retrieval, 6 records excluded at first screening were re-screened (5 entered the core set as IA and 1 as IB), and the reports obtained were added.

Screening and data extraction were performed by a single reviewer, with author verification of a random 10% sample of screening decisions (206 of 2,063; 10.0%), all 53 included amateur records and 20 extraction rows, using a verification workbook; this verification was completed on October 1, 2026. The review therefore reports single-reviewer screening and extraction with sample verification by the author, and it did not use independent duplicate review.

2.5 Data Collection and Data Items

Each core record was extracted into a workbook with prespecified fields: study identifier, citation, DOI, PMID, country, competitive level, sex, age, design, sample size, exposure definition, comparator, outcome definition, exposure denominator, event counts, effect estimates with 95% confidence intervals (CIs), adjustment variables, funding and notes. Every number was recorded with its location in the source (section, paragraph, table) and its text basis (full text, partial text, abstract, secondary source or registry); "not reported" was entered where a value was absent. The initial extraction logged 1,310 numbers and 972 component findings from 192 records; the 95 texts obtained during full-text retrieval were then re-extracted and compared field by field with the initial extraction. Numbers available only from a secondary source were labelled as secondary and attributed to the reporting review, and findings available only from an abstract were labelled so that they could be worded "as reported". An overlap register identified 11 dataset families (for example, the Great Britain squad, Italian female boxing, the US Olympic Training Center and the Moriarity tournaments) so that each population contributed once to any count.

2.6 Full-Text Retrieval

Because many amateur studies were available only as abstracts after screening, full-text retrieval was carried out from September 30 to October 1, 2026. Its 103 targets comprised the reports not retrieved at screening, the 44 priority 1 and 2 records of the extraction workbook, the full texts listed by the pooling feasibility report and the regulatory documents, grouped into 6 clusters by host. Each target was worked through a fixed sequence of 9 routes: (R1) PubMed metadata; (R2) PubMed Central text; (R3) the OpenAlex index for open repository copies; (R4) SciSpace-hosted copies; (R5) the publisher page; (R6) PubMed Central scanned PDFs; (R7) web searches for author, repository, thesis or society copies; (R8) secondary sources that reproduce the primary data, labelled as such; and (R9) passage retrieval through the Consensus and Scholar Gateway search interfaces. Requests to the same host were spaced by at least 60 seconds (120 to 150 seconds for BMJ and PubMed Central hosts), unlicensed copies were not used, and all 550 requests were logged.

Access was constrained throughout. BMJ journal hosts refused programmatic requests (HTTP 429) on both days, including retries hours apart; PubMed Central returned a reCAPTCHA page for every scanned PDF tested; several publishers returned paywall or access-denied pages; and direct file downloads were blocked by the network allowlist of the analysis environment. The web retrieval utility used for web pages returned a text extraction of the page rather than a byte copy, so numbers taken from it carry their location and are flagged for checking against the source PDF; rule and guideline passages that it returned paraphrased (for example, NICE NG232 recommendations 1.2.2 and 1.2.3 and parts of the World Boxing handbook) are not quoted. Retrieval obtained full text for 20 targets, partial text for 9, secondary sources only for 14 and abstracts only for 47, and 13 were not retrieved.

2.7 Risk of Bias in Individual Studies

Risk-of-bias tools were matched to design: the Risk Of Bias In Non-randomized Studies of Exposures (ROBINS-E) tool for nonrandomized exposure comparisons, the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) for screening-test and diagnostic studies, and Joanna Briggs Institute (JBI) checklists for analytical cross-sectional, surveillance and video-analysis studies, case series and case reports. Judgments were made only on full or partial texts; primary studies available only as an abstract or a secondary source were recorded as not assessable. Consensus statements, guidelines, rule documents, reviews and registry records were used for content and cross-checking and were not appraised with a tool. Primary studies read in full during the pooling feasibility work were judged in a second round after full-text retrieval.

2.8 Effect Measures

No comparative effect measure was pooled. Single-study incidence figures were expressed as events per 1,000 units of the study's own denominator (registered boxers, boxers, post-competition checks, bouts or competition hours) with exact 95% CIs: Clopper-Pearson intervals for proportions and an exact Poisson interval for the one rate per competition hour. Where a printed figure did not match its stated numerator and denominator, the reviewer arithmetic and the printed figure are both shown. For acute post-exposure change after a bout, tournament or sparring session, the effect measure was the direction of change reported by the authors (deterioration, no change, improvement or mixed), summarized by vote counting by direction of effect.

2.9 Synthesis Methods

Synthesis followed the SWiM reporting items. (1) Grouping: studies were grouped by the 9 components and, within each, by class (IA, IG, IR, IB), with amateur evidence presented first. (2) Standardized metric: events per 1,000 units with exact CIs for incidence; direction of effect for acute change. (3) Synthesis method: narrative synthesis with vote counting by direction of effect, never as a pooled effect. (4) Heterogeneity: sources of variation (level, sex, age, headgear era, exposure type, timing of assessment, comparator, instrument and outcome definition) were described narratively; no statistical heterogeneity was estimated. (5) Certainty: graded with SORT (section 2.12). (6) Priority: amateur studies first, with risk-of-bias judgments cited where the study was read in full and abstract-only status stated. (7) Verification: each component was written from the extraction data and then checked number by number against the same data in a separate verification round; 35 statements were corrected in the first round, and after full-text retrieval 611 new or changed statements were checked and 13 corrected. (8) Software: the exact intervals were computed in Python 3 with SciPy. An equivalent base R script (`binom.test` and `poisson.test`) and its input file reproduce the same intervals; R could not be installed in the analysis environment because its package repositories were blocked by a network allowlist, so the author runs the R reproduction separately. (9) Version control: every correction prompted by the new texts was recorded in the component flags of the synthesis.

2.10 Reasons Pooling Was Not Performed

The prespecified rule was to pool only when 2 or more amateur studies proved comparable in exposure, comparator, outcome definition and denominator after full-text verification. A pooling feasibility search examined 59 candidate studies, read 22 in full and logged 375 values; no qualifying set was found, and 3 conditional sets were named. After full-text retrieval, each was re-examined. Olympic Games concussion per registered boxer did not qualify: the Rio 2016 report, read in full, recorded 7 of the 12 Games concussions in boxing but did not print the number of registered boxers,¹⁰³ the London 2012 boxing count was inferred from a by-sport listing rather than printed,³⁹ and the Tokyo 2020 and Buenos Aires 2018 boxing concussion counts could not be read, leaving Beijing 2008 as the only Games with both numerator and denominator.⁶² Head-blow stoppage per bout did not qualify, because the candidate studies used different denominators (participants, bouts, rounds) and were reached only through abstracts or secondary tables. Acute pre/post neurocognitive change after sparring did not qualify, because both candidate studies remained abstract-only.^{30,106} A fourth set identified during full-text retrieval, the share of injuries that were concussions, was not prespecified, used injuries rather than exposure as the denominator, and had only 1 study verified on full text; it was not pooled. Pooling was therefore not performed, and subgroup analyses, sensitivity analyses, funnel plots and Egger tests were not applicable.

2.11 Reporting Bias Assessment

Reporting bias across studies was not assessed formally because no pooled estimate was produced and funnel-plot methods were not applicable. Two forms of selective availability are nevertheless described in the Results and Limitations: the large share

of core records available only as abstracts, which limited the outcomes that could be extracted, and the dependence of some figures on secondary sources whose own errors were identified (Appendix B).

2.12 Certainty Assessment

Certainty was graded with the SORT level-of-evidence scale, applied separately to the amateur evidence and to the overall body of evidence for each component: Level 1, good-quality patient-oriented evidence; Level 2, limited-quality patient-oriented evidence; and Level 3, consensus, usual practice, opinion, disease-oriented evidence or case series. Draft recommendations carry SORT strengths: A, consistent and good-quality patient-oriented evidence; B, inconsistent or limited-quality patient-oriented evidence; and C, consensus, usual practice, opinion, disease-oriented evidence or case series. Where recommendations were merged, the merged statement took the lowest strength of its parts. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was not applied, because the article format adopted for this review specifies SORT and because GRADE rates certainty in pooled or comparative effect estimates for defined outcomes, none of which this review could produce.

2.13 Instrument Reconciliation Methods

The instrument under study is the 18-card RACE1 deck designed by the author (source file dated January 28, 2026, originally titled "CTE Rapid Exam"). It was reconciled in 3 documented stages. First, an internal consistency review (September 30, 2026) compared every card with every other card and corrected 21 inconsistencies, sequencing errors, undefined scoring rules and unsupported statements, each recorded with its source card, change and reason, producing edition 2. Second, the evidence synthesis identified points at which the edition 2 deck and the evidence diverged; the author decided each point, and the decisions were applied with the supporting evidence named for each change, producing edition 3. Third, the author restricted use to post-bout screening against a pre-bout baseline, and the resulting changes were logged, producing edition 4, which this article describes. No pilot data were collected, and no item, cut-off or disposition was altered on the basis of performance data, because none exist.

3. Results

3.1 Study Selection

The searches identified 2,250 records: 2,227 from databases (PubMed/MEDLINE 1,847; Consensus 192; Scholar Gateway and Wiley Scholar Gateway 91; SciSpace 83; alphaXiv 14) and 23 from ClinicalTrials.gov (Figure 1; Table 2). After removal of 185 duplicates and 2 records without metadata, 2,063 records were screened and 1,477 were excluded at title and abstract, most often for content other than concussion or acute head-injury assessment (E1, 415), treatment or subacute management (E6, 205) and measures not usable at ringside (E4, 174). Of the 586 records eligible at title and abstract, 382 formed the other-sport and military context set and 204 core reports were sought. Sixteen could not be retrieved on any route; all were title-only records without an abstract, most of them historical case reports from 1947 to 1980 (Appendix B). The remaining 188 were assessed and none was excluded at full text. Citation searching added 16 core records and 1 context record, and the targeted searches at the analysis stage identified 18 records, of which 10 were included, 7 excluded and 1 (a 2020 study of boxers' health care after headgear abolition) was left awaiting classification because its full text could not be obtained and its abstract did not settle eligibility. The core evidence set comprised 214 records: 53 amateur and Olympic-style boxing records (IA), 95 professional or other combat-sport records (IB), 16 consensus statements, guidelines or rule documents (IG) and 50 systematic or scoping reviews (IR). The context set comprised 383 records.

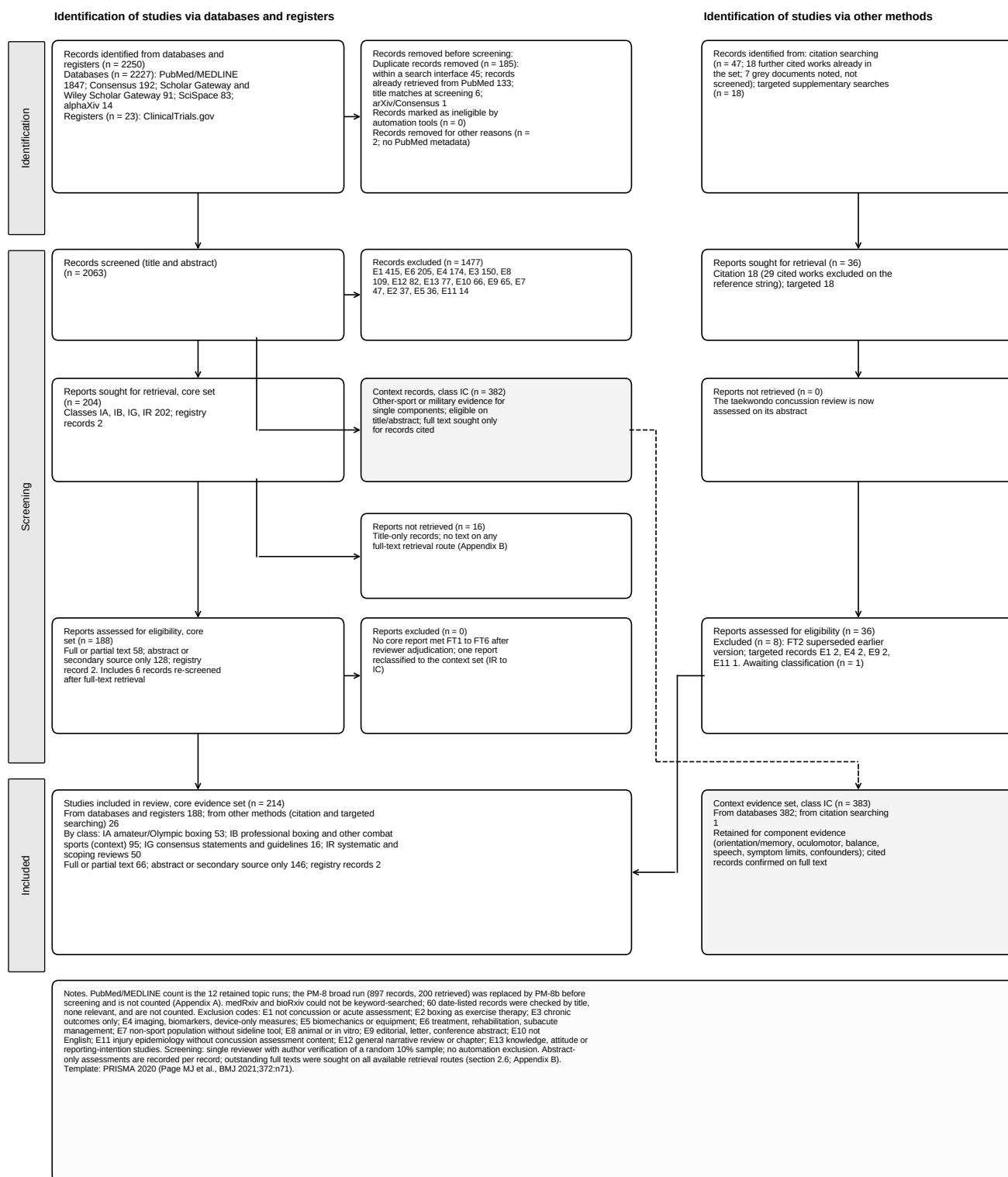


Figure 1. PRISMA 2020 flow diagram for the review. Left column, identification via databases and registers: records identified from databases (n = 2,227: PubMed/MEDLINE 1,847; Consensus 192; Scholar Gateway and Wiley Scholar Gateway 91; SciSpace 83; alphaXiv 14) and from the ClinicalTrials.gov register (n = 23); records removed before screening (185 duplicates, of which 45 within search platforms, 133 records from other platforms already retrieved from PubMed, 6 title matches at screening and 1 arXiv record duplicating a Consensus record; 2 records without PubMed metadata; 0 marked ineligible by automation tools); records screened (n = 2,063); records excluded at title and abstract (n = 1,477, by code); context records (class IC, n = 382),

eligible on title and abstract, with full text sought only for records cited; core reports sought (n = 204, including 2 registry records); reports not retrieved (n = 16); reports assessed (n = 188, of which 58 in full or partial text, 128 on the abstract or a secondary source and 2 as registry records); reports excluded (n = 0). Right column, identification via other methods: citation searching (47 new cited works; 18 sought) and targeted searches at the analysis stage (18); reports assessed (n = 36), excluded (n = 8: 1 superseded version among cited works; 7 targeted records with codes E1, E4, E9 and E11) and awaiting classification (n = 1). Included: core evidence set (n = 214; 188 from databases and registers and 26 from other methods; IA 53, IB 95, IG 16, IR 50; 66 read in full or partial text, 146 on the abstract or a secondary source only, 2 registry records) and context set (n = 383; 382 from databases, 1 from citation searching). The PM-8 broad PubMed query was replaced by PM-8b before screening and is not counted; medRxiv and bioRxiv could not be keyword-searched, and 60 date-listed records checked by title were not counted. Abbreviations: IA, amateur and Olympic-style boxing; IB, professional boxing and other combat sports (context); IC, other-sport or military context evidence; IG, consensus statements, guidelines and rules; IR, systematic and scoping reviews; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Template: PRISMA 2020.

3.2 Characteristics of the Evidence

The core records spanned the 1940s to 2026, but most were recent: 41 were published in the 2000s, 69 in the 2010s and 79 in the 2020s, against 25 before 2000 (Figure 2). Consensus statements, guidelines and reviews appeared almost entirely from the 2000s onward and made up a large share of the records from the 2010s and 2020s, whereas the amateur primary literature was spread across the 1960s to the 2020s.

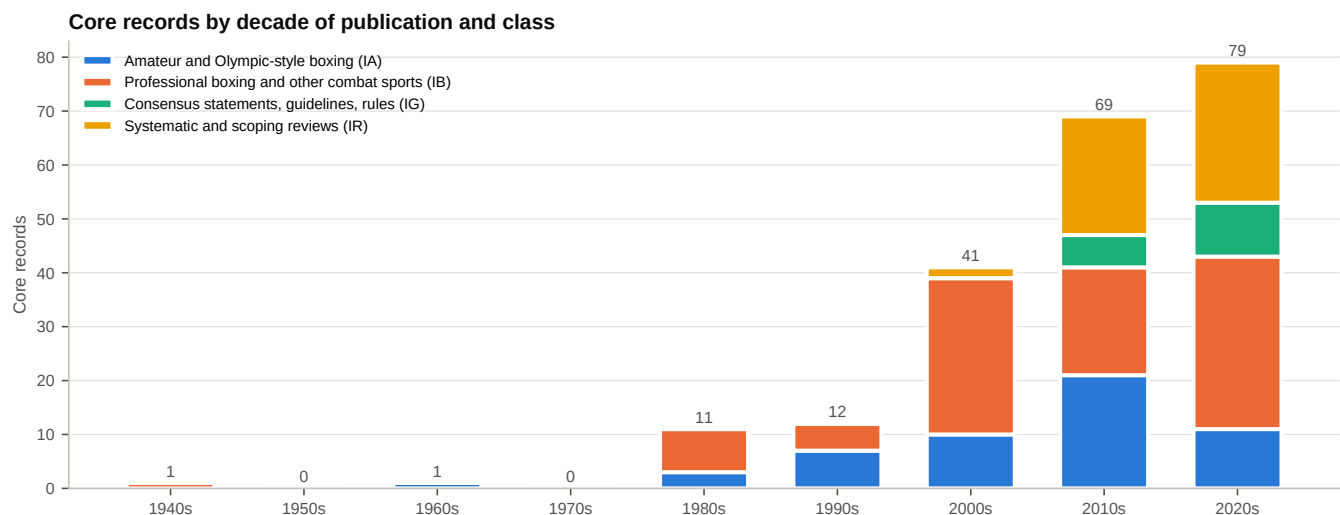


Figure 2. Core records by decade of publication and class (n = 214). Stacked bars show the number of core records published in each decade, divided into amateur and Olympic-style boxing (IA), professional boxing and other combat sports (IB), consensus statements, guidelines and rules (IG) and systematic and scoping reviews (IR); totals are printed above each bar (1940s, 1; 1950s, 0; 1960s, 1; 1970s, 0; 1980s, 11; 1990s, 12; 2000s, 41; 2010s, 69; 2020s, 79). Data source: screening and extraction workbooks (Supplementary Files S2 and S3). Publication year is the year of the cited version; some records have epub and print years that differ.

The distribution of evidence across the RACE1 components was uneven (Figure 3). Background and incidence (component 0) and disposition (component 8) drew more on professional and other combat-sport records than on any other class; the components that bear directly on screening items rested on a handful of amateur records each; and speech and comprehension (component 5) was the thinnest component, with a single amateur study, a single consensus source and a single review tagged at extraction. In the initial extraction, 972 findings were mapped to components (component 0, 257; 1, 103; 2, 72; 3, 77; 4, 76; 5, 3; 6, 119; 7, 114; 8, 151).

Core records contributing findings, by RACE1 evidence component and class

0 Background and incidence	37	53	7	22
1 Observable signs and red flags (Cards 2, 3)	12	39	13	14
2 Orientation and memory (Cards 4B, 6, 7, 15)	15	11	11	19
3 Pupils and eye movements (Cards 8, 9)	5	8	9	22
4 Motor and balance (Cards 10-14)	9	4	11	23
5 Speech and comprehension (Cards 16, 17)	1	0	1	1
6 Symptom self-report (Card 4C)	8	24	9	24
7 Confounding injuries (Card 5)	19	35	12	12
8 Disposition (Card 18)	12	53	15	20
	IA amateur boxing	IB professional and other combat sports	IG consensus, guidelines, rules	IR reviews

A record can contribute to more than one component. Counts from data extraction of the 214 core records.

Figure 3. Evidence map: core records contributing findings to each RACE1 evidence component, by class. Rows are the 9 components (0, background and incidence; 1, observable signs and red flags, Cards 2 and 3; 2, orientation and memory, Cards 4B, 6, 7 and 15; 3, pupils and eye movements, Cards 8 and 9; 4, motor and balance, Cards 10 to 14; 5, speech and comprehension, Cards 16 and 17; 6, symptom self-report, Card 4C; 7, confounding injuries, Card 5; 8, disposition, Card 18); columns are the 4 core classes (IA, IB, IG, IR). Cell numbers are counts of records, and shading increases with the count. A record can contribute to more than one component, so columns do not sum to the class totals. Data source: component tags from the initial extraction and the re-extraction after full-text retrieval (Supplementary File S3). Counts are of records tagged to a component, not of records that supplied usable data; the evidence tables of the synthesis use a wider set of records for some components (for example, consensus documents read during full-text retrieval). Abbreviations as in Figure 1.

Text basis was the main constraint on depth (Figure 4). Of the 214 core records, 60 were read in full text and 6 in part, 9 only through secondary sources, 137 on the abstract alone and 2 as registry entries. For amateur records the split was 20 full text, 3 partial text, 8 secondary source only, 20 abstract only and 2 registry; for professional and other combat-sport records, 79 of 95 rested on the abstract. Most consensus and guideline documents (13 of 16) were read in full, because full-text retrieval targeted them.

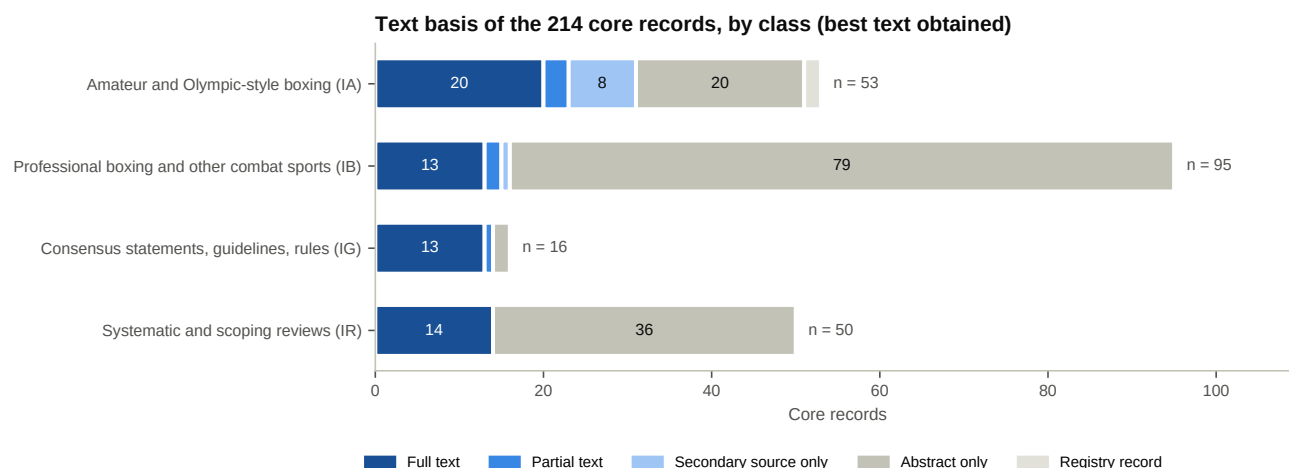


Figure 4. Text basis of the 214 core records, by class (best text obtained after full-text retrieval). Horizontal stacked bars show, for each class, the number of records read in full text, in partial text, through a secondary source only, on the abstract only, or as a registry record; class totals are printed at the right (IA 53, IB 95, IG 16, IR 50). All classes: full text 60; partial text 6; secondary source only 9; abstract only 137; registry 2. "Secondary source only" means that the primary report was not reached and its data were taken from a review or other document that reproduces them; such figures are attributed to the reporting source in the text. Data source: Supplementary File S2. Abbreviations as in Figure 1.

3.3 Risk of Bias in Included Studies

Of the 116 primary studies in the core set, 33 were judged on full or partial text and 83 were not assessable because only an abstract or a secondary source was available (Figure 5A; Table 3). Of the 33, 16 were at high risk of bias, 9 at moderate risk (JBI), 4 at some concerns (ROBINS-E), 2 at low risk and 2 unclear. The high judgments arose mainly from unadjusted confounding (for example, baseline differences between boxers and controls on 8 of 12 tests in one controlled cohort¹⁷) and from period comparisons across rule changes that were ecological.^{10,27} The 3 screening-test studies were limited by patient selection and by the absence of a reference standard: one amateur saccadometry study had a single concussed boxer among 12,⁹² and the MMA King-Devick cohort used volunteers recruited at pre-fight physicals.¹¹⁰ Surveillance studies were limited by outcome definitions (for example, KO counted as cerebral concussion⁷) and, in self-report surveys, by unverified exposure and outcome measurement.^{2,65} The 2 low-risk judgments were a video analysis of professional slap fighting¹⁰⁵ and a kickboxing case report read in part,⁷⁴ neither of which concerns amateur boxing. Risk of bias was assessable for only a minority of the amateur studies that contribute to the screening components, and none of the amateur studies central to the direction-of-effect analysis that remained abstract-only could be judged.



Figure 5. Risk-of-bias summary. Panel A: primary studies in the core set (n = 116) by assigned tool and by whether they could be assessed on full text (ROBINS-E, 10 assessed and 12 not assessable; QUADAS-2, 3 and 8; JBI analytical cross-sectional, 19 and 43; JBI case series, 0 and 5; JBI case report, 1 and 15). Panels B to E: domain-level and overall judgments for the 33 studies assessed (B, ROBINS-E, 10 studies; C, QUADAS-2, 3 studies, including applicability; D, JBI analytical cross-sectional checklist, 19 studies; E, JBI case report checklist, 1 study). Letters carry each judgment so that color is not the only cue: L, low risk; S, some concerns (ROBINS-E) or moderate risk (JBI overall); H, high risk; U, unclear; Y, yes; N, no; ?, no information; dash, not applicable. Abstract-only primary studies (n = 83) were recorded as not assessable and are not shown in Panels B to E. Consensus statements, guidelines, rules, reviews and registry records were not appraised with a tool. Data source: extraction workbook and risk-of-bias judgments (Supplementary Files S3 and S4). Abbreviations: JBI, Joanna Briggs Institute; QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies 2; ROBINS-E, Risk Of Bias In Non-randomized Studies of Exposures.

3.4 Certainty of Evidence

No component reached SORT Level 1, and no level changed after full-text retrieval (Figure 6; Table 4). The amateur evidence reached Level 2 only for background incidence, on the strength of International Olympic Committee (IOC) prospective surveillance; for every screening component it was Level 3, because the amateur outcomes were disease-oriented test scores, stoppage counts or case material and no amateur study measured accuracy against a reference standard. The overall body of evidence reached Level 2 for observable signs, orientation and memory, oculomotor items, motor and balance items and symptom report, but these grades rest on systematic reviews of diagnostic accuracy and measurement properties in other sports, which are indirect for live ringside use in amateur boxing. Speech and comprehension, confounding injuries and disposition remained Level 3 overall. The 26 draft recommendations comprised 6 graded SORT B (one with a separately graded SORT C clause) and 20 graded SORT C.

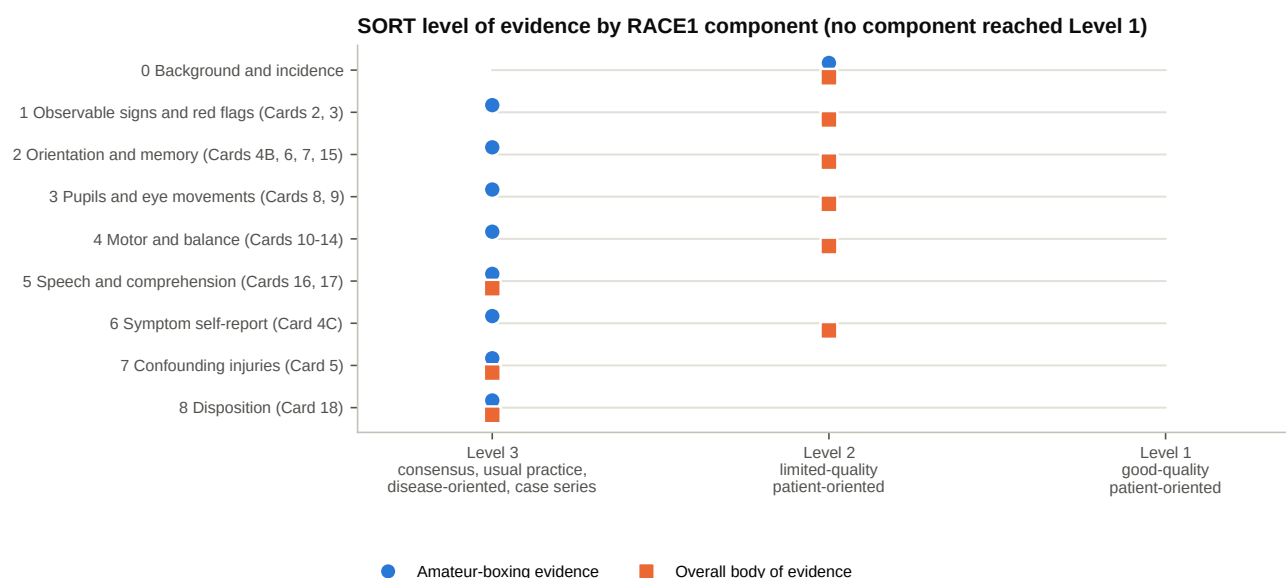
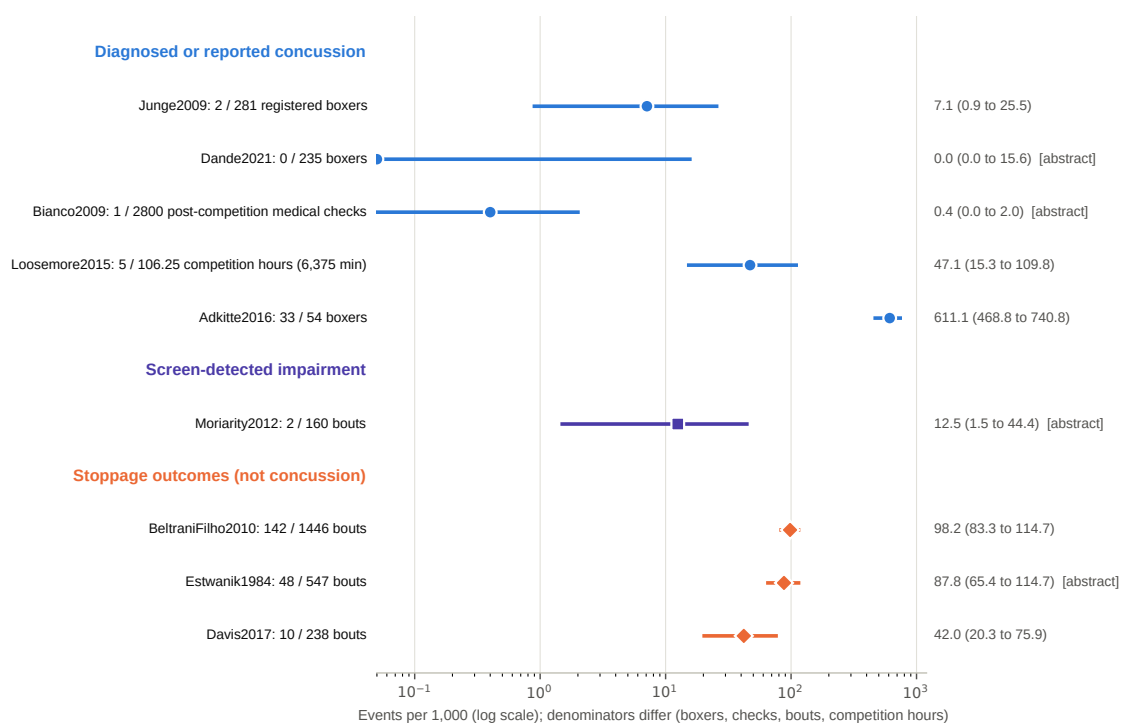


Figure 6. SORT level of evidence by RACE1 evidence component. For each of the 9 components, circles show the level assigned to the amateur and Olympic-style boxing evidence and squares the level assigned to the overall body of evidence, on the 3-level SORT scale (Level 3, consensus, usual practice, opinion, disease-oriented evidence or case series; Level 2, limited-quality patient-oriented evidence; Level 1, good-quality patient-oriented evidence). No component reached Level 1. Amateur evidence was Level 2 only for component 0; overall evidence was Level 2 for components 0 to 4 and 6, and these overall grades depend on other-sport diagnostic reviews that are indirect for amateur boxing. Data source: evidence synthesis (Supplementary File S3). Abbreviation: SORT, Strength-of-Recommendation Taxonomy.

3.5 Single-Study Incidence

Nine amateur or related records provided a numerator and denominator that could be expressed per 1,000 units (Figure 7; Table 5). They are shown in 3 separate outcome groups and were not combined, because both the denominators (registered boxers, boxers, post-competition medical checks, bouts and competition hours) and the outcome definitions differ. For diagnosed or reported concussion, IOC surveillance recorded 2 concussions among 281 registered boxers at the Beijing 2008 Games (7.1 per 1,000; 95% CI, 0.9-25.5);⁶² an abstract reported no concussion among 235 boxers at an Indian women's national championship (0.0 per 1,000; 95% CI, 0.0-15.6);²⁵ and an abstract reported 1 concussion requiring hospitalization among 2,800 post-competition medical checks in Italian female boxing (0.4 per 1,000; 95% CI, 0.0-2.0).¹² In the Great Britain elite squad, 5 competition concussions over 6,375 competition minutes give 47.1 per 1,000 competition hours (95% CI, 15.3-109.8) by reviewer arithmetic, whereas the paper states 0.53 per 1,000 hours, a figure that does not match its own counts and that was read from a repository preprint.⁷¹ A self-report survey of 54 Indian national-level boxers aged 11 to 35 years recorded 33 boxers reporting "cerebral concussion" over 2 years of training and competition combined, a period prevalence of 611.1 per 1,000 boxers (95% CI, 468.8-740.8) without an exposure denominator and at high risk of bias.² For screen-detected impairment, which is not a diagnosis, an abstract reported unrecognized evolving cognitive slowing after 2 of 160 bouts (12.5 per 1,000 bouts; 95% CI, 1.5-44.4).⁸¹ For stoppage outcomes, which are not concussion, KO ended 142 of 1,446 Brazilian amateur bouts (98.2 per 1,000; 95% CI, 83.3-114.7);⁷ the abstract of a 1981-1982 US national championship series reported 48 bouts stopped for head blows among 547 bouts (87.8 per 1,000 bouts; 95% CI, 65.4-114.7), although its printed rate of 4.38% equals 48 of 1,094 participants;⁴⁰ and 10 of 238 bouts at the 2015 World Championships ended in KO or technical knockout (TKO) from any cause (42.0 per 1,000; 95% CI, 20.3-75.9).²⁷

Single-study figures in amateur and Olympic-style boxing, with exact 95% CIs (not pooled)



Zero events are drawn at 0.05 on the log scale. Loosemore 2015: reviewer arithmetic per 1,000 competition hours (published rate inconsistent). Adkitte 2016: self-reported, 2-year period, level not stated.

Figure 7. Single-study figures in amateur and Olympic-style boxing, with exact 95% CIs (not pooled). Points show events per 1,000 units of each study's own denominator on a logarithmic scale, with horizontal lines for the exact 95% CI (Clopper-Pearson for proportions; Poisson for the Loosemore 2015 rate per competition hour); labels give events and denominators, and estimates with CIs are printed at the right. Outcomes are grouped separately: diagnosed or reported concussion (Junge 2009, 2/281 registered boxers; Dande 2021, 0/235 boxers; Bianco 2009, 1/2,800 post-competition medical checks; Loosemore 2015, 5/106.25 competition hours; Adkitte 2016, 33/54 boxers), screen-detected impairment (Moriarity 2012, 2/160 bouts) and stoppage outcomes, which are not concussion (Beltrani Filho 2010, KO, 142/1,446 bouts; Estwanik 1984, stoppage for head blows, 48/547

bouts; Davis 2017, KO or TKO from any cause, 10/238 bouts). Figures from abstracts are marked "[abstract]". Zero events are drawn at 0.05 on the log scale. The Loosemore 2015 figure is reviewer arithmetic from the stated counts, because the published rate (0.53 per 1,000 hours) does not match them; Adkitte 2016 is a self-reported 2-year period prevalence among boxers aged 11 to 35 years whose competitive level was not stated. Denominators differ, so the figures are not comparable with one another. Data source: descriptive incidence analysis (Python output; base R script supplied as Supplementary File S6). Abbreviations: CI, confidence interval; KO, knockout; TKO, technical knockout.

3.6 Direction of Acute Effects

Sixteen amateur studies reported the direction of an acute change after a bout, tournament or sparring session in at least 1 of 7 domains (Figure 8; Table 6). Memory was the domain in which deterioration was reported most often (5 studies deterioration, 3 no change), mostly in studies using sparring or immediate post-bout testing. Processing-speed, reaction-time and executive measures more often improved (4 studies) or did not change (2) than deteriorated (1), with 2 mixed; balance or motor measures did not deteriorate in any study (2 no change, 1 improvement, 1 mixed); the 2 oculomotor studies showed improvement and a mixed result; the single speech or language study showed no change; symptoms deteriorated in 1 study and were mixed in 1; and neurological examination or ringside recognition showed deterioration in 3 studies and no change in 2. Practice effects may explain some of the improvements; the authors of one uncontrolled tournament study acknowledged this possibility in their abstract.⁵⁸ The studies differed in exposure, timing (7 minutes to 6 days) and instrument, and 9 of the 16 were available as abstracts only; full-text retrieval did not obtain the full text of any of them. The counts therefore describe the literature and do not estimate an effect.



Direction as reported by the authors in amateur and Olympic-style boxing studies (bouts, tournaments or sparring); no effect sizes were pooled. Small numbers show outcomes combined in a cell. Symptoms for Chen2012 are post-bout motion-sickness reports.

Figure 8. Effect direction plot: direction of acute change after a bout, tournament or sparring session in 16 amateur and Olympic-style boxing studies, by domain (memory; processing speed, reaction time or executive function; oculomotor; balance or motor; speech or language; symptoms; neurological examination or recognition). Symbols: downward triangle, deterioration after exposure; upward triangle, improvement (which includes practice effects); open circle, no change; diamond, mixed or inconsistent; blank, not measured. Small numbers beside a symbol give the number of outcomes combined in that cell. The text basis of each study (full text or abstract) is shown beside its name. Direction is as reported by the authors; no effect sizes were pooled. For Chen 2012, the symptom outcome is post-bout motion sickness, not a concussion symptom scale. Data source: evidence synthesis (Supplementary File S3). Abbreviation: RT, reaction time.

3.7 Background and Incidence (All Cards)

Amateur findings. Diagnosed concussion was recorded infrequently in amateur and Olympic-style competition, but case definitions and denominators differed and no 2 studies used the same exposure unit. Beyond the Beijing 2008 figure in Table 5,⁶² the Rio 2016 report, read in full, attributed 7 of the 12 concussions recorded at the Games to boxing and stated that 9 of the 12 concussions across all sports were severe, with more than 7 days of absence; it printed a boxing injury incidence of 30.1 per 100 athletes (95% CI, 23.7-36.4) but not the number of registered boxers, so no per-boxer concussion proportion can be formed.¹⁰³ At London 2012, the 6 concussions recorded across all sports were listed as 3 in football and 1 each in water polo, athletics and BMX, so none was listed in boxing; this is an inference from a by-sport listing, because the per-sport table was not obtained.³⁹ Boxing concussion counts for Tokyo 2020 and the Buenos Aires 2018 Youth Olympic Games were not obtained.^{102,104} A pooled

analysis of the 3 Games from 2008 to 2016 did not report boxing concussion separately; its nearest category, brain or spinal cord injury, accounted for 8 of 124 boxing injuries (6.5%), and concussion made up 3.2% of all 315 injuries in the 4 combat sports.⁷³ In female competition, abstracts reported no concussion among 61 boxers at the 2016 Women's World Championships⁵⁸ and among 235 boxers at an Indian championship,²⁵ and 1 concussion with hospitalization among 2,800 Italian post-competition checks.¹² Small cohorts recorded 1 amateur competition concussion over 12 months among 33 Victorian amateurs,¹¹⁶ 1 of 12 university boxers deemed concussed after a bout,⁹² no diagnosis among 15 club boxers¹⁹ and, in an abstract, 1 ringside physician-determined concussion without a denominator.⁷⁰

Proportional and secondary data were heterogeneous and partly conflicting. The abstract of a US Olympic Training Center series reported cerebral injury as 6.5% of 447 injuries in a mainly noncompetitive setting.⁶⁰ A 12-month cohort abstract reported head injury with neurological symptoms in 4.2% of 192 injuries;¹⁰¹ a 2023 meta-analysis classed that cohort as professional.⁷⁵ The Irish amateur cohort abstract described cerebral injuries as occurring only in competition and as predominantly mild concussions,⁹³ whereas the 2023 meta-analysis reported that its 51.2% "concussion" proportion used the definition "any blows to boxer's head that stopped the contest", that is, a head-blow stoppage outcome.⁷⁵ Emergency-department series of unstated competitive level reported concussion or closed head injury in 6.9% of boxing injuries (11.7% at 6 to 11 years), more often after competition than practice injuries (relative risk, 3.30; 95% CI, 2.58-4.22);¹⁰⁹ 8.1% to 8.9% across age bands;⁹⁴ 3.2% of an estimated 47,052 boxing injuries, or 0.92 per 100,000 player-days (95% CI, 0.5-1.3);⁹⁰ and a boxing mild traumatic brain injury incidence of 85.6 per 100,000 person-years, 55.8% of it in patients younger than 20 years.⁶⁹ None of these series separated sanctioned competition from training or recreational punching.

Stoppage outcomes were reported more often than diagnosis and were defined in incompatible ways. Across 29,357 Olympic-style bouts from 1952 to 2011, RSC-H rose from 1.31% to 4.92% after headguards became mandatory, KO fell from 6.44% to 2.09% after computerized scoring, and RSC-H fell from 4.23% to 1.41% when the bout format changed from 5 rounds of 2 minutes to 4 rounds of 2 minutes ($P < .001$ for each).¹⁰ All-cause referee stoppages rose from 1.7% of elite bouts before 2013 to 4.2% after headguard removal for senior men (2 KO and 8 TKO), standing counts fell from 9% to 3% of rounds, and the authors judged any increase in concussive or traumatic brain injury risk after 2013 "equivocal".²⁷ For the head-guard comparison in International Boxing Association (AIBA) tournaments, the primary article was reached only through its abstract; a later review tabulated 45 head-blow stoppages in 14,880 rounds with head guards against 23 in 13,992 rounds without,³¹ and the ARP headguard statement reported a rate ratio of 0.57,²⁸ both as reported by those secondary sources.⁷² A Brazilian series equated KO with cerebral concussion,⁷ a Dutch dissertation summary reported KO in 11% of matches,⁷⁶ and the abstract of a Danish national survey of 5,272 matches reported that preventive measures did not change the frequency of matches stopped for KO or head blows.⁹⁸ Laceration and fracture were recorded as separate injury types: laceration or abrasion was 51 of 124 Olympic boxing injuries (41.1%) and fracture 5 of 124 (4.0%),⁷³ the Rio report listed 2 severe fractures in boxing,¹⁰³ and cuts rose without head guards (45 with against 273 without, as reported by Donnelly et al;³¹ rate ratio 5.30, as reported by the ARP headguard statement²⁸).

Direction of effect was assessable only across rule eras. For head-blow stoppage and headgear, 2 amateur studies were consistent in direction (more RSC-H with mandatory head guards; fewer without head guards, from secondary numbers), while the study using all-cause referee stoppage showed an increase after headgear removal; the difference reflects outcome definition. All-injury incidence in male Olympic boxing was 3 times higher after headgear removal (rate ratio, 3.00; 95% CI, 2.07-4.36),⁷³ and boxing injury incidence at Rio 2016 was higher than at London 2012 (30% vs 9% of athletes);¹⁰³ both are all-injury outcomes. Heterogeneity arose from level, sex (female-only studies recorded 0 or 1 concussion), age (cohorts from 11 or 15 years; emergency-department series including children), headgear rules (removed for senior men in AIBA competition in 2013 but required in all USA Boxing divisions¹¹³), bout format, injury definition, setting of ascertainment and exposure unit.

Consensus and reviews. The ARP consensus stated that very few high-quality studies describe concussion incidence in combat sports and cited 0.53 concussions per 1,000 hours in elite amateur boxers,⁸⁵ the figure whose arithmetic could not be reproduced from the primary counts. The ARP headguard statement held that headguards "should not be relied upon to reduce the risk of concussion or other traumatic brain injury" while being highly effective against facial lacerations.²⁸ A meta-analysis of amateur, professional and emergency-department studies reported concussion as 12.3% (95% CI, 8.7%-15.9%) of boxing injuries with no amateur-professional subgroup difference, and flagged the stoppage-based definition of the Irish cohort as likely to overvalue

real concussion.⁷⁵ A second review cited 0.33 concussions per 100 bouts in amateur and 2.62 in professional boxing, but the primary sources could not be identified;³¹ that figure is not used here.

Combat-sport context. Professional boxing recorded higher concussion frequencies: 20.8 concussions per 100 fights in the professional stratum of a Victorian cohort.¹¹⁶ In professional MMA, an abstract reported severe concussion at 15.4 per 1,000 athlete exposures.⁸⁷ A fatality review attributed 547 of 2,076 boxing deaths (26%) to amateur bouts.²³ These data did not substitute for amateur findings.

Certainty. Amateur evidence for background incidence was SORT Level 2, supported by IOC prospective surveillance at moderate risk of bias but limited by very small numerators (0 to 7 events per study), missing or inferred denominators, the unresolved Great Britain rate, abstract-only records and the indirectness of stoppage and emergency-department data. The overall body was also Level 2.

Implications for the cards. The background supports 3 statements for every card: diagnosed concussion is recorded infrequently and LOC accompanies a minority of concussions, so the cards cannot rely on overt signs; some impairment is not recognized at the time of the bout, so a normal immediate screen does not end observation;⁸¹ and lacerations, contusions and facial and hand injuries are frequent and must be screened as confounders (Card 5). It does not support quoting any single amateur concussion rate, presenting KO, RSC-H, TKO or all-cause stoppage rates as concussion rates, or claiming that headgear status changes concussion incidence. Card 2 therefore records the contest type, rule set, headgear status and bout result with each screen, so that future registry data can separate these factors.

3.8 Observable Signs and Red Flags (Cards 2 and 3)

Amateur findings. No amateur study measured the accuracy or reliability of an observable sign or red flag, and no full text was obtained for the amateur observational studies on this component. Three amateur studies reported a post-bout neurological examination. An abstract reported focal neurological signs after fights in 5 of 13 boxers, without correlation with the number of head punches;⁵⁶ among 30 elite boxers examined after a bout, none had lost consciousness in the last bout, and the examination was normal with a Glasgow Coma Scale (GCS) score of 15 in all;⁸⁶ and an abstract reported normal examination and magnetic resonance imaging in all 9 Golden Gloves boxers suspended after a KO or excessive head blows.⁶¹ Ringside recognition was incomplete in the tournament described in the Introduction, in which 2 boxers not suspected of concussion showed evolving cognitive slowing;⁸¹ only bout winners were eligible, a patient-selection risk. An abstract reported that the boxers whose bouts were stopped by the referee (n = 7) showed slower reaction time within 2 hours.⁸⁰ Trigger events changed with rules: KO fell from 7.55% of bouts in 1952 to 1963 to 0.70% in 2009 to 2011,¹⁰ and standing counts fell from 9% to 3% of rounds after 2013.²⁷ For red flags, the only amateur data were fatality counts, including, as reported in an abstract, 2 deaths among 240 Royal Air Force boxing injuries from 1953 to 1966.¹⁴

Consensus, tools and rules. Consensus documents converged on a core list. The 6 consensus video signs are lying motionless, motor incoordination, impact seizure, tonic posturing, no protective action (floppy) and blank or vacant look, and "the presence of any one sign ... indicates the need to remove the athlete from the playing arena for formal assessment";²⁶ they were developed by 7 professional team-sport bodies, not for combat sports. The 6th consensus statement listed actual or suspected LOC, seizure, tonic posturing, ataxia, poor balance, confusion, behavioral changes and amnesia as signs warranting immediate removal and stated that signs may evolve over minutes, hours or days.⁹¹ The SCAT6 lists 11 red flags, including neck pain or tenderness, double vision, LOC, deteriorating conscious state, vomiting, severe or increasing headache, increasing restlessness or agitation, a GCS score below 15 and visible skull deformity, and 8 observable signs, including falling unprotected to the surface and facial injury after head trauma.³⁵ In a collision-sport Delphi panel of 17 members with a 90% consensus threshold, 17 of 20 clinical signs reached consensus; LOC or suspected LOC, motor incoordination or ataxia, falling without protective action, posturing, seizures, lying motionless, confusion, amnesia, slurred speech and dizziness reached 100% agreement as removal signs and dazed look 94%, whereas "slow to get up" reached 94% as a clinical sign but only 53% as a removal sign and "holding head" reached neither.⁵⁵ The ARP consensus held that a KO from head blows makes concussion likely, that a TKO "does not always have to be associated with a concussion" and that post-bout red flags require emergent transport.⁸⁵ The USA Boxing handbook states that a boxer "temporarily stunned or knocked down and unconscious is a stricken boxer and a medical emergency. This indicates that a concussion has occurred," that spontaneous horizontal nystagmus means the boxer "should not be permitted to continue", and that a boxer down with a head injury is moved with a backboard and rigid cervical collar.¹¹²

Red-flag lists agreed in content but not in GCS threshold. The ARP neuroimaging consensus listed 9 red flags (GCS below 15; suspected open, depressed or basal skull fracture; cerebrospinal fluid from the nose or ears; post-traumatic seizure; focal neurological deficit; more than 1 episode of vomiting; pupillary abnormality; progressive headache, nausea or vomiting, light or noise sensitivity or vision problems; and deterioration of mental status) and recommended urgent non-contrast computed tomography (CT) and immediate ambulance transport to a designated trauma center, preferably Level I with 24-hour neurosurgery and neurology cover.⁹⁹ NICE NG232 directs emergency department referral for, among other criteria, a GCS below 15, any LOC, any focal deficit, amnesia, persistent headache, any vomiting or any seizure, and CT within 1 hour in people aged 16 years or older for a GCS of 12 or less initially or below 15 at 2 hours, skull fracture signs, post-traumatic seizure, focal deficit or more than 1 episode of vomiting.⁸⁴ The thresholds elsewhere were below 14 for hospitalization in the collision-sport panel,⁵⁵ 14 or less for CT in World Boxing rules¹¹⁵ and below 13 in the ARP older-fighter statement.⁹ The AMSSM required emergency transfer for deteriorating mental status, focal findings including abnormal or unequal pupils or extraocular movement abnormalities, or worsening symptoms;⁵⁰ the American Academy of Neurology (AAN) guideline, now marked retired, listed LOC, post-traumatic amnesia, GCS below 15, focal deficit, skull fracture signs and deterioration as reasons for CT;⁴⁷ and the Australian Institute of Sport and Australian Medical Association statement listed neck pain, increasing confusion or irritability, repeated vomiting, seizure, limb weakness or tingling, deteriorating conscious state, severe or increasing headache, unusual behavior and double vision for immediate referral.³⁸

Measurement properties in other sports. Across professional sports, visible signs were identified in 53% to 78.9% of concussions, with specificity of 97% for tonic posturing, 96% for impact seizure, 93% for suspected LOC, 81% for ataxia or motor incoordination with difficulty getting up, 62% for blank, vacant or dazed look and 55% for abnormal behavior.³⁷ Across 6 studies with 718 concussions, most signs had sensitivity below 50% and specificity above 90%, "slow to get up" had sensitivity of 0.80 and specificity of 0.27, and inter-rater kappa ranged from 0.44 to 0.68 for novice and from 0.08 to 0.89 for expert raters.¹⁰⁸ Clinical judgment within a multimodal assessment had sensitivity of 0.766 and specificity of 0.866.⁵³ No review included a boxing study in its accuracy analyses.

Combat-sport and case context. In professional slap fighting, a video analysis at low risk of bias found observable signs of concussion after a substantial share of strikes.¹⁰⁵ A 42-year-old kickboxer kicked on the jaw did not lose consciousness and completed his match, reported flu-like symptoms, mild headache and neck stiffness the next day, was diagnosed with influenza on day 3 and collapsed on day 6 with subarachnoid hemorrhage from vertebral artery dissection.⁷⁴ In an abstract describing 18 literature cases of repetitive sports head injury, 10 of 15 had no LOC at the insult.⁷⁹ Professional case material on lucid intervals and deterioration after leaving the ring was available only as abstracts.^{4,66}

Certainty. Amateur evidence was SORT Level 3: no accuracy or reliability data, abstract-only observational studies, a high-risk ringside-recognition cohort and inconsistent headgear contrasts confounded by concurrent scoring and format changes. The overall evidence for observable signs was Level 2, from professional team-sport data identified mostly on video, which are indirect for live ringside observation. Red-flag evidence was Level 3 throughout; the differing GCS thresholds are an inconsistency among consensus sources, not a difference in evidence.

Implications for the cards. Card 2 uses the consensus video-sign names with disorientation or confusion, records the source of the observation (examiner, referee, corner or video) and treats any sign as precluding "no deficit detected". "Slow to get up" prompts the examination but is not scored as a sign, because it lacked removal consensus and had specificity of 0.27. Absence of signs is never reassurance. Card 3 holds one red-flag list with one action, states a GCS threshold of below 15 with its sources (SCAT6, ARP neuroimaging consensus, NICE NG232), and requires the red-flag check to be repeated before the boxer leaves the venue. A KO with LOC from head blows is managed as concussion under the governing rules;^{85,112} RSC-H, TKO and standing counts are recorded on Card 2 as triggers for the examination, not as diagnoses. The gaps are complete: no amateur data on the accuracy or inter-rater reliability of any Card 2 or Card 3 item, and no female or youth amateur data.

3.9 Consciousness, Memory and Symptoms (Card 4)

Card 4 records 3 elements: alteration of consciousness immediately after the impact (4A), memory of the events before and after the impact (4B) and symptoms reported by the boxer, which are not scored (4C).

Alteration of consciousness and memory of the event (4A, 4B). No amateur study tested a question on post-impact confusion or peri-event amnesia. Confusion or disorientation and memory disturbance or amnesia reached 100% agreement in the collision-

sport panel both as clinical signs and as removal red flags;⁵⁵ the 6th consensus statement lists confusion and amnesia among signs warranting immediate removal;⁹¹ and the ARP named disorientation and confusion as signs consistent with concussion.⁸⁵ Amnesia carries a referral consequence in general-population guidance: NICE NG232 makes amnesia for events before or after the injury a criterion for emergency department referral and, in people aged 16 years or older with LOC or amnesia, more than 30 minutes of retrograde amnesia a risk factor for CT.⁸⁴ World Boxing lists persistent amnesia at the time of examination as an indication for CT,¹¹⁵ and a football consensus listed persistent anterograde amnesia as a day-of-injury CT criterion.⁴² In professional boxers, a survey abstract described retrograde amnesia after a fight as very rare and quickly resolving, without counts.⁸⁸

Symptoms: amateur findings (4C). Amateur symptom data were small observational cohorts in which symptoms were an outcome, not a test. In the only amateur study that applied a standard concussion symptom scale before and after head-impact exposure, the abstract reported that 7 competitive boxers followed over 16 sparring sessions showed no group change in SCAT5 total symptom severity from immediately before to immediately after sparring (median change, -1; $P = .85$), but 4 sessions (25%), from 3 boxers, showed a change greater than 5 points, and severity at 48 hours was lower than before sparring ($P = .02$).⁶⁷ In a club cohort, 7 of 15 adult male boxers (47%) reported motion sickness after the bout, none before or after the warm-up, and the authors noted that motion sickness can occur without concussion or head trauma;¹⁹ abstracts reported post-bout motion sickness in 9 of 19 adolescents,²¹ 7 of 20 adolescent female boxers²² and 7 of 13 adult males, among whom concussion-related symptoms were elevated immediately after boxing in those who were motion sick.²⁰ Among 30 elite boxers examined 1 to 6 days after a bout, 1 reported a concussion-related symptom (headache), symptom questionnaires resembled those of controls, and the authors concluded that absence of clinical symptoms or cognitive impairment did not appear to be equivalent to absence of brain injury.⁸⁶ In a retrospective survey of 663 Japanese amateur boxers, more self-reported post-KO symptoms were associated with lower seriousness in practice ($\beta = -0.144$; $P = .009$) and lower fighting spirit ($\beta = -0.112$; $P = .041$).⁶⁵ Counted by direction, 1 amateur study showed symptom emergence after the bout and 1 showed no group change with individual increases.

Symptoms: consensus and rules. USA Boxing requires that, at the pre-bout examination, the boxer be questioned about head blows, blackouts and concussions and be "free of any post-concussion symptoms",¹¹² which provides a natural point to record a symptom baseline; World Boxing includes a symptom inquiry before the bout and makes the latest SCAT, with its symptom scale, mandatory after a KO or a stoppage for head blows.¹¹⁵ The ARP consensus treated symptoms persisting 30 minutes after a bout as probable concussion, required evaluation immediately after the bout and again in a quieter setting such as the dressing room, prohibited sparring or competing while symptomatic, and noted that fatal outcomes had often followed training head injuries not disclosed to the physician.⁸⁵ Graded symptom checklists that score symptom number and severity separately, rather than as a composite total for which there was no supporting evidence, were recommended in the SCAT lineage.⁴⁸ The SCAT6 retains 22 symptoms rated 0 to 6, with a baseline instruction to rate "how you typically feel" and a post-injury instruction to rate "how you feel now",³⁵ and its introduction warns that concussed athletes may perform within normal ranges.³⁴ The 5th and 6th consensus statements described evolving and delayed-onset symptoms and called for serial evaluation regardless of a negative sideline screen.^{78,91} A football consensus stated that an athlete may not have or report symptoms immediately and that clearance should be made regardless of dissimulation.⁴²

Symptoms: measurement properties in other sports. The AAN guideline judged that a graded symptom checklist or post-concussion symptom scale likely identifies concussion (sensitivity, 64%-89%; specificity, 91%-100%; Class III studies).⁴⁷ In a pediatric review of 23 case-control studies, headache had a likelihood ratio of 3.1 (95% CI, 2.0-4.9) and its absence 0.20 (95% CI, 0.10-0.39), mental fog had a likelihood ratio of about 12 and nausea 6.7 (95% CI, 3.1-15), and the authors concluded that no single symptom rules concussion in or out.¹⁰⁰ Symptoms were elevated in all symptom articles within 24 and 48 hours, falling to 64% of articles at 7 days.³⁷ Under-reporting was consistent: all 26 adolescent studies in one review found non-disclosure, and education did not appear to deter it.⁴³

Symptoms: combat-sport context. In MMA, symptom components were the only parts of the SCAT5 that separated traumatic events from other bouts (symptom score change 2.4 ± 5.1 vs 0.0 ± 3.7 ; $P = .042$; symptom severity area under the curve [AUC], .679), and overall SCAT5 sensitivity was 77.78% with specificity of 52.99%.¹¹⁰ In taekwondo, 22% of athletes hid symptoms from medical staff and 21% returned the same day despite suspected concussion.¹⁶ Symptom reports were confounded: concussion and rapid-weight-loss symptom scores were reportedly correlated ($r_s = 0.6-0.7$) in combat athletes,¹¹¹ a history of headache was associated with combatives concussion diagnosis in military cadets (odds ratio, 1.43; 95% CI, 1.18-1.73), which the

authors attributed partly to symptom overlap,¹ and eye injury alone produces photophobia, blurred vision and headache.⁵⁷ Symptom resolution did not mark recovery: in cadets concussed in boxing instruction, an abstract reported reaction-time slowing that persisted after physical symptoms had resolved.¹¹⁴

Certainty. Amateur evidence for Card 4 was SORT Level 3; the overall body was Level 2 for symptom report (limited-quality diagnostic evidence from other sports and consistent survey evidence of under-reporting) and Level 3 for the consciousness and memory-of-event questions, which rest on consensus and guideline sources.

Implications for the card. Card 4A and 4B use open, neutral questions, and a yes or unknown on 4A or any memory gap on 4B precludes "no deficit detected". Card 4C draws a short list from the SCAT6 symptom scale, records a pre-bout baseline line, is interpreted after the Card 5 eye check, and treats any reported symptom as precluding "no deficit detected" without applying a composite threshold. The card states that observed findings take priority over self-report, because concealment, delayed evolution and false-negative screens are documented. Red-flag symptoms (severe or increasing headache, repeated vomiting, increasing confusion or agitation, persistent double vision) are routed to Card 3 rather than scored on Card 4.

3.10 Confounding Injuries (Card 5)

Amateur findings. No amateur study measured how a coexisting injury or physiological state changes a concussion-screen result. The post-bout motion-sickness series described above shows that a non-concussive post-bout symptom is common and co-occurs with concussion-type symptoms.^{19,20} An abstract described an amateur boxer who presented 15 minutes after a match with an orbital blowout fracture that radiographs did not show and CT confirmed.⁶⁴ Facial injury types that would be present at the post-bout examination were frequent: contusion made up 18.5% and the head and neck 62.1% of Olympic boxing injuries;⁷³ epistaxis occurred in 68 of 1,446 Brazilian bouts (4.7%) and ended 27, and 6 bouts were stopped for glenohumeral dislocation;⁷ and a self-report survey recorded 44 lip lacerations, 32 nosebleeds, 28 periorbital hematomas and 7 nasal fractures among 820 injuries, with ophthalmological injuries 7.43%.² An abstract of the Great Britain squad reported hand injuries at 302 per 1,000 hours of competition.⁷¹ Italian female boxers showed nasal septum deviation in 42.6% of prospectively examined athletes, as reported in an abstract.¹² In emergency-department data, septal deviations rose from 16 to 97 after the 2013 rule change while lacerations did not decrease.³

Consensus and rules. Statements consistently placed cervical spine and fracture assessment before or alongside concussion assessment. The SCAT6 specifies a cervical spine screen (neck pain at rest, tenderness, active pain-free range of movement, and limb strength and sensation) and lists neck pain as a red flag.³⁵ The AMSSM directs that a collapsed athlete be assessed for airway, breathing and heart function and then for cervical spine and serious brain injury before a concussion examination begins,⁵⁰ and the Australian statement holds that cervical spine injury should be suspected with any LOC, neck pain or relevant mechanism, with manual in-line stabilization and a hard collar until it is excluded.³⁸ The collision-sport panel agreed that signs of cervical spine injury and suspected skull or maxillofacial fracture are hospitalization criteria (100%).⁵⁵ USA Boxing recommends a brief examination area between the ring and the locker room for mental status and a quick survey of the head, face, neck and upper extremities,¹¹² and the World Boxing post-bout head injury assessment includes cranial fractures, otoscopy and neck and cervical spine assessment.¹¹⁵ The ARP eye-conditions statement lists signs (proptosis or enophthalmos, suspected orbital or blowout fracture, irregular pupil, circumferential subconjunctival hemorrhage, hyphema, traumatic iritis with miosis or mydriasis not resolving within 1 hour, suspected globe rupture, lid-margin lacerations) and symptoms (reduced acuity, photophobia, diplopia, halos, deep eye pain, flashes or floaters) that require emergent ophthalmology referral; it advises monitoring traumatic miosis or mydriasis without head trauma for 45 to 60 minutes, advises against penlight examination immediately after an in-competition eye injury, and notes that permanent visual loss from retrobulbar hematoma can occur within 90 minutes.⁵⁷ The 5th and 6th consensus definitions state that concussion signs and symptoms "cannot be explained solely by (but may occur concomitantly with)" drugs, alcohol, medication, other injuries such as cervical injury or peripheral vestibular dysfunction, or comorbidities, and the 6th statement allows attribution of a removal sign to another cause only after an experienced clinician's multimodal assessment.^{78,91} Other named modifiers were footwear, surface, ankle tape or braces and lower-extremity injury for balance testing;⁵⁰ drug or alcohol intoxication, anticoagulant or antiplatelet treatment and bleeding disorders as independent referral criteria;⁸⁴ and age over 35 years and blood pressure above 160/100 mm Hg in the ARP older-fighter statement.⁹

Measurement properties in other sports. Exertion increased Balance Error Scoring System (BESS) errors from 11.6 to 15.8, with return to pre-test values by about 20 minutes, and ankle bracing or taping increased errors;⁶ sideline testing produced more

errors than locker-room testing (14.3 vs 11.0);⁹⁷ and King-Devick times were 1.4 seconds faster than baseline after competition or exercise in 92 athletes.⁴⁶ No review reported the accuracy of any confounder screen.

Combat-sport context. In the kickboxing case above, neck stiffness that might have been attributed to a benign cause was the presenting feature of a vascular injury.⁷⁴ Eyelid and eyebrow lacerations made up 81.31% of professional boxing eye injuries in Nevada commission records.¹⁸

Certainty. Amateur and overall evidence for Card 5 was SORT Level 3: case material, injury-type frequencies, a single research program on motion sickness and consensus, guideline and rule documents, without patient-oriented outcome data.

Implications for the card. Card 5 is completed before any standing task and before Cards 4C, 8 and 9 are interpreted. Section A is the SCAT6 cervical screen, and any abnormal finding is a Card 3 red flag; Section B records skull, facial, jaw and orbital fracture suspicion, with transfer for CT and the statement that normal radiographs do not exclude orbital fracture; Section C is an eye and periocular screen with emergent ophthalmology referral and a brief deferral of the penlight test after an eye injury; Section D marks tests made invalid by an injury as unreliable (U), which scores 0 and precludes "no deficit detected"; and Section E records time since the bout, exertion, rapid weight loss, anticoagulant or antiplatelet use, suspected alcohol or drugs and relevant history. The evidence does not support any rule that attributes an abnormal finding to a confounder at ringside, and Card 5 states that context is recorded and never used to dismiss a suspected concussion.

3.11 Orientation and Memory (Cards 6, 7 and 15)

Amateur findings. Thirteen primary amateur studies measured cognition, memory or attention after competition or sparring; none used a concussion reference standard and none reported results for an orientation item. (One of the 13, an event-related potential study, was classed as amateur only by a later review and was recorded as excluded among the targeted-search records; it is not cited here.) For memory, vote counting gave 5 studies showing deterioration, 4 showing no change and none showing improvement. In the controlled sparring study, paired-associate learning errors rose from 3 to 6 immediately after three 3-minute rounds against a mock-sparring control ($P = .01$), with a spatial working-memory interaction ($P = .03$); the sample combined amateur boxers and Muay Thai athletes.²⁹ An abstract reported impaired memory and planning in 38 competing amateur boxers against 28 non-competing boxer controls ($P < .001$ for Logical Memory short- and long-term recall; Digit Symbol, $P = .02$),⁷⁶ and the dissertation summary of the same cohort reported a median of 8 head hits per match, more than 10 in 35% of boxers, and negative correlations of weight class, head blows and KOs with memory and planning.⁷⁶ An abstract reported impaired verbal and incidental memory after a fight in an uncontrolled study of 23 boxers,⁵⁴ and abstracts of 2 sparring studies reported declines in delayed memory, with other scores increased or not significantly decreased in one,¹⁰⁶ and, in the other, the number of impacts and concussion history predicted the decline, with a mean of 27.63 impacts above 9.6 g per boxer over two 2-minute rounds.³⁰ No change was found in 86 boxers aged 12.6 to 26.1 years tested 1 to 6 days after a bout against water polo and rugby controls (immediate and delayed word recall, not significant),¹⁷ in working memory within 2 hours of 1, 2 or 3 bouts, as reported in an abstract,⁸⁰ in 30 elite boxers 1 to 6 days after a bout compared with controls (Digit Span, 7.1 vs 6.5; $P = .13$),⁸⁶ or in Digit Span forward and backward in either headgear condition of a crossover study.⁸⁹ For processing speed, reaction time and executive function, which RACE1 does not score as orientation or memory, 1 study deteriorated, 4 improved, 3 did not change and 1 was mixed; improvement was the dominant within-subject pattern on speed tests, consistent with practice effects in uncontrolled designs. Two amateur findings bear directly on a single post-bout screen: an abstract reported that 17 boxers (10.6%) failed the first post-bout computerized test, 12 of them (71%) passed a repeat test, and 2 boxers showed evolving slowing not recognized at ringside;⁸¹ and the authors of the elite cohort concluded that, without a baseline and in the absence of clinical symptoms, neuropsychological assessment could not detect small axonal injuries.⁸⁶ Timing ranged from minutes (sparring studies) to 1 to 6 days; only abstracts and sparring studies represented the minutes after exposure that matter at ringside.

Consensus and rules. The AMSSM recommended a cognitive evaluation of orientation, past and immediate memory, new learning and concentration and described the accuracy of sideline tests across ages, cultures and settings as largely undefined.⁵⁰ The 5th consensus statement judged standard orientation questions (time, place, person) unreliable in sport compared with memory assessment,⁷⁸ and the 6th retained the Maddocks questions as a brief on-field screen for athletes over 12 years without clear signs, with incorrect answers warranting a more detailed evaluation.⁹¹ The SCAT6 retains team-sport Maddocks questions (venue, half, last scorer, last team, last result), 5 orientation items, 3 trials of a 10-word list, digits backward, timed months in reverse and delayed recall scored out of 10;³⁵ its introduction reported removal of the 5-word list and stated that translation with

cultural and linguistic adaptation is imperative, "particularly immediate memory".³⁴ In the collision-sport panel, the Maddocks questions reached 94% agreement as part of on-field assessment.⁵⁵ The ARP recommended annual baseline neuropsychological evaluation, described computerized testing as a snapshot that should not be the sole basis for management, and noted that no combat sports organization required baseline testing.⁸⁵ Amateur rules already use bout-specific items: the USA Boxing handbook asks the boxer's name, location, day and year, the opponent's name and the round, and asks the boxer to repeat 3 words after 5 minutes,¹¹² and the World Boxing handbook lists modified Maddocks questions on the opponent, whether the bout was stopped and the round (wording paraphrased in the text obtained) and makes the latest SCAT mandatory after a KO or a stoppage for head blows.¹¹⁵

Measurement properties in other sports. The AAN guideline judged that the Standardized Assessment of Concussion (SAC) likely identifies concussion early after injury (sensitivity, 80%-94%; specificity, 76%-91%; Class III studies) and recommended that sideline tools be used only as an adjunct.⁴⁷ In a meta-analysis, the SAC worsened in only 48% of concussed athletes, against 85% for the King-Devick test and 75% for timed tandem gait, with an AUC of 0.66 (95% CI, 0.53-0.79).⁴⁶ In the systematic review for the SCAT6, 238 studies addressed cognition; the 10-item word list had better psychometric properties than the 5-item list, which showed ceiling effects; test-retest reliability of SAC scores was poor (0.22-0.52); and SCAT discrimination was greatest within 72 hours and diminished up to 7 days.³⁷ In a pediatric review, difficulty remembering had a likelihood ratio of 3.3 (95% CI, 1.5-7.4) and specificity of 0.89.¹⁰⁰ Immediate memory and Maddocks questions were weak, non-significant predictors in one included study, and males scored worse on the SAC than females in another ($P = .012$).²⁴

Combat-sport context. In MMA, a SAC worsening of 3 or more points did not distinguish traumatic events from other bouts.¹¹⁰ Abstracts from military boxing instruction reported slowed reaction time in 14 concussed cadets at less than 1 hour and again at 4 days, after symptoms had resolved,¹¹⁴ and impairment on the day of injury and at 1 to 2 days, with recovery by 3 to 7 days and absent practice effects as a marker of recent concussion.¹³

Certainty. Amateur evidence was SORT Level 3: disease-oriented scores, no orientation data, 8 of 13 studies on the abstract, small samples (10 to 96 boxers), varied timing and inconsistent direction. The overall evidence was Level 2, downgraded for case-control designs, high risk of bias, poor test-retest reliability, inconsistency and indirectness. Bout-specific orientation questions are usual practice (Level 3) and have not been evaluated.

Implications for the cards. Card 6 asks the time of day, the venue, the opponent's name and the last round fought (4 points), following the bout-specific approach of both amateur federations, and records "How did the bout end?" without scoring it, because the examiner may not know the answer. Cards 7 and 15 keep 3-word lists for ringside speed, give immediate memory (3 points, trial 1) and delayed recall after at least 5 minutes (3 points), use List A at baseline, List B after the bout and List C at re-test, and use adapted, not literally translated, lists in the boxer's language. A 3-word list is shorter than the 10-word list now favored, so ceiling effects are likely, and Card 7 states that a full score does not exclude concussion. The evidence supports neither any orientation or memory cut-off nor the use of a full score as evidence that concussion is absent.

3.12 Pupils and Eye Movements (Cards 8 and 9)

Amateur findings. Four amateur studies measured an oculomotor or rapid-naming variable around competition, none in enough concussed boxers to estimate accuracy, and none evaluated the pupil examination, pursuit, convergence or the Vestibular/Ocular Motor Screening (VOMS). In 61 female Olympic-style boxers retested within a day of tournament elimination, an abstract reported that King-Devick time improved from 18.0 to 14.2 seconds ($P = .002$), with no concussion; the authors attributed the improvement partly to practice effects.⁵⁸ In 12 university-club boxers tested with a head-mounted saccadometer within 12 hours before and 7 minutes after a bout, the saccadic latency distribution changed significantly in 9; median latency increased in 6 and decreased in 2, and the 1 boxer deemed concussed shifted by 34 milliseconds.⁹² An abstract of a study in which sports parents masked to head-trauma status gave the King-Devick test reported that post-fight times were better than the best baseline in the absence of concussion (41 vs 39.3 seconds; $P = .34$), that the single boxer judged concussed by the ringside physician worsened by 3.2 seconds with more errors, and that test-retest reliability was high (intraclass correlation coefficient [ICC], 0.90; 95% CI, 0.84-0.97); the first author was affiliated with the test's manufacturer.⁷⁰ A fourth study used a letter-search task only before the bout.¹⁹ Among clinical signs, an abstract described 1 Italian female boxer with nystagmus and a normal cerebral magnetic resonance image at a re-admission examination after a stoppage for dangerous head blows.¹¹ By

direction, the 2 studies with group data showed improvement or no worsening in boxers without concussion, and in the 2 studies with an identified concussed boxer that boxer's value moved in the adverse direction, a single-case observation in each.

Consensus and rules. USA Boxing instructs the physician to check that the pupils are equal, round and reactive and states that "the presence of spontaneous horizontal nystagmus indicates that the boxer is very vulnerable and should not be permitted to continue";¹¹² World Boxing includes the pupils and light reflex in the pre-bout examination and the pupils and eyes in the post-bout head injury assessment.¹¹⁵ The ARP eye-conditions statement recommends a penlight check for anisocoria immediately before competition, notes that hyphema can produce anisocoria, and requires ophthalmology clearance for an irregular pupil, persistent traumatic miosis or mydriasis, photophobia or diplopia.⁵⁷ Pupillary abnormality and progressive vision problems are red flags in the ARP neuroimaging consensus,⁹⁹ and abnormal or unequal pupils and extraocular movement abnormalities are focal findings requiring emergency transfer in the AMSSM statement.⁵⁰ Double vision is a red flag in the SCAT6 and the Australian statement.^{35,38} The SCAT6 added an ocular and motor screen asking whether the patient can look side to side and up and down without double vision while keeping the head still, and whether observed extraocular movements are normal.³⁵ The ARP listed blurred or double vision as a sign of concussion during a bout and recommended baseline vestibular and ocular testing where possible.⁸⁵ In the collision-sport panel, nystagmus did not reach the consensus threshold (82% as a clinical sign; 88% as a removal sign).⁵⁵ A systematic review for an earlier consensus concluded that an oculomotor examination "seems indicated, although the most valid method for assessing oculomotor function is not clear".³⁶

Measurement properties in other sports. In a meta-analysis of 15 studies, any King-Devick worsening from an individual baseline had sensitivity of 86% (95% CI, 78%-92%) and specificity of 90% (95% CI, 85%-93%); concussed athletes worsened by 4.8 seconds while controls improved by 1.9 seconds, and test-retest ICC was 0.92 with a 2.8-second learning effect.⁴⁶ Other reviews reported a summary sensitivity of 0.77 and specificity of 0.82 at very low GRADE credibility, as reported in an abstract,⁵¹ AUCs from 0.51 to 0.92,⁵³ and sensitivity of 5% to 48% in athletes with baseline examinations.⁵ The systematic review for the SCAT6 reported King-Devick and near point of convergence sensitivities of 21% to 39% and 9% to 64% in collegiate athletes, lower than the VOMS, which it recommended as an optional SCAT6 task.³⁷ In a pediatric review, abnormal pursuits, saccades and vestibulo-ocular reflex findings had specificity of 0.92 to 0.96 but sensitivity no higher than 0.40.¹⁰⁰ Composites outperformed single tests: worsening on at least 1 of the King-Devick test, the SAC or timed tandem gait occurred in all concussed athletes in one analysis.⁴⁶

Combat-sport context. In 140 MMA athletes tested within 15 minutes of the match, a King-Devick cut-off of 5 seconds or any error had sensitivity of 21.05% and specificity of 93.39%, and failure to show the expected improvement (a -3-second cut-off) had sensitivity of 79.0% and specificity of 43.0%.¹¹⁰ An MMA abstract reported worsening after a KO, TKO, choke or submission and improvement without one.⁵⁹ Outside competition, combat athletes more often had at least 1 abnormal VOMS or convergence result than controls (45% vs 22.5%), as reported in an abstract,¹⁵ which implies a false-positive burden for such items. In Nevada professional boxing, traumatic mydriasis (0.14%) and double vision (0.14%) were recorded as eye injuries rather than concussion findings.¹⁸

Certainty. Amateur evidence was SORT Level 3 (disease-oriented variables, single-case concussion observations, small samples). The overall evidence for rapid-naming and oculomotor tests was Level 2, with inconsistent and imprecise accuracy and high or unassessable risk of bias in the combat-sport data. Pupil items rested on consensus, guideline, rule and eye-injury statements (Level 3); no study evaluated the pupil examination as a concussion screen.

Implications for the cards. Card 8 records the pre-bout pupil baseline and scores pupils after the Card 5 eye check, with a brief deferral of the penlight test after an eye injury; a new inequality or a sluggish or nonreactive pupil is a red flag unless the ringside physician attributes it to a direct eye injury. Card 9 uses the SCAT6-type bedside screen (an H pattern with the head still, double vision asked at each end position) and treats a few beats of nystagmus at the far end of gaze as normal; persistent double vision, spontaneous or sustained nystagmus or loss of eye movement in one direction routes to Card 3 and the Card 5 eye check. Each card carries 1 point. An abnormal finding counts against "no deficit detected", but a normal result does not exclude concussion, and RACE1 does not borrow accuracy figures from timed tests. If a timed rapid-naming task is added alongside RACE1, the evidence supports scoring change from the boxer's own same-event baseline and treating failure to improve as a flag.

3.13 Motor and Balance, Including the Functional Ring Tasks (Cards 10 to 14)

Amateur findings. No study, in boxing or any other sport, evaluated the RACE1 functional ring tasks (standing and inserting the mouthpiece, raising the guard, resisting downward pressure, stepping laterally and removing the mouthpiece). The amateur data

concern standing balance and general motor function, and no within-subject study found post-bout deterioration. In 61 female boxers, an abstract reported that modified BESS (mBESS) errors fell from 5.5 to 2.2 ($P < .001$) within a day of elimination, with practice effects likely;⁵⁸ force-plate postural control was "unaltered for all conditions" immediately and 24 hours after sparring;²⁹ motor skills, balance, coordination and gait were normal in 30 elite boxers 1 to 6 days after a bout, and finger tapping did not differ from controls (dominant hand, 52.2 vs 52.8; $P = .94$);⁸⁶ and an abstract reported enhanced motor functions after a fight.⁵⁴ In a crossover of 14 boxers fighting with and without headgear, a condition-by-time interaction on a balance tracking system ($P = .039$) and lower post-bout sway with headgear were reported, with fewer head attacks received per bout with headgear (38.5 vs 51.1; $P = .047$);⁸⁹ this is a between-condition balance difference in a small sample at high risk of bias, not evidence about concussion. In club boxers, a pre-bout warm-up raised mediolateral sway ($P < .001$) and a wider stance reduced it.¹⁹ By vote count, 2 studies showed improvement, 2 no change and none deterioration.

Consensus, tools and rules. The video-sign consensus defines motor incoordination as appearing unsteady on the feet (loss of balance, struggling to get up, falling over, staggering or stumbling) or in the upper limbs (fumbling).²⁶ The 6th consensus statement lists ataxia and poor balance among removal signs unless an experienced clinician attributes them to another cause such as a musculoskeletal injury.⁹¹ The SCAT6 examination includes finger-to-nose, three 20-second mBESS stances on a hard surface and timed tandem gait over 3 meters, with an optional dual-task gait,³⁵ and its introduction states that static balance should precede single- and dual-task tandem gait and that the mBESS is most accurate when given by the same person at baseline and after injury.³⁴ In the collision-sport panel, motor incoordination or ataxia and balance disturbance reached 100% agreement as clinical and removal signs, while the mBESS did not reach consensus (76%).⁵⁵ The AMSSM described balance disturbance as specific but not very sensitive and noted that footwear, surface, ankle tape or braces and lower-extremity injury alter sideline balance.⁵⁰ The ARP named balance difficulty and gait issues as concussion signs.⁸⁵ USA Boxing directs the physician to look for facial weakness, hemiparesis or other focal signs.¹¹²

Measurement properties in other sports. The AAN guideline judged the BESS to have low to moderate accuracy (sensitivity, 34%–64%; specificity, 91%).⁴⁷ A review found that the BESS identified about 35% of concussed athletes, had test-retest ICCs of 0.50 to 0.75, required a change of about 7 errors with the same examiner or 9 with different examiners to exceed measurement error, and showed learning effects of 3 to 4 errors.⁹⁷ Concussed athletes made about 17 errors against 8 on day 1 and returned to baseline within 3 to 5 days.⁶ The systematic review for the SCAT6 reported BESS and mBESS sensitivities of 60% and 71% in the first week against baseline and, in 1 adolescent study within 10 days of injury, single-task tandem gait at a 16-second cut-point with sensitivity of 87.5% and specificity of 72.4%;³⁷ other reviews reported tandem gait AUCs of about 0.5 to 0.7⁵ and worsening in 75% of concussed athletes, with an AUC of 0.81.⁴⁶

Combat-sport context. In MMA, mBESS, tandem-stance and double-leg errors showed no pre-post change after traumatic events.¹¹⁰ A case report abstract linked ataxia after a KO to cerebellar hemorrhage.⁶³

Certainty. Amateur evidence was SORT Level 3; the overall evidence for standing balance and gait tests was Level 2, with inconsistent sensitivity and conflicting reliability estimates. For the functional ring tasks, only consensus definitions of observable motor signs were found (Level 3).

Implications for the cards. The ring tasks are presented as consensus-derived and unvalidated. The mouthpiece tasks correspond to the upper-limb (fumbling) element of the consensus definition of motor incoordination, and the stand, guard and lateral-step tasks to its balance and gait elements. Card 10 is performed only after a normal cervical screen, with surface, footwear and a shoulder-width stance recorded; injuries that invalidate a task are marked U on Card 5; and Cards 10 to 14 are repeated after a short rest before the final disposition, because exertion degrades balance for about 20 minutes. New weakness in one limb, ataxia after a KO and progressive imbalance route to Card 3. A clear abnormality precludes "no deficit detected", but normal performance does not exclude concussion.

3.14 Speech and Comprehension (Cards 16 and 17)

Amateur findings. One amateur study addressed speech or language. Among 30 elite boxers, speech was normal on neurological examination, and vocabulary (31.9 vs 30.5; $P = .61$) and verbal fluency (36.9 vs 37.6; $P = .91$) did not differ from controls 1 to 6 days after a bout.⁸⁶ None of these boxers had lost consciousness in the last bout, so the study provides no data on speech in concussed boxers.

Consensus, tools and rules. USA Boxing instructs the physician examining a stricken boxer to "Note speech - altered, slow or repetitive?" alongside the orientation and recall questions; this is the only amateur rule text found that names a speech check.¹¹² In the collision-sport panel, slurred speech reached 94% agreement as a clinical sign and 100% as a removal sign.⁵⁵ The SCAT6 lists "inability to respond appropriately to questions" within an observable sign and includes the GCS verbal component,³⁵ and the AMSSM lists answering questions slowly and repeating questions among cognitive signs.⁵⁰ The SCAT6 introduction records language preference and states that literal translation of assessment tools is not adequate or valid.³⁴

Measurement properties and context. A pediatric review described language evaluation (naming, word-finding and comprehension) as part of the cognitive examination but reported no accuracy data for it.¹⁰⁰ No source reported the sensitivity, specificity, reliability or practice effects of a speech or comprehension item. In professional boxers, an abstract reported a significant within-subject change in verbal fluency after a bout, with one-month scores above baseline.⁹⁶

Certainty. Amateur and overall evidence was SORT Level 3.

Implications for the cards. Cards 16 and 17 are observational checks scored from the boxer's speech and responses throughout the examination, 1 point each, in the boxer's preferred language. Slurred, slow, altered or repetitive speech, word-finding difficulty, a blank stare or inability to respond appropriately precludes "no deficit detected". A facial, jaw or dental injury or a language barrier allows the speech item to be marked U. The evidence does not support treating these items as discriminating tests.

3.15 Disposition, Restrictions and Return to Participation (Card 18)

Amateur findings. No amateur study tested a disposition rule, suspension period or return criterion against an outcome. Abstracts described amateur practice incidentally: re-admission after a stoppage for dangerous head blows once the electroencephalogram had normalized and clinical signs had resolved in Italian female boxing,¹¹ suspension of Golden Gloves boxers after a KO or excessive head blows for an unstated period,⁶¹ and continued tournament participation conditional on no significant computerized-test deterioration within 24 hours.⁸¹

Rules. The primary rule documents set out the current amateur schedules directly. Under the USA Boxing National Rule Book, the ringside physician classifies a KO or severe head blow that ends a bout and prescribes a minimum restriction of 30 days without LOC, 90 days for LOC under 1 minute and 180 days for LOC over 1 minute; a second LOC within 90 days of resuming boxing doubles the highest applicable period, 3 LOCs within 365 days carry a minimum of 540 days, and return requires written clearance from a qualified medical physician and a Restriction Affidavit.¹¹³ The Rule Book also contains a separate KO-count rule (at least 30 days after 1 KO or stoppage for hard head blows, at least 90 days after 2 within 90 days and at least 1 year after 3 within 12 months),¹¹³ whereas the Medical Handbook sets 18 months after a third KO within 365 days and doubles the longer suspension for a second event within 90 days;¹¹² the schedules for repeat events are not consistent with one another. The handbook gives the ringside physician authority to stop or terminate a bout, with that decision taking "precedence over all other considerations".¹¹² World Boxing requires a post-bout examination of all boxers, the latest SCAT after a KO or a stoppage for head blows, CT for any LOC, persistent amnesia, a GCS of 14 or less or deterioration, and a declaration of fitness by a doctor or neurologist before return, if possible after CT or magnetic resonance imaging; its suspension periods are not quoted here because their mapping to LOC status could not be verified in the text obtained.¹¹⁵

Consensus and guidelines. The ARP consensus recommended evaluating every athlete, winners included, immediately and again in a quieter setting, minimum suspensions of 30, 60 and 90 days after TKO from head blows, KO without LOC and KO with LOC, and clearance by a concussion-trained specialist.⁸⁵ The ARP neuroimaging consensus specified transport for red flags as described above and repeat brain magnetic resonance imaging before the next bout after significant head impact exposure,⁹⁹ and the older-fighter statement held that suspension after concussion or KO or TKO from head blows "should be individualized such that recovery is documented prior to clearance".⁹ Lack of full recovery and clearance from the most recent concussion is an ARP high-risk criterion, as reported in an abstract.⁸² The 6th consensus statement held that a player with removal signs should not return that day unless an experienced clinician's multimodal assessment attributes the sign elsewhere, that such an assessment takes at least 10 to 15 minutes, and that any screen short of it "may be inadequate to allow continued sports participation".⁹¹ The SCAT6 "should NOT be used by itself to make, or exclude, the diagnosis of concussion", an athlete "may have a concussion even if their SCAT6 assessment is within normal limits", and its scores are not a stand-alone basis for return decisions.³⁵ The AMSSM prohibited same-day return after diagnosis;⁵⁰ the AAN guideline recommended more conservative return for athletes of high-

school age or younger;⁴⁷ the Australian statement set return to contact for children no sooner than 14 days after symptoms resolve;³⁸ the collision-sport panel agreed that return should be considered only with no clinical signs and a normal head injury assessment (100%);⁵⁵ and the CRT6 advises that a removed athlete not be left alone, drink alcohol or drive.³³

Context. Professional suspension practice was described as arbitrary and not standardized, and in a 2022 survey of 64 commissions, licensure imaging requirements ranged from none to annual magnetic resonance imaging or angiography.⁹⁹ Cadets were cleared to full activity 4 days after a boxing concussion while still slowed, as reported in an abstract.¹¹⁴

Certainty. Amateur and overall evidence was SORT Level 3. The suspension periods (30 to 180 days for a first event in USA Boxing; 30 to 90 days in the ARP schedule; 540 days, 1 year or 18 months for repeat events, depending on the document) have no outcome data behind them.

Implications for the card. Card 18 assigns the first disposition that applies. Emergency follows any red flag at any time; no score total triggers it, and the "total below 15" trigger of the earlier edition was removed because no source supported it. Not cleared follows a total below 20 or any sign, altered consciousness, memory gap, symptom or unreliable test, with no return to participation, a mandatory multimodal physician evaluation and the governing body's minimum restriction. No deficit detected is not a clearance and permits no same-day return. Card 18 records LOC presence and duration (the federations tier restrictions on it), the rule set and written instructions, and RACE1 is described as the first step that precedes, and never replaces, a multimodal evaluation such as the SCAT6, which World Boxing requires after a KO or stoppage for head blows.

4. The RACE1 Ringside Acute Concussion Examination (Edition 4)

4.1 Design Principles

Role of the cards. The RACE1 cards are intended to give the ringside clinician structured guidance after the bout. They do not supersede the authority, clinical judgment or decisions of the ringside physician or any other licensed ringside clinician, and they do not replace the rules or medical requirements of the governing body. Whether to stop a bout, whether to transport, and whether and when an athlete is cleared remain decisions of the ringside physician. The complete deck is reproduced in Appendix C.

Seven principles follow from the evidence in section 3. First, any observable sign, altered consciousness, memory gap, symptom, examination deficit or unreliable test after the bout precludes a "no deficit detected" result and any return to participation that day, because no single domain was sensitive enough to exclude concussion. Second, a normal screen is never a clearance, because no item or combination has been validated in boxing and even the SCAT6 can be normal in a concussed athlete.³⁵ Third, red flags are checked first, at every card, and again before the boxer leaves the venue, because deterioration can follow an initially normal course.⁷⁴ Fourth, confounding injuries are screened before the items they affect are interpreted, and a confounder is never used at ringside to dismiss a suspected concussion.⁹¹ Fifth, items are brief, bout-specific and need only the deck, a pen, a penlight, a timer and examination gloves. Sixth, a stoppage is recorded as a trigger for the examination, never as a diagnosis. Seventh, winners and losers are screened alike.^{85,115}

4.2 Post-Bout Use and the Pre-Bout Baseline

RACE1 is used only after the bout has ended, whether by KO, stoppage, corner retirement or the final bell. It is not calibrated for use while a bout or any active combat is in progress, it is never used between rounds, and it is never used to determine return to participation the same day or during active competition. Edition 4 removed the earlier provisions for use after a knockdown or whenever an evaluation was requested during a bout, and removed the "bout ongoing" status. The decision to stop a bout remains the ringside physician's in-competition decision under the governing body's rules,¹¹² and nothing in RACE1 substitutes for it.

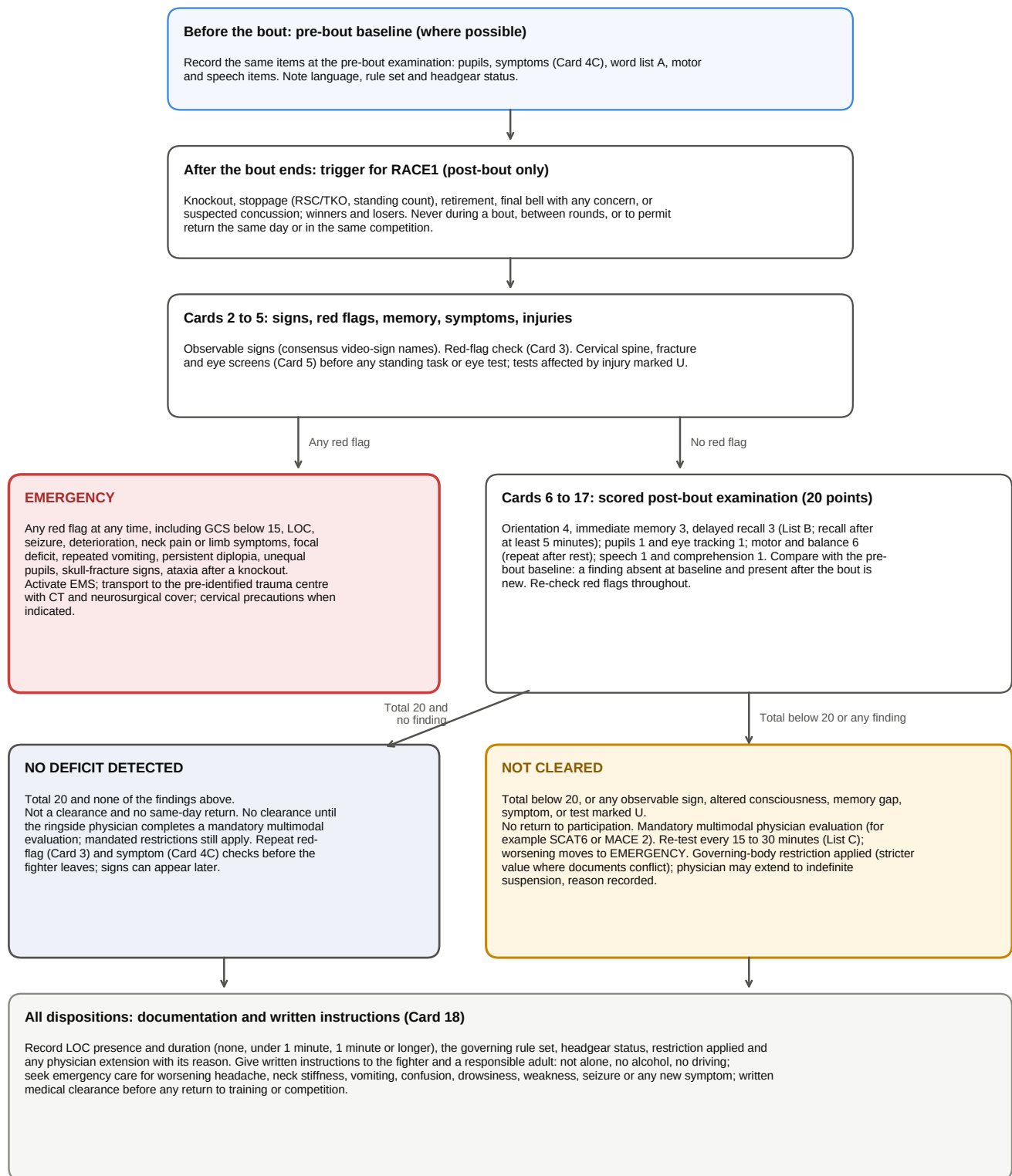
Wherever possible, the same items are recorded at the pre-bout examination that federations already require, as the boxer's own baseline: pupils, symptoms, word List A and the motor and speech items, with the boxer's language, the rule set and headgear status. Items that cannot be recorded before the bout (the opponent's name and the last round) are left blank. Card 18 carries pre-bout baseline, post-bout and re-test columns, and a finding absent at baseline and present after the bout is new. The baseline is a same-event baseline by design, because practice effects and exertion confound comparisons with a pre-tournament baseline after several bouts,^{46,58} and because balance comparisons are most accurate with the same examiner.³⁴

4.3 Card-by-Card Description

RACE1 has 18 cards (Table 7). Card 1 states the purpose, the examiner (the ringside physician or a licensed clinician working under the physician's direction), the materials and 7 global rules: a red flag at any point ends the examination; Card 5 is completed before any standing task or eye test; word List A is used at baseline, List B after the bout and List C at re-test, in the boxer's preferred language; a test made invalid by an injury is marked U and scores 0; Cards 10 to 14 are repeated after a short rest; winners and losers are screened; and, when in doubt, the boxer is not cleared. Cards 2 to 5 are unscored and record the incident and bout details (contest type, headgear, rule set, result, language and interpreter), mechanism, bout status, observable signs, red flags, altered consciousness, memory of the event, symptoms and confounding injuries. Cards 6 to 17 hold the scored items: orientation (4 points), immediate memory (3) and delayed recall (3), for a cognition subtotal of 10; pupils (1) and eye tracking (1), for an oculomotor subtotal of 2; 5 functional ring tasks (standing and inserting the mouthpiece, 2; guard, 1; resistance, 1; lateral movement, 1; mouthpiece removal, 1), for a motor and balance subtotal of 6; and speech (1) and comprehension (1), observed throughout, for a subtotal of 2. The total is 20. Card 18 holds the score summary, LOC duration, disposition, restriction, written instructions and signatures. The score bands are provisional and have not been validated against a clinical diagnosis, and a total of 20 does not exclude concussion.

4.4 Decision Pathway

Card 18 assigns the first applicable disposition (Figure 9). Emergency applies to any red flag at any time, including a GCS score below 15; the examiner activates emergency medical services under the emergency action plan and transports the boxer to the pre-identified trauma center with CT and neurosurgical cover, with cervical precautions when indicated. Not cleared applies to a total below 20 or to any observable sign, altered consciousness, memory gap, symptom or test marked U: the boxer does not return to participation; a multimodal physician evaluation, for example the SCAT6 or the Military Acute Concussion Evaluation 2 (MACE 2), is mandatory; the boxer is re-tested every 15 to 30 minutes with a new word list, and any worsening leads to Emergency; and the governing body's minimum restriction is applied. No deficit detected applies only to a total of 20 with none of those findings; it is not a clearance and permits no same-day return, no clearance is given until the physician completes a mandatory multimodal evaluation, mandated restrictions still apply, and the red-flag and symptom checks are repeated before the boxer leaves.



RACE1 never diagnoses or excludes concussion and never clears a fighter; score bands are provisional and unvalidated.

Card numbers refer to RACE1 (edition 4).

Figure 9. RACE1 decision pathway (edition 4). Top: before the bout, the same items are recorded where possible as a pre-bout baseline (pupils, symptoms on Card 4C, word List A, motor and speech items), with language, rule set and headgear status. RACE1 is triggered only after the bout ends (KO; stoppage, including referee stoppage, TKO and standing count; retirement; or

the final bell with any concern or suspected concussion), for winners and losers, and is never used during a bout, between rounds or to permit return the same day or in the same competition. Cards 2 to 5 record observable signs, red flags, memory, symptoms and injuries, with the cervical spine, fracture and eye screens completed before any standing task or eye test and tests affected by injury marked U. Any red flag leads to EMERGENCY (activation of emergency medical services and transport to the pre-identified trauma center with CT and neurosurgical cover; cervical precautions when indicated). Without a red flag, Cards 6 to 17 give the scored post-bout examination (20 points), compared with the baseline. A total below 20 or any finding leads to NOT CLEARED (no return to participation; mandatory multimodal physician evaluation, for example SCAT6 or MACE 2; re-test every 15 to 30 minutes with List C, with worsening moving to EMERGENCY; governing-body restriction, with the stricter value where documents conflict and physician extension up to indefinite suspension with the reason recorded). A total of 20 with no finding leads to NO DEFICIT DETECTED, which is not a clearance and permits no same-day return; red-flag and symptom checks are repeated before the boxer leaves. All dispositions record LOC presence and duration, rule set, headgear status and restriction, and include written instructions. RACE1 never diagnoses or excludes concussion and never clears a boxer; score bands are provisional and unvalidated. Source: RACE1 (edition 4), October 1, 2026. Abbreviations: CT, computed tomography; EMS, emergency medical services; GCS, Glasgow Coma Scale; KO, knockout; LOC, loss of consciousness; MACE 2, Military Acute Concussion Evaluation 2; RSC, referee stopped contest; SCAT6, Sport Concussion Assessment Tool 6; TKO, technical knockout; U, unreliable.

4.5 Disposition, Restriction and Documentation

Card 18 records LOC presence and duration (none, under 1 minute, 1 minute or longer, or unknown), because both federations tier their minimum restrictions on it, together with the governing rule set and the result. Section C records the minimum restriction under that rule set; where the governing body's documents conflict, the stricter value applies (for USA Boxing, 18 months after 3 KOs in the Medical Handbook against 1 year in the Rule Book), and the physician may extend any restriction on clinical judgment, up to an indefinite suspension pending further evaluation, recording the reason. Section D lists the written instructions given to the boxer and a responsible adult: not to stay alone that night, drink alcohol or drive; to seek emergency care for worsening headache, neck stiffness, vomiting, confusion, drowsiness, weakness, seizure or any new symptom in the following days; and to obtain written medical clearance before any return to training or competition.^{33,74} Section E records the final disposition and the physician's decision after the multimodal evaluation, limited to release from the venue with instructions and restriction, or transport; the option "cleared" was removed. In line with the objective of a protocol that applies regardless of rule set, the deck is intended for use after professional and amateur bouts across combat sports, with contest type, rule set and headgear status recorded, although the evidence reviewed concerns mainly amateur and Olympic-style boxing and RACE1 has not been evaluated in any sport. No separate youth item was added.

Figure 10 shows 4 cards as printed in half-letter format.

RACE1 Ringside Acute Concussion Examination, edition 4: selected cards (half-letter format)

Card 3: red flags

RACE1 • Ringside Acute Concussion Examination

CARD 3 of 18 Red Flags: Stop and Activate the Emergency Plan

If ANY red flag is present at ANY point in the exam, stop RACE1, do not clear the fighter, obtain immediate ringside physician evaluation, and activate EMS under the commission's emergency action plan.

- ☐ Glasgow Coma Scale score below 15
- ☐ Loss of consciousness or unresponsiveness of any duration. Duration: ☐ under 1 minute ☐ 1 minute or longer ☐ unknown
- ☐ Seizure or convulsion
- ☐ Deteriorating or fluctuating level of consciousness
- ☐ Increasing confusion, agitation, or combativeness
- ☐ Neck pain, midline neck tenderness, or painful or restricted neck movement (Card 5A)
- ☐ Weakness, numbness, tingling, or paralysis in any limb
- ☐ New focal neurological deficit (for example, facial droop or loss of eye movement in one direction)
- ☐ Severe or increasing headache
- ☐ Vomiting more than once
- ☐ Persistent double vision
- ☐ Unequal pupils, or a sluggish or non-reactive pupil, not explained by an eye injury (Card 5C)
- ☐ Spontaneous or sustained nystagmus
- ☐ Signs of skull fracture: bruising behind the ear (Battle's sign), bruising around both eyes (raccoon eyes), blood or clear fluid from the ears or nose, or a palpable skull deformity
- ☐ Ataxia after a knockout, progressive loss of balance, or unable to stand or walk without assistance

Unconscious or unresponsive fighter: assume a cervical spine injury. Do not move the head or neck. Protect the airway.

Result

- ☐ No red flag: continue to Card 4
- ☐ Red flag present: STOP. Record the time and go to Card 18 (Emergency).

Time: _____

GCS threshold score: SCAT6 (2023): Association of Ringside Physicians neurosurgery consensus (2022); NICE NG232 (2023). Repeat this red-flag check before the fighter leaves the venue: deterioration can follow a lucid interval.

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Card 5 (front): cervical spine, fracture and eye screens

RACE1 • Ringside Acute Concussion Examination

CARD 5 of 18 Confounding Injuries and Test Reliability

Complete Sections A to C before any standing task (Cards 10 to 14) and before interpreting Cards 4C, 8, and 9.

A. Cervical spine screen

- ☐ Neck pain at rest
- ☐ Midline tenderness on palpation
- ☐ Pain or restriction on active neck rotation (only if no pain at rest and no tenderness)
- ☐ Arm or leg weakness, numbness, or tingling
- ☐ All normal

Any abnormal finding is a red flag (Card 3): immobilize and transport; do not perform standing tasks.

B. Fracture suspicion

- ☐ Skull fracture signs (Card 3 red flag)
- ☐ Facial or jaw fracture (deformity, malocclusion, step-off)
- ☐ Orbital fracture (eye movement restriction, numb cheek, enophthalmos)
- ☐ None

Suspected facial, jaw, or orbital fracture: transfer for CT. Normal radiographs do not exclude orbital fracture.

C. Eye and periorbital screen

- ☐ Hyphema, globe injury, or eye swollen shut
- ☐ Sudden loss or reduction of vision, flashes, or floaters
- ☐ Laceration of the eyelid or around the eye
- ☐ None

Any finding: emergent ophthalmology referral (Association of Ringside Physicians eye conditions statement). After an in-competition eye injury, defer the tonight test briefly; mark Cards 8 and 9 U if the eye cannot be examined visibly.

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Card 18 (front): score summary with baseline, post-bout and re-test columns

RACE1 • Ringside Acute Concussion Examination

CARD 18 of 18 Scoring, Disposition, and Signatures

A. Score summary

Domain and card	Max	Pre-bout baseline	Post-bout exam	Re-test
Orientation (Card 6)	4			
Immediate memory (Card 7)	3			
Delayed recall (Card 15)	3			
Cognition subtotal	10			
Pupils (Card 8)	1			
Eye tracking (Card 9)	1			
Oculomotor subtotal	2			
Stand up and moultplace (Card 10)	2			
Guard (Card 11)	1			
Resistance (Card 12)	1			
Lateral movement (Card 13)	1			
Moultplace removal (Card 14)	1			
Motor and balance subtotal	6			
Speech (Card 16)	1			
Comprehension (Card 17)	1			
Speech and comprehension subtotal	2			
TOTAL	20			

Pre-bout baseline items not recordable before the bout (opponent, last round) are left blank. A finding absent at baseline and present after the bout is new.

Tests marked U: _____ Word list: Baseline _____ Post-bout _____

Re-test: _____ Motor re-test time: _____

Loss of consciousness: ☐ None ☐ Under 1 minute ☐ 1 minute or longer ☐ Unknown

Signatures

Examiner name and credential: _____

Signature: _____

Ringside physician: _____

Signature: _____

Exam start and finish times: _____

Re-test times: _____

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Card 18 (reverse): disposition, restriction, instructions

RACE1 • Ringside Acute Concussion Examination

CARD 18 of 18 (reverse) Disposition, Restriction, and Signatures

B. Disposition (apply the first category that fits)

Category	Criteria	Action
EMERGENCY	Any red flag (Card 3) at any time, including GCS below 15	Activate EMS. Transport to the pre-identified trauma center (CT, neurosurgery). Cervical precautions when indicated.
NOT CLEARED	Total below 20; or any observable sign (Card 2) or altered consciousness, memory gap, or symptom (Card 4); or any test marked U	No return to participation. Mandatory multimodal physician evaluation (e.g., SCAT6, MACE 2). Re-test every 15 to 30 min with a new word list. If worse, EMERGENCY. Apply Section C.
NO DEFICIT DETECTED	Total 20, with none of the findings above	Not a clearance and no same-day return: no clearance until the physician completes a mandatory multimodal evaluation; mandated restrictions still apply. Repeat Cards 3 and 4C before the fighter leaves. Signs can appear later.

The score bands are provisional and have not been validated against clinical diagnosis. A total of 20 does not exclude concussion.

C. Restriction (governing body minimum; physician may extend)

Rule set (Card 2): _____ Minimum restriction under that rule set: _____ days

Where the governing body's documents conflict, apply the stricter value.

Physician extension: ☐ None ☐ Extended to _____ days ☐ Indefinite suspension pending further evaluation

Reason for extension: _____

D. Written instructions given to the fighter and a responsible adult

- ☐ Do not stay alone tonight; do not drink alcohol; do not drive
- ☐ Seek emergency care for worsening headache, neck stiffness, vomiting, confusion, drowsiness, weakness, seizure, or any new symptom in the following days
- ☐ Written medical clearance is required before any return to training or competition

E. Final disposition

- ☐ Emergency transport ☐ Not cleared ☐ No deficit detected

Physician decision after multimodal evaluation: ☐ Released from venue with instructions and restriction ☐ Transport

RACE1 card deck, recorded edition v4 • © 2026 Sears, LLC • For licensed healthcare professionals

Figure 10. Selected RACE1 cards, edition 4, half-letter format. Left to right: Card 3, red flags (15 items, including GCS below 15 with its sources, LOC of any duration with duration boxes, persistent double vision, unequal or nonreactive pupil not explained by eye injury, spontaneous nystagmus, skull fracture signs and ataxia after a KO; any red flag stops RACE1 and activates the emergency plan; the check is repeated before the boxer leaves the venue); Card 5 front, cervical spine screen, fracture suspicion and eye and periorbital screen, completed before any standing task and before Cards 4C, 8 and 9 are interpreted; Card 18 front, score summary with pre-bout baseline, post-bout and re-test columns, unreliable tests, word lists, LOC duration and signatures; and Card 18 reverse, disposition table (Emergency, Not cleared, No deficit detected), restriction (governing body minimum, stricter value where documents conflict, physician extension), written instructions and final disposition. The score bands are provisional and unvalidated. Source: RACE1 (edition 4), © 2026 Sears, LLC; for licensed health care professionals. Abbreviations as in Figure 9.

4.6 Reconciliation History From the "CTE Rapid Exam" to Edition 4

The source deck (January 28, 2026) was titled "CTE Rapid Exam," although chronic traumatic encephalopathy cannot be assessed at ringside. Its internal review found red flags on 4 cards with different wording, LOC listed as a red flag on one card and only as an observable sign on another, duration boxes that left exactly 1 minute unassigned, a card titled "Symptoms" that listed only red flags (so that a boxer with a headache could score 20 and be classed as normal), an amnesia question that tested orientation, standing tasks in an impossible order, an undefined "verbal domain" score, and a 4/5/6/5 domain score that mirrored the GCS. Edition 2 corrected 21 such problems: the title was changed; an instruction card was added; red flags were merged into one list with one action; an unscored symptom report was added; confounding injuries and test reliability were merged, with unreliable tests marked U; immediate memory was scored, with alternate word lists and a minimum 5-minute recall delay; the standing tasks were reordered; speech and comprehension were scored by observation throughout; and the scoring became Cognition 10, Oculomotor 2, Motor and balance 6 and Speech and comprehension 2. Edition 3 applied the author's evidence-based decisions: the unsupported "total below 15" emergency trigger was removed and a GCS red flag added with its sources; the cervical spine, fracture and eye screens, context fields, bout-specific orientation, adapted word lists, a pre-bout pupil baseline, standardized conditions and repetition of the motor items, LOC duration, restriction rules, written instructions and professional-bout fields were added; and the "no deficit detected" category was defined as not a clearance. Edition 4 restricted use to the period after the bout: post-bout use only, a pre-bout baseline of the same items, word lists assigned to baseline, post-bout and re-test, baseline columns on Card 18, and the explicit statement that a "no deficit detected" result permits no same-day return. The 20-point structure and the provisional status of the score bands were not changed after edition 2. Table 8 condenses the 3 sets of changes.

5. Discussion

5.1 Principal Findings by Outcome

No amateur or Olympic-style boxing study has measured the accuracy, reliability or practice effect of any item that a ringside physician can administer in the minutes after a bout. Every amateur screening component was graded SORT Level 3, and the Level 2 overall grades rest on team-sport, pediatric, collegiate, MMA and military evidence. What the amateur literature does provide differs by outcome, and the outcomes do not substitute for one another.

For diagnosed concussion, the amateur data consist of small numerators against incompatible denominators: 2 concussions among 281 registered boxers at one Olympic Games,⁶² 7 of 12 Games concussions in boxing at another without a boxer denominator,¹⁰³ zero or single events in female competitions,^{12,25,58} and a widely cited elite-squad rate that cannot be reproduced from its own counts.^{71,85} These data support saying that diagnosed concussion is recorded infrequently; they do not support any single incidence figure, and recorded frequency depends on how actively concussion is sought.

For screen-detected impairment, the amateur studies show that a negative ringside impression does not exclude impairment. An abstract reported evolving cognitive slowing in boxers not suspected at ringside,⁸¹ an abstract reported delayed-memory decline after sparring,¹⁰⁶ and memory deteriorated more often than any other domain in the direction-of-effect analysis. Speed and balance measures more often improved, which is what practice and exertion effects would produce; this pattern is the main reason RACE1 compares post-bout findings with a same-event baseline rather than a pre-tournament one.

For stoppage and KO, rates changed with headgear rules, scoring systems and bout formats,^{10,27} and the direction of the headgear contrast depended on whether head-blow stoppages or all-cause stoppages were counted. Stoppage is a referee decision under a given rule set, not a diagnosis; one series equated KO with concussion⁷ and one widely cited "concussion" proportion was a head-blow stoppage proportion, as reported by a later meta-analysis.⁷⁵ RACE1 therefore records the bout status as the trigger for the examination and keeps it separate from the disposition.

For laceration and fracture, the data are comparatively consistent: lacerations and abrasions were the largest single injury type in Olympic boxing, fractures were less frequent, and cuts rose after headgear removal for senior men, as reported by 2 reviews.^{31,73} Their relevance to the screen is as confounders: they obscure vision, impair speech and mouthpiece handling and produce symptoms and signs that overlap with concussion, which is why Card 5 precedes the scored items.

5.2 Comparison With Existing Tools and Guidance

The SCAT6 is the reference multimodal assessment and the source of most RACE1 item formats: the cervical screen, the symptom list and its baseline wording, the ocular and motor screen, and the observable-sign and red-flag lists.³⁵ RACE1 differs from it in 4 ways. It is shorter; it replaces team-sport Maddocks items with the bout-specific questions already used in amateur rules;^{112,115} it uses 3-word rather than 10-word lists, accepting a likely ceiling effect that the SCAT6 review documented for shorter lists;³⁷ and it replaces the mBESS and tandem gait with functional ring tasks that no study has evaluated. Each difference is a trade-off. Because the 6th consensus statement warned that screening short of a multimodal evaluation of at least 10 to 15 minutes may be inadequate,⁹¹ RACE1 is defined as the first step before a multimodal evaluation and is never a substitute for one.

The CRT6 is a recognition tool for non-clinicians that directs removal on suspicion and lists red flags, observable signs and symptoms; its post-removal instructions (not alone, no alcohol, no driving) are carried into Card 18.³³ Its developers acknowledged little systematic research on its utility, and its item lists were read here only in an adapted copy. RACE1 is intended for licensed clinicians and adds scored examination items, so the two tools serve different users.

MACE 2 appears on RACE1 only as an example of a multimodal physician evaluation. The searches targeted its reliability, validity and administration time, but the synthesis extracted no measurement data on MACE 2 itself; the only related boxing finding was an abstract reporting that post-fight King-Devick scores correlated with post-fight MACE scores in boxers and MMA fighters ($r = -0.79$).⁴⁵ No comparison of RACE1 with MACE 2 can be made from this evidence base.

ARP guidance is the closest combat-sport reference.^{9,57,85,99} RACE1 follows it in evaluating winners and losers, repeating the evaluation in a quieter setting, treating red flags as indications for transport to a trauma center with neurosurgical cover, deferring the penlight test briefly after an eye injury, and individualizing restrictions. It departs from it in using a GCS threshold of below 15 (the ARP older-fighter statement used below 13⁹) and in not adopting the ARP 30-minute symptom rule as a scored criterion, although any persisting symptom already precludes a "no deficit detected" result. The ARP suspension schedule (30, 60 and 90 days) differs from both federations' schedules, and Card 18 directs the physician to the governing body's own minimum rather than to the ARP schedule.

5.3 Considerations for Governing Bodies, by Outcome

The author serves on a state athletic commission (see Declarations), so the regulatory implications are stated as considerations for any governing body rather than as recommendations for a particular one. For diagnosed concussion, bodies that publish injury data could report diagnosed concussion separately from stoppage outcomes, with a stated case definition and an exposure denominator, because the current literature cannot be combined for want of both. For screen-detected impairment, the evidence that impairment can evolve after a negative ringside impression supports a structured post-bout re-examination and written instructions, both of which are already implied by World Boxing's post-bout examination of all boxers and the ARP consensus. For stoppage and KO, restriction schedules tied to LOC duration require that LOC presence and duration be recorded consistently, which RACE1 Card 18 does; the internal inconsistency between USA Boxing's Rule Book and Medical Handbook for repeat events^{112,113} is a matter its authors may wish to resolve, and the World Boxing suspension mapping to LOC status could not be verified in the text obtained. For laceration and fracture, the eye and fracture pathways (ophthalmology referral; CT for suspected orbital fracture even with normal radiographs) are independent of concussion and could be stated in event medical plans. Across outcomes, the identification of a receiving trauma center with neurosurgical cover before the first bout is consistent with the ARP neuroimaging consensus.⁹⁹ Licensure imaging requirements varied among 64 professional commissions

in a 2022 survey, from none to annual magnetic resonance imaging;⁹⁹ that survey listed the Alabama Athletic Commission, on which the author serves, as having no requirement at that time, a listing that has not been checked against current rules and is reported here for transparency only.

5.4 Generalizability

Sex. Female amateur data were limited to tournament and survey cohorts recording 0 or 1 concussion,^{12,25,58} 1 adolescent female motion-sickness cohort²² and a mixed-sex sparring cohort;¹⁰⁶ no study examined sex as a modifier of any ringside item. In other sports, females reported more and worse symptoms in 4 of 5 studies in one review,⁴¹ and SAC scores differed by sex in one study,²⁴ so sex-specific norms may matter for Cards 4C and 6 to 15.

Age. Amateur cohorts included boxers as young as 11² and 12.6 years;¹⁷ emergency-department series recorded concussion or closed head injury in 11.7% of boxing injuries in children aged 6 to 11 years¹⁰⁹ and 55.8% of boxing mild traumatic brain injuries in patients younger than 20 years.⁶⁹ Consensus recommends more conservative return for athletes of high-school age or younger⁴⁷ and at least 14 days after symptom resolution before contact for children,³⁸ and the AMSSM noted that second impact syndrome is "reported as more common in boxers and athletes under the age of 18".⁵⁰ RACE1 has no youth-specific item, and its 3-word lists and functional tasks have not been examined in children or adolescents.

Level and headgear. The evidence ranges from elite international tournaments to university clubs and military instruction, and headgear rules differ between federations (required in all USA Boxing divisions;¹¹³ removed for senior men in AIBA competition in 2013). RACE1 records level, rule set and headgear status so that these factors can be examined, but no conclusion about headgear and concussion can be drawn from the evidence reviewed.²⁸

Other combat sports and rule sets. RACE1 is intended as a post-bout protocol for combat sports regardless of the rule set, including professional boxing, MMA, bare-knuckle boxing, kickboxing, Toughman contests, amateur MMA and amateur boxing. Amateur boxing was used as the model because of its more stringent concussion rules and medical requirements, but the evidence base for this review is amateur and Olympic-style boxing, with professional boxing and other combat sports as context. Professional boxing recorded more concussions per fight than amateur boxing in the one cohort that reported both,¹¹⁶ and professional fighters reported concealing symptoms.⁸ Other combat sports differ from amateur boxing in protective equipment and permitted techniques, which may change both the post-bout findings and the confounding injuries. The ring tasks, word lists and dispositions have not been examined in any of these contests, including amateur boxing.

5.5 Mechanisms

This review did not set out to study mechanisms, and only mechanisms stated in the sources are noted here, each as proposed by its authors. Improvement on speed and balance tests after a tournament was attributed in part to practice effects by the authors of one abstract.⁵⁸ The increase in pre-bout sway after warm-up was attributed to physiological arousal.¹⁹ The authors of the elite cohort proposed that neuropsychological assessment without a baseline could not detect small axonal injuries.⁸⁶ A professional combat-sport consensus attributed ring deaths mainly to acute catastrophic events such as acute subdural hematoma.⁹⁹ In the kickboxing case, the delayed collapse was due to vertebral artery dissection with subarachnoid hemorrhage after a kick to the jaw.⁷⁴ In military cadets, the association of headache history with combatives concussion diagnosis was attributed partly to symptom overlap.¹ None of these proposals was tested in the evidence reviewed.

5.6 Fairness Considerations

Language. Amateur boxing is international, and the SCAT6 developers stated that literal translation of assessment tools is neither adequate nor valid.³⁴ A boxer examined in a second language may fail orientation, memory or comprehension items for reasons unrelated to injury. RACE1 records the preferred language and the use of an interpreter on Card 2, uses adapted word lists, allows the speech item to be marked U for a language barrier, and treats a resulting U as precluding "no deficit detected". This protects the boxer against false reassurance but may increase the number of boxers who are not cleared for non-medical reasons; validation should measure that effect.

Youth. Patients younger than 20 years accounted for more than half of boxing mild traumatic brain injuries in one emergency-department series,⁶⁹ youth boxers have the weakest ringside evidence base, and the consensus position is to be more conservative with them.⁴⁷ A screen that is unvalidated in adults should not be assumed valid in children.

Female boxers. The near-absence of female concussion data means that every RACE1 item is untested in women; female-specific evaluation should be built into validation rather than added later.

Access to imaging. The red-flag pathway assumes ambulance transport to a center with CT and neurosurgical cover. Where such a center is distant, the event medical plan has to identify it in advance;⁹⁹ a screen cannot compensate for its absence.

Winners and losers. The ringside-recognition cohort that found unrecognized impairment studied bout winners only,⁸¹ and the ARP and World Boxing call for the examination of all boxers.^{85,115} RACE1 applies the same examination to both, so that the result of the bout does not determine whether a boxer is screened.

6. Validation and Research Agenda

Validation should proceed in stages, each with prespecified methods and reporting. Stage 1 is feasibility and reliability: the time to complete the deck at ringside, the proportion of items completed and marked U, and inter-rater reliability of Card 2 signs, Card 3 red flags, each scored item and the Card 18 disposition, estimated with kappa statistics on paired live examinations and on video. The wide range of agreement on observable signs among expert raters in other sports (kappa, 0.08 to 0.89)¹⁰⁸ and the examiner dependence of balance error counts⁹⁷ make this the first priority. Stage 2 is agreement: concordance between the RACE1 disposition and the ringside physician's independent decision after a multimodal evaluation such as the SCAT6. Stage 3 is accuracy: sensitivity, specificity and likelihood ratios of the disposition and of each domain against a reference-standard concussion diagnosis made by a clinician blinded to the RACE1 result, with follow-up to capture delayed diagnoses. Stage 4 is item evaluation: the functional ring tasks against the SCAT6 balance sequence of mBESS and single- and dual-task timed tandem gait,^{35,37} the 3-word lists against a 10-word list for ceiling effects, the equivalence of Lists A, B and C, and the effect of exertion by comparing immediate and post-rest motor results. Stage 5 is baseline studies: test-retest stability of the pre-bout baseline within an event, practice effects across successive bouts of a tournament, and normative values by sex, age group and language. Stage 6 is a registry: completed cards record rule set, headgear status, LOC duration, dispositions and re-test times, and, with consent and governance, could link ringside findings to later diagnosis, restriction and return to participation. Youth and female boxers, professional bouts, other combat sports and different rule sets should be sampled explicitly in each stage, and the cut-offs and dispositions should not be described as validated until stages 2 and 3 are complete.

7. Limitations

The search departed from the planned 2-database protocol: at the author's direction, Scholar Gateway and Wiley Scholar Gateway, SciSpace, alphaXiv and ClinicalTrials.gov were added to PubMed/MEDLINE and Consensus. The added sources increase coverage, but the semantic search platforms return a fixed number of ranked results per query (Consensus 20, SciSpace 10, Scholar Gateway 20 passages), lower-ranked records were not retrieved, and the same query may rank records differently on another date, so their yield is neither exhaustive nor fully reproducible. PubMed/MEDLINE is the only source with fully reproducible field-tagged syntax. Preprint servers could not be keyword-searched. Some SciSpace queries were re-run because their first query text was not preserved.

Screening and extraction were performed by a single reviewer, with author verification of a 10% sample of screening decisions, all included amateur records and 20 extraction rows, and did not use independent duplicate review; errors outside the verified sample could remain. The synthesis was checked number by number in a separate verification round, but that round also used the extraction data.

The review was not registered; its protocol documents are available on request.

The amateur evidence was observational and heterogeneous, with small samples and differing exposures, timings, instruments, comparators and outcome definitions, which precluded pooling and limited the synthesis to description and vote counting, a method that ignores effect size and precision.

Of the 214 core records, 137 were available only as abstracts and 9 only through secondary sources, largely because BMJ journal hosts refused programmatic requests and the PubMed Central scanned archive returned a reCAPTCHA page throughout full-text retrieval; 16 title-only reports were not retrieved at all. Abstract-only findings are worded as reported, and secondary figures are attributed to the reporting source, but these choices cannot recover data that only the full text contains, and several secondary sources were themselves shown to contain errors (Appendix B).

Several rule, guideline and journal texts were obtained through a web retrieval utility that returned a text extraction of the page rather than a byte copy. Paraphrased passages are not quoted (World Boxing suspension periods and question wording; NICE NG232 recommendations 1.2.2 and 1.2.3; the CRT6 item lists, read from an adapted copy), and a number of values taken from full texts at the analysis stage (for example, for Bianco 2013, Davis 2017, Loosemore 2015 and Junge 2009) remain to be checked against the published PDFs.

The Level 2 overall grades for observable signs, orientation and memory, oculomotor, motor and balance and symptom items rest on other-sport evidence that is indirect for live ringside use in amateur boxing.

RACE1 is unvalidated. No item, cut-off, sequence or disposition has been tested for reliability, agreement or accuracy, the functional ring tasks have no direct evidence, and its use across combat sports other than amateur boxing rests on design intent alone.

The author designed RACE1 and holds regulatory roles in combat sports, which are disclosed in the Declarations.

8. Conclusions

This work set out to create a standardized post-bout ringside concussion protocol for combat sports regardless of the rule set, with amateur boxing, which has more stringent concussion rules and medical requirements, as the model. The published evidence, which concerns mainly amateur and Olympic-style boxing, supports a multidomain post-bout ringside screen in which any observable sign, red flag, altered consciousness, memory gap, symptom or examination deficit precludes a "no deficit detected" result and any return to participation that day. It does not support clearing an athlete on a normal screen. No amateur study has measured the accuracy or reliability of any ringside item, and the existing evidence must be kept separate by outcome, because diagnosed concussion, screen-detected impairment, stoppage, laceration and fracture answer different questions. RACE1 (edition 4) standardizes what the ringside physician records after the bout against a pre-bout baseline where possible, routes red flags to emergency transport, screens confounding injuries first, and links non-clearance to the governing body's restriction. It is never used during a bout or between rounds, assists the ringside physician, and never clears an athlete or permits return the same day or during active competition. RACE1 has not been evaluated in any sport. Its items and cut-offs require staged reliability, agreement and accuracy studies in amateur boxing and in the other combat sports it is intended to serve.

9. Clinical Recommendations

Table 9 lists all 26 draft recommendations of the evidence synthesis, each with its SORT strength and supporting sources; recommendations 4, 24 and 25 were reworded so that stopping a bout is stated as the ringside physician's in-competition decision, separate from RACE1, which is applied after the bout, and recommendation 26 was amended so that unverified World Boxing suspension periods are not quoted and the stricter value applies where USA Boxing documents conflict. No recommendation reached strength A. The 6 statements graded B are the strongest: after the bout, any observable sign, recorded with the consensus video-sign names, or confusion or amnesia precludes clearance, and absence of signs does not exclude concussion (recommendation 4); brief orientation, immediate-memory and delayed-recall items belong in a multimodal screen but never alone (recommendation 7); oculomotor items count against clearance when abnormal but do not clear when normal (recommendation 10); any timed oculomotor or naming task is scored against a same-event baseline, with failure to improve treated as a flag (recommendation 11); a clear motor or balance abnormality precludes clearance while normal performance does not exclude concussion (recommendation 13); and any reported post-bout symptom supports suspected concussion while absence of symptoms does not override signs or examination findings (recommendation 19). The remaining 20 statements, including all red-flag, confounding-injury, speech and disposition recommendations, are graded C because they rest on consensus, usual practice, rules or case material.

10. Declarations

Author Contributions

Casey C. Sears conceived the study, designed and reconciled the RACE1 instrument, set the eligibility criteria and the review decisions, verified the screening and extraction samples, and approved the final text.

Author Declarations / Competing Interests

Casey C. Sears serves as an appointed Commissioner for the Alabama Athletic Commission (AAC) and Principal Investigator for the AAC Combat Sports Health and Safety research project. He is the original developer of the RACE-1 and HTRP ringside medical protocols discussed in this manuscript. The author is also the founder of Sears Publishing Company, which serves as the distributor of this preprint.

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Use of Artificial Intelligence

This article was produced with the assistance of AI through an LLM. Any questions related to its use should be directed to editor@searspublishing.net.

Ethics

This review used published studies and public documents only and involved no human participants; ethics approval was not required.

Data Availability

The following supplementary files are available from the author on request: Supplementary File S1, search logs with the exact query strings, parameters, dates and counts and the DOI look-up lists; S2, screening workbook and screening log; S3, extraction workbook and evidence synthesis tables; S4, risk-of-bias judgments; S5, full-text retrieval report and retrieval texts; and S6, analysis scripts (Python output and base R script with its input file). The pooling feasibility report, the author verification workbook, the author decision record and the 3 RACE1 reconciliation records are also available on request.

Deviations From the Planned Protocol

The departures from the planned methods are listed in Table 10 with their reasons and handling.

Invitation to Collaborate and Review

This preprint is released to seek co-authors and initial peer review before journal submission. It has not been peer reviewed. Clinicians, ringside physicians, athletic trainers, researchers and regulators are invited to comment on the evidence review, the RACE1 cards and the validation agenda, and to express interest in co-authorship or in multi-site validation. Comments, corrections and reports of errors in any figure, citation or rule quotation can be sent to editor@searspublishing.net, preferably with the section, table or figure number. With the commenter's permission, comments will be acknowledged in the revised version.

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12. Tables

Table 1. Information sources, dates and record counts

Source	Content searched	Query runs (identifiers)	Date run	Records recorded (raw)	Unique within source	Entered screening	Notes
PubMed/MEDLINE	Biomedical literature, field-tagged Boolean queries	13 topic runs (PM-1 to PM-12, PM-8b); 17 DOI look-up runs (DX-1 to DX-17)	Sept 30, 2026	2,402 (all 13 runs)	1,970	1,847 (screening set) plus 111 PubMed-indexed records found only by other platforms	PM-8 (897 returned, 200 recorded) superseded by PM-8b and not screened; no date, language or type limits
Consensus	Semantic search, peer-reviewed literature	12 (CN-1 to CN-12)	Sept 30, 2026	240	192	192	Top 20 per query; no filters
Scholar Gateway and Wiley Scholar Gateway	Wiley Online Library full-text passages (same corpus)	13 (SG-1 to SG-9; WL-1 to WL-4)	Sept 30, 2026	260 passages; 128 article hits	91	91	20 passages per query; shared quota
SciSpace	Semantic search, multidisciplinary index	9 (SS-1 to SS-9)	Sept 30, 2026	90	83	83	10 per query; 6 queries re-run with recorded text
alphaXiv	arXiv (non-biomedical)	2 (AX-1, AX-2)	Sept 30, 2026	19	14	14	Context only; 1 off topic
ClinicalTrials.gov	Trial register	2 (CT-1, CT-2)	Sept 30, 2026	25	23	23	Most CT-2 records were exercise

Source	Content searched	Query runs (identifiers)	Date run	Records recorded (raw)	Unique within source	Entered screening	Notes
							interventions
medRxiv	Preprints	1 (MX-1), date-bounded listing	Sept 30, 2026	30	30	0	No keyword search available; 0 relevant by title; not counted
bioRxiv	Preprints	1 (BX-1), neuroscience listing	Sept 30, 2026	30	30	0	No keyword search available; 0 relevant by title; not counted
Backward citation searching	Reference lists of included boxing studies, the combat-sport consensus statement and key reviews	Not applicable	Sept 30, 2026	47 new cited works	Not applicable	18 sought	16 core and 1 context record included
Targeted searches (analysis stage)	Pooling feasibility candidates	Not applicable	Sept 30, 2026	18	Not applicable	18	10 included, 7 excluded, 1 awaiting classification
Web retrieval of full texts and documents	Publisher, repository and society sites; federation rules; NICE NG232	9 fixed routes, 550 logged requests	Sept 30 to Oct 1, 2026	103 targets	Not applicable	Not applicable	Full text 20, partial 9, secondary only 14, abstract only 47, not retrieved 13

Records identified for PRISMA: databases 2,227 (PubMed/MEDLINE 1,847; Consensus 192; Scholar Gateway and Wiley 91; SciSpace 83; alphaXiv 14) and register 23. The 111 PubMed-indexed records identified only by the semantic search platforms are counted under those platforms. Of 311 unique DOIs from non-PubMed sources, 244 were PubMed-indexed and 67 were not. Exact query strings are in Appendix A. Abbreviations: DOI, digital object identifier; NICE, National Institute for Health and Care Excellence; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Table 2. PRISMA 2020 flow counts

Stage	Count
Records identified from databases	2,227
Records identified from registers (ClinicalTrials.gov)	23
Duplicates removed before screening	185 (45 within platforms; 133 records from other platforms already retrieved from PubMed; 6 title matches; 1 arXiv-Consensus)
Records removed for other reasons	2 (no PubMed metadata)
Records marked ineligible by automation tools	0
Records screened (title and abstract)	2,063
Records excluded at title and abstract	1,477 (E1 415; E6 205; E4 174; E3 150; E8 109; E12 82; E13 77; E10 66; E9 65; E7 47; E2 37; E5 36; E11 14)
Eligible at title and abstract	586 (core 204; context 382)
Core reports sought for retrieval	204 (including 2 registry records)
Core reports not retrieved	16
Core reports assessed for eligibility	188
Core reports excluded at full text	0
Core records included from databases and registers	188
Other methods: citation searching, new cited works / sought / excluded at full text / included	47 / 18 / 1 / 17 (16 core, 1 context)
Other methods: targeted searches, identified / excluded / awaiting classification / included	18 / 7 / 1 / 10
Core evidence set	214 (IA 53; IB 95; IG 16; IR 50)
Context set (IC)	383 (382 from databases; 1 from citation searching)
Core set by text basis	Full text 60; partial text 6; secondary source only 9; abstract only 137; registry 2
Primary studies with risk of bias judged on full text / not assessable	33 / 83

Exclusion codes are defined in section 2.2. Counts are from the screening workbook (Supplementary File S2). Abbreviations: IA, amateur and Olympic-style boxing; IB, professional boxing and other combat sports; IC, other-sport or military context; IG, consensus statements, guidelines and rules; IR, systematic and scoping reviews.

Table 3. Risk of bias of the 33 primary studies judged on full or partial text

Study	Class	Design and setting	Tool	Overall judgment
Adkitte 2016 ²	IA	Cross-sectional retrospective questionnaire survey, 54 Indian national-level boxers	JB1 cross-sectional	High
Aderman 2025 ¹	IB	Retrospective cohort, military academy cadets	ROBINS-E	Some concerns

Study	Class	Design and setting	Tool	Overall judgment
		(combatives)		
Beltrani Filho 2010 ⁷	IA	Tournament surveillance, Brazilian amateur bouts 2000-2009	JB1 cross-sectional	High
Bennett 2018 ⁸	IB	Cross-sectional survey, professional boxers and MMA fighters	JB1 cross-sectional	High
Bianco 2013 ¹⁰	IA	Retrospective analysis of Olympic-style tournament verdicts, 1952-2011	JB1 cross-sectional	High
Brown 2024 (PMID 39095970)	IB	Retrospective cohort, Australian MMA competition	JB1 cross-sectional	Moderate
Brown 2025 ¹⁶	IB	Cross-sectional survey, taekwondo athletes	JB1 cross-sectional	Moderate
Butler 1993 ¹⁷	IA	Prospective controlled pre/post cohort, boxers vs water polo and rugby players	ROBINS-E	High
Chang 2023 ¹⁸	IB	Retrospective cohort, Nevada professional boxing and MMA	ROBINS-E	High
Chen 2012 ¹⁹	IA	Prospective cohort, club boxers (sway and motion sickness)	QUADAS-2	Unclear; high applicability concern
Davis 2017 ²⁷	IA	Video analysis before and after the 2013 rule change, elite bouts	ROBINS-E	High
Di Virgilio 2019 ²⁹	IA	Controlled pre/post sparring experiment (mock-sparring control)	ROBINS-E	Some concerns
Engelbrechtsen 2013 ³⁹	IA	IOC injury surveillance, London 2012 (partial text)	JB1 cross-sectional	Unclear
Flotatos 2021 ⁴⁴	IB	Surveillance of eye injuries, professional MMA, Nevada	JB1 cross-sectional	High
Ha 2022 ⁴⁹	IB	Video analysis, taekwondo World Championships	JB1 cross-sectional	Moderate
Hart 2017 ⁵²	IA	Single-group cohort, novice university boxers	ROBINS-E	High
Junge 2009 ⁶²	IA	IOC injury surveillance, Beijing 2008	JB1 cross-sectional	Moderate
Komatsu 2023 ⁶⁵	IA	Cross-sectional survey, Japan Amateur Boxing Federation members	JB1 cross-sectional	High
Le Flao 2026 ⁶⁷	IA	Prospective pre/post sparring cohort (SCAT5 symptoms)	ROBINS-E	Some concerns
Leeds 2019 ⁶⁸	IB	Post-session comparison, military instructional boxing	ROBINS-E	High
Loosemore 2015 ⁷¹	IA	Prospective injury surveillance, Great Britain squad (preprint basis)	JB1 cross-sectional	High
Lystad 2021 ⁷³	IA	Prospective cohort, IOC data from 3 Games 2008-2016	JB1 cross-sectional	Moderate
Malek 2000 ⁷⁴	IB	Case report, kickboxer (partial text)	JB1 case report	Low
Mañka-Malara 2022 (PMID 36293623)	IB	Official statistics, professional MMA	JB1 cross-sectional	Moderate
Neselius 2014 ⁸⁶	IA	Nonrandomized comparison, elite boxers vs controls after a bout	ROBINS-E	Some concerns
Paizante 2024 ⁸⁹	IA	Within-boxer crossover, bouts with and without headgear	ROBINS-E	High
Pappas 2007 ⁹⁰	IA (level not stated)	Emergency-department surveillance (NEISS), 2002-2005	JB1 cross-sectional	Moderate
Pearson 2007 ⁹²	IA	Screening-tool study, saccadometry before and 7 minutes after a bout	QUADAS-2	High
Soligard 2017 ¹⁰³	IA	IOC injury surveillance, Rio 2016	JB1 cross-sectional	Moderate
Stewart 2026 ¹⁰⁵	IB	Video analysis, professional slap fighting	JB1 cross-sectional	Low
Suleman 2024 ¹⁰⁷	IA	Cross-sectional survey, female Indonesian amateur boxers	JB1 cross-sectional	High
Twohey 2023 ¹¹⁰	IB	Prospective cohort, MMA athletes (SCAT5 and King-Devick)	QUADAS-2	High
Zazryn 2006 ¹¹⁶	IA	Prospective cohort, amateur and professional boxers, Victoria	JB1 cross-sectional	Moderate

Two studies judged on full text (Brown 2024, Mañka-Malara 2022) contribute professional or MMA context only and are identified by PMID rather than cited. Summary: high 16; moderate 9; some concerns 4; low 2; unclear 2. "Moderate" is the overall category used with the JBI checklists and "some concerns" the ROBINS-E category. The remaining 83 primary studies in the core set were not assessable from an abstract or secondary source. Domain-level judgments are shown in Figure 5. Abbreviations: IOC, International Olympic Committee; JBI, Joanna Briggs Institute; MMA, mixed martial arts; NEISS, National Electronic Injury Surveillance System; QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies 2; ROBINS-E, Risk Of Bias In Non-randomized Studies of Exposures; SCAT5, Sport Concussion Assessment Tool 5.

Table 4. Evidence by RACE1 component, with SORT levels and the main points supported and not supported

Component (cards)	Evidence-table rows (rows revised after full-text retrieval)	SORT level, amateur evidence	SORT level, overall	Recommendation strengths	Supported	Not supported
0 Background and	73 (23)	2	2	C, C, C	Diagnosed concussion recorded	Any single amateur

Component (cards)	Evidence-table rows (rows revised after full-text retrieval)	SORT level, amateur evidence	SORT level, overall	Recommendation on strengths	Supported	Not supported
incidence (all)					infrequently; LOC in a minority; some impairment unrecognized at ringside; lacerations and contusions recorded more often than brain injury	concussion rate; stoppage rates presented as concussion rates; claims that headgear changes concussion incidence
1 Observable signs and red flags (2, 3)	40 (16)	3	2	B, C, C	Consensus video-sign names and definitions; removal on any sign; a combat-sport red-flag list with ambulance transport; repeat red-flag check	Absence of signs as reassurance; "slow to get up" or "holding head" as scored signs
2 Orientation and memory (4B, 6, 7, 15)	55 (20)	3	2	B, C, C	Brief orientation, immediate and delayed recall within a multimodal screen; bout-specific questions; adapted word lists; same-event baseline	A full score as evidence that concussion is absent; any orientation or memory cut-off
3 Oculomotor and pupil (8, 9)	43 (14)	3	2	B, B, C	Bedside SCAT6-type ocular items; pre-bout pupil baseline; abnormal pupils, persistent diplopia and spontaneous nystagmus routed to red flags with an eye-injury check	Clearing on a normal oculomotor result; accuracy figures borrowed from timed tests
4 Motor and balance (10 to 14)	46 (14)	3	2	B, C, C	Non-clearance on a clear motor or balance abnormality; standardized stance, surface and footwear; repeat after rest	Excluding concussion on normal balance; any validity claim for the functional ring tasks
5 Speech and comprehension (16, 17)	13 (8)	3	3	C, C	Slurred or altered speech and inability to respond as findings precluding clearance; language recorded before the bout	Scoring speech and comprehension as a discriminating test
6 Symptom self-report (4C)	52 (12)	3	2	C, B (with a C clause), C	Graded checklist drawn from the SCAT6; baseline and post-bout wording; repeated inquiry; red-flag symptoms to the emergency pathway	A symptom total as a stand-alone rule; a negative report as clearance
7 Confounding injuries and factors (5)	38 (14)	3	3	C, C, C	Cervical spine screen; fracture and orbital fracture suspicion; eye screen before Cards 8, 9 and 4C; recording exertion, weight loss and medication	Attributing an abnormal finding to a confounder at ringside
8 Disposition and return to participation (18)	78 (13)	3	3	C, C, C	No same-day return; immediate and later multimodal evaluation; evaluation of winners; written instructions; red flags to a pre-identified trauma center; LOC duration and rule set recorded	Numeric totals as decision rules; "no deficit detected" as clearance

SORT levels: 1, good-quality patient-oriented evidence; 2, limited-quality patient-oriented evidence; 3, consensus, usual practice, opinion, disease-oriented evidence or case series. No level changed after full-text retrieval. Overall Level 2 grades rest on other-sport diagnostic reviews that are indirect for amateur boxing. Data source: evidence synthesis (Supplementary File S3). Abbreviations: LOC, loss of consciousness; SCAT6, Sport Concussion Assessment Tool 6; SORT, Strength-of-Recommendation Taxonomy.

Table 5. Single-study incidence figures in amateur and Olympic-style boxing (outcomes kept separate; not pooled)

Outcome group	Study	Setting	Outcome as defined	Events / denominator	Per 1,000 (exact 95% CI)	Text basis and note
Diagnosed concussion	Junge 2009 ⁶²	Beijing 2008 Olympic Games	Diagnosed concussion	2 / 281 registered boxers	7.1 (0.9-25.5)	Full text; IOC surveillance
Diagnosed concussion	Dande 2021 ²⁵	Indian women's national championship, 2019	Diagnosed concussion	0 / 235 boxers	0.0 (0.0-15.6)	Abstract; athlete-bout total not in abstract
Diagnosed concussion	Bianco 2009 ¹²	Italian female competition	Concussion requiring hospitalization	1 / 2,800 post-competition checks	0.4 (0.0-2.0)	Abstract; denominator approximates boxer-bouts
Diagnosed concussion	Loosemore 2015 ⁷¹	Great Britain squad, 2005-2009	Diagnosed concussion in competition	5 / 106.25 competition hours (6,375 min)	47.1 (15.3-109.8) per 1,000 h	Preprint full text; reviewer arithmetic; published 0.53 per 1,000 h does not match

Outcome group	Study	Setting	Outcome as defined	Events / denominator	Per 1,000 (exact 95% CI)	Text basis and note
						the stated counts
Self-reported concussion	Adkitte 2016 ²	Indian national-level boxers, 2 years, training and competition	Self-reported concussion (period prevalence)	33 / 54 boxers	611.1 (468.8-740.8)	Full text; level not stated; ages 11-35 y; no exposure denominator; high risk of bias
Screen-detected impairment (not a diagnosis)	Moriarity 2012 ⁸¹	US amateur single-elimination competition	Unrecognized evolving cognitive slowing on computerized screen	2 / 160 bouts	12.5 (1.5-44.4)	Abstract; bout winners only
Stoppage (not concussion)	Beltrani Filho 2010 ⁷	Brazilian amateur bouts, 2000-2009	KO (authors equated KO with cerebral concussion)	142 / 1,446 bouts	98.2 (83.3-114.7)	Full text
Stoppage (not concussion)	Estwanik 1984 ⁴⁰	US national championships, 1981-1982	Bout stopped for head blows	48 / 547 bouts	87.8 (65.4-114.7)	Abstract; printed 4.38% equals 48 of 1,094 participants
Stoppage (not concussion)	Davis 2017 ²⁷	World Championships, 2015	KO or TKO, all causes	10 / 238 bouts	42.0 (20.3-75.9)	Full text; 2 KO and 8 TKO; TKO includes injury stoppages

Exact Clopper-Pearson intervals for proportions; exact Poisson interval for the Loosemore 2015 rate. Computed in Python 3 (SciPy); base R script and input supplied for reproduction. Denominators and definitions differ, so figures are not comparable. Rio 2016 recorded 7 of the 12 Games concussions in boxing but printed no boxer denominator,¹⁰³ so no figure is given. Abbreviations: CI, confidence interval; IOC, International Olympic Committee; KO, knockout; TKO, technical knockout.

Table 6. Direction of acute effects after a bout, tournament or sparring session in 16 amateur studies (number of studies)

Domain	Deterioration	No change	Improvement	Mixed
Memory	5	3	0	0
Processing speed, reaction time or executive function	1	2	4	2
Oculomotor	0	0	1	1
Balance or motor	0	2	1	1
Speech or language	0	1	0	0
Symptoms	1	0	0	1
Neurological examination or recognition	3	2	0	0

Studies: Le Flao 2026;⁶⁷ Paizante 2024;⁸⁹ Doan 2021;³⁰ Di Virgilio 2019;²⁹ Howell 2017;⁵⁸ Neselius 2014;⁸⁶ Chen 2012;¹⁹ Moriarity 2012;⁸¹ Stojsh 2008;¹⁰⁶ Pearson 2007;⁹² Moriarity 2004;⁸⁰ Matser 2000;⁷⁶ Butler 1993;¹⁷ Holzgraefe 1992;⁵⁶ Heilbronner 1991;⁵⁴ Jordan 1988.⁶¹ Nine of the 16 were available as abstracts only. Direction is as reported by the authors; vote counting describes the literature and does not estimate an effect. The effect direction plot records Moriarity 2004 only in the processing-speed domain (mixed), whereas the orientation and memory synthesis (section 3.11) counts its working-memory result as a separate no-change finding, giving 4 no-change memory studies there against 3 here. Per-study directions are shown in Figure 8.

Table 7. The 18 RACE1 cards (edition 4): purpose, items, scoring, evidence basis and strength of the supporting recommendation

Card	Purpose	Items	Scoring and routing	Evidence basis (component; main sources)	SORT strength of supporting recommendation (Table 9)
1 Instructions and sequence	States what RACE1 is and is not; sets global rules	Purpose (post-bout screen; never during a bout, between rounds or to permit return the same day or in the same competition; never clears); examiner (ringside physician or licensed clinician under direction); materials (deck, pen, penlight, timer, gloves, pre-bout baseline); 7 global rules; sequence	Not scored	Components 7 and 8; SCAT6 and 6th consensus on multimodal evaluation; ^{35,91} ARP on winners and losers ⁸⁵	C (24, 26)
2 Incident, bout details, observable signs	Records context and observed signs	Fighter, opponent, event, round and time; contest (amateur or professional), headgear (none or worn), rule set, result, language and interpreter; mechanism; bout status (KO; RSC or TKO with or without head blows; standing count; physician stoppage; corner retirement; distance); signs with source (examiner, referee, corner, video): LOC or unresponsiveness, seizure, lying	Not scored; any sign excludes "no deficit detected"; LOC or seizure to Card 3; stoppage recorded as a trigger, not a diagnosis	Components 0 and 1; video-sign consensus; ²⁶ collision-sport Delphi; ⁵⁵ sign accuracy reviews ^{37,108}	B (4); C (3, 6)

Card	Purpose	Items	Scoring and routing	Evidence basis (component; main sources)	SORT strength of supporting recommendation (Table 9)
		motionless, motor incoordination, no protective action, tonic posturing, disorientation or confusion, blank or vacant look; "slow to get up" prompts the examination only			
3 Red flags	Identifies emergencies	GCS below 15; LOC of any duration (under 1 minute, 1 minute or longer, unknown); seizure; deteriorating consciousness; increasing confusion or agitation; neck pain or tenderness; limb weakness, numbness or tingling; new focal deficit; severe or increasing headache; vomiting more than once; persistent double vision; unequal or nonreactive pupil not explained by eye injury; spontaneous or sustained nystagmus; skull fracture signs; ataxia after a KO, progressive imbalance or inability to stand or walk	Not scored; any red flag stops RACE1 and leads to Emergency; cervical precautions for an unconscious boxer; check repeated before the boxer leaves	Component 1; ARP neuroimaging consensus; ⁹⁹ SCAT6; ³⁵ NICE NG232; ⁸⁴ USA Boxing handbook ¹¹²	C (5, 25)
4 Consciousness, memory and symptoms	Records altered consciousness, peri-event amnesia and symptoms	A, dazed or confused after impact; B, memory before and after the impact (open questions); C, symptom list (headache, dizziness, nausea, blurred vision, light or noise sensitivity, ringing in the ears, feeling slowed or foggy, "don't feel right") with a pre-bout baseline line, interpreted after the Card 5 eye check	Not scored; yes or unknown in A, a gap in B or any symptom in C excludes "no deficit detected"; observed findings take priority over self-report	Components 2 and 6; collision-sport Delphi; ⁵⁵ SCAT6 symptom scale; ³⁵ ARP consensus; ⁸⁵ under-reporting ⁸	B (19); C (9, 18, 20)
5 Confounding injuries and test reliability (2 sides)	Screens injuries before the items they affect	A, cervical spine screen; B, skull, facial, jaw and orbital fracture suspicion; C, eye and periocular screen; D, injuries that make tests unreliable (eye, ear, upper limb, lower limb, facial or dental, laceration obscuring vision); E, context (time since bout, exertion, rapid weight loss, anticoagulant or antiplatelet use, alcohol or drugs, previous concussion, migraine, ADHD, learning or mood disorder, motion sickness)	Not scored; abnormal cervical finding to Card 3; suspected facial or orbital fracture to CT; eye finding to ophthalmology; affected tests marked U (score 0); any U excludes "no deficit detected"; context never used to dismiss a suspected concussion	Component 7; SCAT6; ³⁵ ARP eye-conditions statement; ⁵⁷ orbital fracture case; ⁶⁴ consensus definition ⁹¹	C (21, 22, 23)
6 Orientation (seated)	Tests orientation with bout-specific questions	Time of day; venue; opponent's name; last round fought; "How did the bout end?" recorded unscored	4 points	Component 2; USA Boxing and World Boxing handbooks; ^{112,115} 5th consensus ⁷⁸	B (7); C (8)
7 Immediate memory (seated)	Tests registration of 3 words	List A (baseline), B (post-bout), C (re-test), in the preferred language with adapted lists; up to 3 registration trials; time words given	3 points (trial 1); ceiling-effect note	Component 2; SCAT6 and its introduction; ^{34,35} SCAT6 review ³⁷	B (7); C (8)
8 Pupil response (seated)	Detects new pupil asymmetry or poor reactivity	Pre-bout baseline; penlight after the Card 5C check, deferred briefly after an eye injury	1 point (normal), 0 (abnormal) or U; abnormal pupil to Card 3 unless attributed to direct eye injury	Component 3; ARP eye-conditions statement; ⁵⁷ ARP neuroimaging; ⁹⁹ USA Boxing handbook ¹¹²	C (12)
9 Eye tracking (seated)	Screens pursuit, diplopia and nystagmus	H pattern with the head still; double vision asked at each end position; end-gaze nystagmus of a few beats treated as normal	1, 0 or U; persistent diplopia, spontaneous or sustained nystagmus or gaze loss to Card 3 and Card 5C	Component 3; SCAT6 ocular screen; ³⁵ King-Devick meta-analysis ⁴⁶	B (10); C (12)
10 Stand up and insert mouthpiece	Tests standing balance and upper-limb coordination	Only after a normal Card 5A; surface, footwear and shoulder-width stance recorded; stand steadily; insert mouthpiece on first attempt (gloved examiner)	2 points (1 each); mouthpiece item U if none available	Component 4; motor incoordination definition; ²⁶ balance conditions ^{19,50}	B (13); C (14, 15)
11 Guard position (standing)	Tests prompt bilateral arm raising and stance	"Put your hands up"	1, 0 or U	Component 4; consensus definitions only	B (13); C (15)
12 Resistance in guard (standing)	Tests bilateral strength and footing	Moderate downward pressure on both forearms for about 2 seconds	1, 0 or U; new weakness in one limb to Card 3	Component 4; USA Boxing focal-sign instruction ¹¹²	B (13); C (15)
13 Lateral movement and return (standing)	Tests gait and direction following	2 steps to the right and return	1, 0 or U; ataxia after a KO or progressive imbalance to Card 3	Component 4; KO ataxia case ⁶³	B (13); C (15)

Card	Purpose	Items	Scoring and routing	Evidence basis (component; main sources)	SORT strength of supporting recommendation (Table 9)
14 Remove and hand over mouthpiece (standing)	Tests fine motor control and 2-step command	Single command	1, 0 or U; Cards 10 to 14 repeated after a short rest before disposition	Component 4; exertion effect ⁶	B (13); C (14, 15)
15 Delayed recall (seated)	Tests recall of the Card 7 words	At least 5 minutes after Card 7; no hints	3 points	Component 2; USA Boxing 5-minute recall; ¹¹² amateur delayed-memory findings ^{30,106}	B (7); C (8)
16 Speech fluency (observed throughout)	Detects slurred, slow, altered or repetitive speech or word-finding difficulty	Scored from Cards 4 to 15 in the preferred language	1, 0 or U (facial, jaw or dental injury or language barrier)	Component 5; collision-sport Delphi; ⁵⁵ USA Boxing handbook ¹¹²	C (16, 17)
17 Comprehension and processing (observed throughout)	Detects slowed processing, blank stare or inappropriate responses	Scored from Cards 6 to 15	1 or 0	Component 5; SCAT6 observable sign ³⁵	C (16, 17)
18 Scoring, disposition, restriction and signatures (2 sides)	Summarizes findings and assigns a provisional disposition	Score summary with pre-bout baseline, post-bout and re-test columns; tests marked U; word lists; motor re-test time; LOC duration; disposition (Emergency, Not cleared, No deficit detected); restriction (governing body minimum, stricter value, physician extension); written instructions; final disposition; signatures	Total 20; first applicable disposition (Figure 9); bands provisional and unvalidated	Component 8; USA Boxing and World Boxing rules; ^{112,113,115} ARP consensus; ⁸⁵ 6th consensus ⁹¹	C (2, 24, 25, 26)

Card contents are from RACE1 (edition 4), October 1, 2026. Cards 5 and 18 are printed on 2 sides. The score bands are provisional and unvalidated; a total of 20 does not exclude concussion. Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ARP, Association of Ringside Physicians; CT, computed tomography; GCS, Glasgow Coma Scale; KO, knockout; LOC, loss of consciousness; RSC, referee stopped contest; SCAT6, Sport Concussion Assessment Tool 6; SORT, Strength-of-Recommendation Taxonomy; TKO, technical knockout; U, unreliable.

Table 8. Reconciliation history of the RACE1 deck, from the source "CTE Rapid Exam" (January 28, 2026) to edition 4 (October 1, 2026)

Element	Source deck	Edition 2 (Sept 30, 2026; internal consistency)	Edition 3 (Oct 1, 2026; evidence-based author decisions)	Edition 4 (Oct 1, 2026; post-bout use only)
Title and purpose	"CTE Rapid Exam"; no instruction card	Retitled Ringside Acute Concussion Examination (chronic traumatic encephalopathy cannot be assessed at ringside); instruction card added	Never clears; assists the physician, who decides after a mandatory multimodal evaluation; amateur and professional bouts	Post-bout use only; never during a bout, between rounds or for return the same day or in the same competition; use after a knockdown or on request during a bout removed
Bout details and signs (Card 2)	TKO and referee stoppage listed as different outcomes; facial injury listed as a sign	Fighter and event fields; bout status corrected; facial injury moved to Card 5; "slow to get up" added	Contest type, rule set, headgear, result, language and interpreter; standing count; RSC for head blows; consensus video-sign names; "slow to get up" prompts only; stoppages are triggers	"Bout ongoing" status and "ongoing" result removed
Red flags (Card 3)	On 4 cards with different wording; LOC a red flag on one card and a sign on another; duration boxes left exactly 1 minute unassigned; balance problems a red flag yet tested later	One list with one action; LOC under 1 minute or 1 minute or longer; "unable to stand or walk without assistance"; focal deficit added	GCS below 15 with sources; persistent double vision; spontaneous nystagmus; ataxia after a KO and progressive imbalance; neck item linked to Card 5; repeat check before release	Unchanged
Symptoms and memory (Card 4)	"Symptoms" card listed only red flags; amnesia example tested orientation	Unscored symptom report added; amnesia questions ask about memory before and after the impact	Symptoms interpreted after the Card 5 eye check	Pre-bout baseline symptom line added
Confounding injuries (Card 5)	Injuries recorded twice on 2 cards; no rule for unreliable tests	Merged table; unreliable tests marked U and scored 0	Cervical spine screen; fracture suspicion (orbital fracture to CT); eye and periocular screen; context fields; 2-sided card	Unchanged

Element	Source deck	Edition 2 (Sept 30, 2026; internal consistency)	Edition 3 (Oct 1, 2026; evidence-based author decisions)	Edition 4 (Oct 1, 2026; post-bout use only)
Orientation (Card 6)	Answer choices read aloud; round question unsuited to post-bout use	Choices no longer read; round question reworded	Time of day, venue, opponent, last round (4 points); "How did the bout end?" unscored; day of week removed	Unchanged
Memory (Cards 7, 15)	Unscored registration; "Cat, Dog, House"; no recall interval; "0 to 1 correct is a STRONG SIGN"	Trial 1 scored (3 points); up to 3 registration trials; alternate lists B and C; unrelated words; at least 5-minute delay; unsupported interpretation removed	Adapted lists in the preferred language; language recorded; ceiling-effect note	List A at baseline, B post-bout, C re-test
Pupils and eye tracking (Cards 8, 9)	Unequal pupils a red flag on one card and only abnormal on another; any nystagmus abnormal; double vision inconsistent	Pupil abnormality linked to red flags with eye-injury exception; end-gaze nystagmus normal; diplopia and gaze restriction linked to red flags	Card 5C first; brief penlight deferral after eye injury; pre-bout pupil baseline; diplopia asked at each end position	Unchanged
Motor tasks (Cards 10 to 14)	Tested "still standing" in guard before standing the fighter up; lateral instability called a red flag	Reordered (stand and mouthpiece, guard, resistance); stand-and-mouthpiece scored as 2 items; red flag removed from Card 13	Only after normal cervical screen; surface, footwear and stance recorded; ataxia after a KO a red flag; repeat after rest	Unchanged
Speech and comprehension (Cards 16, 17)	"Full points in the Verbal domain" undefined	Moved to the end; scored by observation throughout, 1 point each	Slow, altered or repetitive speech; inability to respond appropriately; language barrier allows U	Unchanged
Scoring	Eye/Verbal/Motor/Executive 4/5/6/5, mirroring the GCS; no card assigned to any domain	Cognition 10, Oculomotor 2, Motor and balance 6, Speech and comprehension 2 (total 20), each mapped to cards	Unchanged	Score summary with pre-bout baseline, post-bout and re-test columns
Disposition (Card 18)	18 to 19 "Undetermined, re-test" (allowing same-day return); "20 = no acute head injury suspected"; "STOP FIGHT"; SCAT5	Emergency (red flag or total below 15); Not cleared (15 to 19 or any sign, symptom, memory gap or U); No deficit detected (20 and none); provisional status stated; SCAT6 and MACE 2 named	"Total below 15" removed (Emergency on red flags only); Not cleared linked to governing-body restriction; No deficit detected not a clearance; LOC duration; restriction section (stricter value; physician extension); written instructions; "cleared" option removed	"Not a clearance and no same-day return"

Condensed from the 3 RACE1 reconciliation records (21 changes in the first). The 20-point structure and the provisional status of the score bands were unchanged after edition 2. Abbreviations: CT, computed tomography; GCS, Glasgow Coma Scale; KO, knockout; LOC, loss of consciousness; MACE 2, Military Acute Concussion Evaluation 2; RSC, referee stopped contest; SCAT5 and SCAT6, Sport Concussion Assessment Tool 5 and 6; TKO, technical knockout; U, unreliable.

Table 9. Clinical recommendations (all 26 draft recommendations of the evidence synthesis) with SORT strength

No.	Component (cards)	Recommendation	SORT	Supporting sources
1	Background (all)	RACE1 background material should report diagnosed concussion, KO, RSC-H or other stoppage, laceration and fracture frequencies as separate figures with their original denominators, should state the case definition used (for example, that the Porter 1996 "concussion" proportion was a head-blow stoppage proportion), and should not present stoppage rates as concussion rates.	C	7,10,27,75,85
2	Background (all)	Ringside physicians using RACE1 should be told that diagnosed concussion is recorded infrequently in amateur and Olympic-style competition (2 among 281 registered boxers at Beijing 2008; 7 boxing concussions at Rio 2016), that LOC accompanies only a minority of concussions, and that some cases are not recognized at the time of the bout, so a normal immediate post-bout screen after a KO, head-blow stoppage or suspected concussion does not end observation.	C	50,62,81,92,103
3	Background (all)	RACE1 event documentation should record sex, age category, governing rule set, headgear status and bout format with each screen, because stoppage, laceration and all-injury frequencies differed across these factors and headgear rules differ between federations.	C	10,72,73,113,115
4	Signs (2, 3)	Any observable sign after a head blow, recorded with the 6 consensus video-sign names and definitions (lying motionless, motor incoordination, impact seizure, tonic posturing, no protective action-floppy, blank or vacant look), or confusion or amnesia, should be treated as an indication for removal and full assessment; during a bout, removal is the ringside physician's in-competition decision, separate from RACE1, and after the bout any such sign precludes a "no deficit detected" result. "Slow to get up" or "holding head" alone should prompt assessment but not be scored as a sign, and the absence of observable signs should not be used to exclude concussion.*	B	26,37,50,55,81,91,108
5	Red flags (3)	A boxer with any red flag (GCS below 15, suspected skull fracture or cerebrospinal fluid leak, seizure, focal neurological deficit, more than 1 episode of vomiting, pupillary abnormality, progressive headache or other progressive symptoms, deteriorating mental status, neck pain, or limb weakness or tingling) should be	C	4,35,47,50,66,84,99,112,115

No.	Component (cards)	Recommendation	SORT	Supporting sources
		transported by ambulance to a pre-identified trauma center with CT and neurosurgical cover, and the red-flag check should be repeated after the bout and before release, because deterioration may follow a lucid interval and may occur after the boxer leaves the ring.		
6	Signs (2, 3)	A KO from head blows with LOC should be recorded and managed as a concussion, whereas a TKO, RSC-H or standing count should be recorded as a trigger for the full RACE1 screen rather than as a concussion diagnosis, and stoppage counts should not be reported as concussion counts.	C	10,75,85,112
7	Orientation, memory (4B, 6, 7, 15)	The ringside screen should include brief standardized orientation, immediate-memory and delayed-recall items as one element of a multimodal assessment, and the result of these items should not be used alone to diagnose or exclude concussion.	B	35,37,46,47,50,77,85,100
8	Orientation, memory (4B, 6, 7, 15)	In amateur and Olympic-style boxing, the orientation items on Cards 4B and 6 should use bout-specific questions (opponent, round, whether the bout was stopped) in addition to, or in place of, time-place-person items, and the memory items on Cards 7 and 15 should retain a delayed recall, use word lists adapted to the boxer's language, and be interpreted against a same-event baseline where one exists, with attention to ceiling and practice effects.	C	13,30,34,35,37,78,91,106,112,115
9	Orientation, memory (4B, 6, 7, 15)	A normal post-bout orientation and memory result should not be taken as clearance on its own. Boxers with an abnormal orientation or memory item, a reported memory gap, or a contest stopped for head blows should be re-examined later in a quieter setting before any disposition other than Not cleared, and persistent amnesia should be routed to the referral and imaging pathway (Cards 3 and 18), because post-bout cognitive deficits in boxing have been reported to evolve over the hours after the bout and amnesia is a referral and CT criterion in guidelines and in World Boxing rules.	C	78,80,81,84,85,91,95,106,114,115
10	Oculomotor (8, 9)	Keep the oculomotor items on Cards 8 and 9 as one domain of a multidomain ringside screen, using bedside items of the SCAT6 ocular and motor type (diplopia on gaze with the head still; observed extraocular movements; spontaneous nystagmus). An abnormal finding should count against clearance, but a normal oculomotor result should not by itself be used to clear a boxer, because single oculomotor tests show limited and inconsistent sensitivity.	B	24,32,35,37,46,51,100,110
11	Oculomotor (8, 9)	If a timed saccadic or rapid number-naming task is used alongside RACE1, score it as change from the boxer's own pre-bout baseline taken at the same event. Treat failure to show the expected improvement on retest as a flag, and do not rely on a pre-tournament baseline after several bouts.	B	45,46,58,59,70,110
12	Pupil (8, 9)	Record a pre-bout pupil baseline, keep the post-bout pupil check and diplopia inquiry on consensus, guideline and rule grounds, and route unequal or abnormal pupils, persistent diplopia or spontaneous nystagmus to the red-flag pathway (Card 3) while checking for local eye injury (Card 5). No study evaluated pupil examination as a concussion screen.	C	11,18,35,42,50,57,85,99,112
13	Motor, balance (10 to 14)	Keep the motor and balance items on Cards 10 to 14 within the multidomain screen. A clear motor or balance abnormality should preclude clearance, but normal performance should not be taken to exclude concussion, because standing balance and gait tests show low and variable sensitivity.	B	5,6,37,46,47,50,83,97,110
14	Motor, balance (10 to 14)	Standardize stance, surface and footwear for the motor items, record any lower-limb or other musculoskeletal injury on Card 5 before attributing imbalance to it, and use the same examiner for any baseline comparison. Do not interpret post-bout performance against a pre-tournament baseline without allowing for practice effects, warm-up and exertion; repeat the items after a short recovery before a final disposition.	C	6,19,34,48,50,58,85,91,97
15	Motor, balance (10 to 14)	Describe the functional ring tasks (standing and inserting the mouthpiece, guard, resistance, lateral steps, mouthpiece removal) as consensus-derived and unvalidated, map them to the consensus definition of motor incoordination, and prioritize them for prospective evaluation in amateur competition against a reference-standard concussion diagnosis, using the SCAT6 balance sequence (mBESS and timed tandem gait) as a comparator. Route ataxia after a KO, progressive balance dysfunction or a focal motor deficit to the red-flag pathway.	C	26,35,42,49,50,55,63,85
16	Speech (16, 17)	Slurred, altered, slow or repetitive speech, or an inability to respond appropriately to questions, observed at ringside should be recorded and treated as a finding that precludes clearance, pending further evaluation; the speech and comprehension items should be regarded as observational checks rather than as validated tests.	C	35,50,55,86,100,112
17	Speech (16, 17)	Before interpreting Cards 16 and 17, the examiner should record the boxer's preferred language and any mouth, jaw or dental injury (Card 5), and should give the comprehension item in an adapted form in the boxer's language, because literal translation of assessment tools is not considered valid.	C	34,35
18	Symptoms (4C)	Card 4C should use a structured graded symptom checklist, drawn from the SCAT6 symptom scale, that records symptom number and severity as separate items within a multimodal ringside screen, with matching pre-bout ("how you typically feel") and post-bout ("how you feel now") wording, and should not apply a composite symptom score as a stand-alone diagnostic threshold.	C	35,47,48,50,85,100
19	Symptoms (4C)	Any reported concussion symptom after a bout should be treated as supporting suspected concussion, and the absence of reported symptoms should not override observable signs or abnormal examination findings. The symptom inquiry should be	B (final sentence C)	8,16,37,42,47,78,81,86,91,100,110 final sentence ⁸⁵

No.	Component (cards)	Recommendation	SORT	Supporting sources
		repeated in a quiet area after the bout and serially thereafter. Symptoms persisting 30 minutes after the bout should be treated as probable concussion, a consensus rule of the ARP that has not been tested in amateur boxing (this final sentence is graded C).		
20	Symptoms (4C)	Card 4C should record pre-bout symptoms and known confounders (motion sickness, exertion, rapid weight loss, pre-existing headache, ear or vestibular symptoms, local eye injury) so that post-bout symptoms are interpreted against the boxer's own baseline, and red-flag symptoms (severe or increasing headache, repeated vomiting, increasing restlessness or agitation, progressive light or noise sensitivity or vision problems) should be routed to the Card 3 emergency pathway.	C	1,19,20,35,57,67,84,99,111,112
21	Confounders (5)	Card 5 should direct the examiner to complete a cervical spine screen (neck pain at rest, tenderness, active pain-free range of movement, limb strength and sensation) and to look for signs of skull, facial or orbital fracture before attributing findings to concussion; suspected cervical injury, skull fracture or maxillofacial fracture should lead to immobilization as needed and hospital transfer, and a suspected orbital fracture should be imaged by CT even when radiographs are normal.	C	35,38,50,55,64,99
22	Confounders (5)	Card 5 should include an ocular and periocular injury screen, completed before the pupil, diplopia and vision items of Cards 8, 9 and 4C are interpreted, with emergent ophthalmology referral for the signs and symptoms listed by the ARP eye-conditions statement, and should record lacerations, epistaxis and hand injury that may interfere with vision-dependent or coordination items.	C	2,28,57,64,73
23	Confounders (5)	Card 5 should record the time since the end of the bout and recent exertion, post-bout motion-sickness-like symptoms, rapid weight loss, alcohol or drug use, anticoagulant or antiplatelet use, age over 35, pre-bout blood pressure and pre-existing migraine, ADHD, learning or mood disorder as factors that may overlap with or modify concussion findings; balance items within about 20 minutes of exertion should be repeated after rest, and none of these factors should be used at ringside to dismiss a suspected concussion, because concussion signs may co-occur with other conditions and attribution to another cause requires an experienced clinician's multimodal assessment.	C	6,9,19,50,78,84,91,111
24	Disposition (18)	Stopping a bout for an observable sign, symptom or deficit suggesting concussion is the ringside physician's in-competition decision, separate from RACE1.* After the bout, a boxer with any such finding should not return to participation that day or in the remainder of the competition, and should be evaluated immediately after the bout and again in a quieter setting with a multimodal assessment of at least 10 to 15 minutes (such as the SCAT6, which World Boxing requires after a KO or a stoppage for head blows), of which RACE1 is the first step and not a substitute; the same post-bout evaluation should apply to winners, and a removed boxer should receive written instructions not to be left alone, drink alcohol or drive.	C	33,35,47,50,78,85,91,112,115
25	Disposition (18)	Any red flag recognized by the ringside physician during the bout, or found at any point of the post-bout RACE1 screen, should trigger urgent ambulance transport to a pre-identified trauma center with CT and 24-hour neurosurgical cover, independent of any screen total, and the GCS threshold used on the card should be stated with its source.*	C	9,55,84,85,99,112,115
26	Disposition (18)	The Card 18 disposition should record LOC presence and duration and the governing rule set and should link to that body's current minimum restriction (USA Boxing Rule Book 2025: 30, 90 or 180 days by LOC status, with escalation for repeat events and, where USA Boxing documents conflict, the stricter value; World Boxing periods to be entered after verification against the handbook) and its clearance requirement (USA Boxing written clearance by a qualified physician and Restriction Affidavit; World Boxing fitness declared by a doctor or neurologist); suspensions should be individualized and lengthened rather than shortened for children, adolescents and older fighters, and a "no deficit detected" result should not be treated as clearance.†	C	9,38,47,82,85,112,113,115

SORT strength: A, consistent, good-quality patient-oriented evidence; B, inconsistent or limited-quality patient-oriented evidence; C, consensus, usual practice, opinion, disease-oriented evidence or case series. No recommendation reached A.

*Reworded so that in-competition removal and bout stoppage are stated as the ringside physician's decision, separate from RACE1, which is applied only after the bout; strength unchanged. †World Boxing suspension periods removed and the stricter-value rule added, because the mapping of World Boxing periods to LOC status could not be verified in the text obtained; strength unchanged. Recommendation wording otherwise follows the evidence synthesis (Supplementary File S3). Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ARP, Association of Ringside Physicians; CT, computed tomography; GCS, Glasgow Coma Scale; KO, knockout; LOC, loss of consciousness; mBESS, modified Balance Error Scoring System; RSC-H, referee stoppage for head blows; SCAT6, Sport Concussion Assessment Tool 6; SORT, Strength-of-Recommendation Taxonomy; TKO, technical knockout.

Table 10. Deviations from the planned protocol

Planned method (written protocol)	What was done	Reason	Handling and effect
Search PubMed/MEDLINE and Consensus only	Also searched Scholar Gateway and Wiley Scholar Gateway, SciSpace, alphaXiv and ClinicalTrials.gov; preprint servers listed by date only	Author's direction on September 30, 2026, to expand to all available research databases and search platforms	All sources reported with dates and counts (Table 1, Appendix A); semantic search platforms return fixed ranked results and are not fully reproducible (Limitations)
Searches logged once as written	PM-8 (897 records) replaced by PM-8b before screening; 6 SciSpace queries re-run because their first query text was not preserved	Query too broad; incomplete log of the first runs	PM-8 not screened or counted; re-run records logged
Single-reviewer screening with author verification of the screening decisions	Single-reviewer screening and extraction; author verification of a random 10% sample of screening decisions (206 of 2,063), all 53 amateur records and 20 extraction rows	Author decision on the scope of verification	Completed October 1, 2026; reported as sample verification (Limitations)
Protocol registration	Not registered	No registration was made before searching	Stated in Methods; protocol documents named and available
Analysis in R	Intervals computed in Python 3 (SciPy); equivalent base R script and input supplied	R package repositories blocked by the network allowlist of the analysis environment	Author runs the R script separately
Full texts for all included records	137 of 214 core records on the abstract only; 9 on secondary sources only; 16 reports not retrieved	BMJ host rate limits, PubMed Central reCAPTCHA, paywalls, download block in the analysis environment	Full-text retrieval with 9 routes and 550 logged requests; abstract-based findings worded "as reported"; secondary figures attributed
Risk of bias for all primary studies	Judged on full text for 33 of 116 primary studies; 83 not assessable	Abstract-only or secondary-only records	Stated in Results and Figure 5; study-level judgments added after full-text retrieval
Pool when 2 or more comparable studies	Not pooled; SWiM synthesis with direction-of-effect vote counting	No comparable set verified on full text, before or after full-text retrieval	Reasons stated (section 2.10); single-study figures with exact CIs
Other methods limited to backward citation searching	Targeted searches at the analysis stage added 18 records (10 included)	Pooling feasibility testing	Reported as other methods in the PRISMA flow; 1 record awaiting classification
Certainty with GRADE where pooled estimates exist	SORT levels and strengths only	Target format specifies SORT; no pooled estimates	Stated in Methods
Numbers verified against PDFs before entering the manuscript	Some values rest on text extractions of web pages or on analysis-stage full texts not re-obtained	Retrieval constraints	Paraphrased rule and guideline passages not quoted; affected values flagged (Appendix B)
Sports Health Clinical Review of 4,500 words	Prepublication release by Sears Publishing Company without a word limit, with embedded figures	Author's direction (preprint released to seek co-authors and initial peer review before journal submission)	Journal-format elements retained (structured abstract, SORT, AMA style, PRISMA reporting)

Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SORT, Strength-of-Recommendation Taxonomy; SWiM, Synthesis Without Meta-analysis.

13. Figure Legends

The legend for each figure appears directly under its figure image in the text.

Appendix A. Exact Search Strings

All searches were run on September 30, 2026. Query strings are reproduced verbatim from the search log (Supplementary File S1). "Returned" is the count reported by the source and "Recorded" the number of records retrieved into the log.

A.1 PubMed/MEDLINE (field-tagged Boolean queries)

PM-1 (PubMed/MEDLINE). Purpose: Concussion and head injury in amateur, Olympic, youth and collegiate boxing.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab]) AND ("Brain Concussion"[MeSH] OR "Brain Injuries, Traumatic"[MeSH] OR "CranioCerebral Trauma"[MeSH] OR concussion[tiab] OR concussions[tiab] OR "head injury"[tiab] OR "head injuries"[tiab] OR "traumatic brain injury"[tiab]) AND (amateur[tiab] OR Olympic[tiab] OR youth[tiab] OR junior[tiab] OR novice[tiab] OR collegiate[tiab] OR elite[tiab] OR AIBA[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 156. Recorded: 156. Reproduced the earlier search version (identical PMIDs).

PM-2 (PubMed/MEDLINE). Purpose: Ringside recognition: stoppage, knockout, loss of consciousness, referee and ringside physician.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab] OR "combat sports"[tiab]) AND (ringside[tiab] OR sideline[tiab] OR stoppage[tiab] OR stoppages[tiab] OR knockout[tiab] OR knockouts[tiab] OR "loss of consciousness"[tiab] OR "referee"[tiab] OR "ringside physician"[tiab] OR "medical suspension"[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 123. Recorded: 123. Reproduced the earlier search version (identical PMIDs).

PM-3 (PubMed/MEDLINE). Purpose: Assessment components in boxing and combat sports: cognitive, balance, oculomotor, symptom and screening tools.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab] OR "combat sports"[tiab]) AND ("Neuropsychological Tests"[MeSH] OR "Postural Balance"[MeSH] OR "Eye Movements"[MeSH] OR "Vision Tests"[MeSH] OR "Sport Concussion Assessment Tool"[tiab] OR SCAT[tiab] OR "King-Devick"[tiab] OR "Military Acute Concussion Evaluation"[tiab] OR "balance error scoring"[tiab] OR oculomotor[tiab] OR vestibular[tiab] OR "symptom"[tiab] OR "screening tool"[tiab] OR "assessment tool"[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 178. Recorded: 178. Reproduced the earlier search version (identical PMIDs).

PM-4 (PubMed/MEDLINE). Purpose: Reference tools: SCAT6, MACE 2 and video observable signs (context evidence).

("Sport Concussion Assessment Tool 6"[tiab] OR SCAT6[tiab] OR "Military Acute Concussion Evaluation"[tiab] OR "MACE 2"[tiab] OR ("video"[tiab] AND "observable signs"[tiab] AND concussion[tiab]))

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 177. Recorded: 177. Reproduced the earlier search version (identical PMIDs).

PM-5 (PubMed/MEDLINE). Purpose: Observable signs at the moment of impact in boxing and combat sports: video signs, fencing response, tonic posturing, impact seizure, motor incoordination, vacant stare.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab] OR "combat sports"[tiab] OR "mixed martial arts"[tiab] OR "Martial Arts"[MeSH]) AND ("video"[tiab] OR "observable signs"[tiab] OR "visible signs"[tiab] OR "fencing response"[tiab] OR "tonic posturing"[tiab] OR "impact seizure"[tiab] OR "motor incoordination"[tiab] OR "vacant stare"[tiab] OR "blank stare"[tiab]) AND (concussion[tiab] OR concussions[tiab] OR "head injury"[tiab] OR "head trauma"[tiab] OR "Brain Concussion"[MeSH])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 24. Recorded: 24. Added in the updated search.

PM-6 (PubMed/MEDLINE). Purpose: Sideline cognitive screening: Maddocks and orientation questions, immediate memory, delayed recall, Standardized Assessment of Concussion (context evidence).

("Maddocks"[tiab] OR "orientation questions"[tiab] OR "immediate memory"[tiab] OR "delayed recall"[tiab] OR "Standardized Assessment of Concussion"[tiab] OR "word list"[tiab] OR "cognitive screen"[tiab]) AND ("Brain Concussion"[MeSH] OR concussion[tiab] OR concussions[tiab]) AND (sideline[tiab] OR acute[tiab] OR athletes[tiab] OR athlete[tiab] OR sport[tiab] OR sports[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 198. Recorded: 198. Added in the updated search.

PM-7 (PubMed/MEDLINE). Purpose: Pupillary and oculomotor screening: pupils, smooth pursuit, saccades, nystagmus, eye tracking, near point of convergence, VOMS (context evidence).

("pupil"[tiab] OR "pupils"[tiab] OR "pupillary"[tiab] OR "smooth pursuit"[tiab] OR "saccades"[tiab] OR nystagmus[tiab] OR "eye tracking"[tiab] OR "near point of convergence"[tiab] OR VOMS[tiab] OR "oculomotor"[tiab]) AND ("Brain Concussion"[MeSH] OR concussion[tiab]) AND (sideline[tiab] OR acute[tiab] OR athletes[tiab] OR sport[tiab] OR sports[tiab] OR boxing[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 402. Recorded: 402. Added in the updated search.

PM-8 (PubMed/MEDLINE). Purpose: Balance and gait after concussion, broad terms (run in full; superseded by PM-8b because the broad terms gait and balance returned 897 records).

("Postural Balance"[MeSH] OR "Balance Error Scoring System"[tiab] OR BESS[tiab] OR "tandem gait"[tiab] OR "Romberg"[tiab] OR "gait"[tiab] OR "balance"[tiab]) AND ("Brain Concussion"[MeSH] OR concussion[tiab]) AND (sideline[tiab] OR acute[tiab] OR athletes[tiab] OR sport[tiab] OR sports[tiab] OR boxing[tiab])

Parameters: None (as above). Only the first 200 of 897 PMIDs were retrieved; the query was judged too broad for a targeted acquisition, was not screened, and was superseded by PM-8b. It is logged so that the search history is complete. Date run: 2026-09-30. Returned: 897. Recorded: 200. First 200 retrieved; not screened; superseded by PM-8b.

PM-8b (PubMed/MEDLINE). Purpose: Balance tests with accuracy or reliability terms: BESS, tandem gait, Romberg, postural balance (context evidence).

("Balance Error Scoring System"[tiab] OR BESS[tiab] OR "tandem gait"[tiab] OR "Romberg"[tiab] OR "Postural Balance"[MeSH]) AND ("Brain Concussion"[MeSH] OR concussion[tiab]) AND (sideline[tiab] OR "diagnostic accuracy"[tiab] OR sensitivity[tiab] OR specificity[tiab] OR reliability[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 170. Recorded: 170. Added in the updated search.

PM-9 (PubMed/MEDLINE). Purpose: Symptom under-reporting and non-disclosure in athletes, boxers and combat-sport athletes.

("Brain Concussion"[MeSH] OR concussion[tiab] OR concussions[tiab]) AND ("underreport"[tiab] OR "underreporting"[tiab] OR "under-reporting"[tiab] OR "nondisclosure"[tiab] OR "non-disclosure"[tiab] OR "disclosure"[tiab] OR "self-report"[tiab] OR "symptom report"[tiab]) AND (athletes[tiab] OR athlete[tiab] OR boxing[tiab] OR boxers[tiab] OR "combat sports"[tiab] OR "mixed martial arts"[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 251. Recorded: 251. Added in the updated search.

PM-10 (PubMed/MEDLINE). Purpose: Red flags and catastrophic outcomes in boxing: subdural haematoma, intracranial injury, skull fracture, fatality, second impact, cervical spine.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab]) AND ("Hematoma, Subdural"[MeSH] OR subdural[tiab] OR intracranial[tiab] OR "skull fracture"[tiab] OR "Skull Fractures"[MeSH] OR fatal[tiab] OR fatalities[tiab] OR death[tiab] OR deaths[tiab] OR mortality[tiab] OR "second impact"[tiab] OR "cervical spine"[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 309. Recorded: 309. Added in the updated search.

PM-11 (PubMed/MEDLINE). Purpose: Return to competition, medical suspension and clearance in boxing and combat sports.

("Boxing"[MeSH] OR boxing[tiab] OR boxer[tiab] OR boxers[tiab] OR "combat sports"[tiab] OR "mixed martial arts"[tiab]) AND ("return to play"[tiab] OR "return to competition"[tiab] OR "return to sport"[tiab] OR "medical suspension"[tiab] OR suspension[tiab] OR suspensions[tiab] OR clearance[tiab] OR "Return to Sport"[MeSH])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 69. Recorded: 69. Added in the updated search.

PM-12 (PubMed/MEDLINE). Purpose: Reliability, validity and diagnostic accuracy of SCAT3/5/6, MACE, Concussion Recognition Tool, King-Devick and SAC (context evidence).

("inter-rater"[tiab] OR interrater[tiab] OR reliability[tiab] OR validity[tiab] OR validation[tiab] OR "diagnostic accuracy"[tiab]) AND ("Sport Concussion Assessment Tool"[tiab] OR SCAT3[tiab] OR SCAT5[tiab] OR SCAT6[tiab] OR "Military Acute Concussion Evaluation"[tiab] OR "Concussion Recognition Tool"[tiab] OR "King-Devick"[tiab] OR "Standardized Assessment of Concussion"[tiab])

Parameters: None. Field tags as written; no date, language, species or article-type limits; publication date through the run date. Retrieved in consecutive pages of 200 records until all records were returned. Date run: 2026-09-30. Returned: 145. Recorded: 145. Added in the updated search.

A.2 Consensus (natural-language queries; top 20 records per query; no filters)

CN-1 (Consensus). Purpose: Ringside concussion assessment in amateur boxing.

ringside concussion assessment amateur boxing

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Reproduced the earlier search version (identical records).

CN-2 (Consensus). Purpose: Concussion and head injury incidence in amateur and Olympic competition.

concussion and head injury incidence in amateur and Olympic boxing competition

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Reproduced the earlier search version (identical records).

CN-3 (Consensus). Purpose: Sideline screening tools and observable signs (context evidence).

sideline concussion screening tool observable signs diagnostic accuracy

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Reproduced the earlier search version (identical records).

CN-4 (Consensus). Purpose: Symptom under-reporting versus examiner-observed signs.

Do boxers and combat sport athletes underreport concussion symptoms, and how does self-report compare with examiner-observed signs?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-5 (Consensus). Purpose: Observable signs at the moment of impact.

Which observable signs at the moment of head impact (loss of consciousness, tonic posturing, fencing response, motor incoordination, blank stare, slow to get up) predict concussion?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-6 (Consensus). Purpose: Orientation, Maddocks questions, immediate memory and delayed recall.

How accurate are orientation questions, Maddocks questions, immediate memory and delayed recall for detecting acute sport-related concussion?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-7 (Consensus). Purpose: Pupil, eye tracking, smooth pursuit and VOMS.

How accurate are pupil examination, eye tracking, smooth pursuit and vestibular ocular motor screening for detecting acute concussion at the sideline?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-8 (Consensus). Purpose: BESS and tandem gait.

How accurate are balance and gait tests such as the Balance Error Scoring System and tandem gait for detecting acute sport-related concussion?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-9 (Consensus). Purpose: Red flags: intracranial haemorrhage, skull fracture, ringside emergency management.

What red flags indicate intracranial hemorrhage or skull fracture after boxing head trauma and how should ringside emergency management proceed?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-10 (Consensus). Purpose: Medical suspension and return to competition.

What medical suspension and return-to-competition rules follow a knockout or concussion in amateur boxing?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-11 (Consensus). Purpose: MACE 2 and SCAT6 reliability, validity and administration time.

What are the reliability, validity and administration time of the Military Acute Concussion Evaluation (MACE 2) and Sport Concussion Assessment Tool 6 (SCAT6)?

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

CN-12 (Consensus). Purpose: Youth and female amateur boxers.

Concussion assessment and management in youth and female amateur boxers

Parameters: None. No filters applied (year, study type, domain, human, open access, journal all unset); top 20 results returned by the platform (page size); further pages not retrieved. Date run: 2026-09-30. Returned: 20. Recorded: 20. Added in the updated search.

A.3 Scholar Gateway and Wiley Scholar Gateway (Wiley Online Library full-text passages; 20 per query)

SG-1 (Scholar Gateway (Wiley)). Purpose: Incidence and ringside recognition in amateur and Olympic-style boxing.

What is the incidence of concussion and head injury in amateur and Olympic-style boxing competition, and how is concussion recognized and assessed at ringside by the ringside physician?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 4. 20 passages; 4 unique articles.

SG-2 (Scholar Gateway (Wiley)). Purpose: Observable signs at the moment of impact.

Which observable clinical signs at the moment of a head impact (loss of consciousness, tonic posturing, fencing response, impact seizure, motor incoordination, vacant stare, slow to rise) are reliable and valid indicators of concussion in combat sports and other collision sports?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 5. 20 passages; 5 unique articles.

SG-3 (Scholar Gateway (Wiley)). Purpose: Sideline cognitive tests: orientation, Maddocks, immediate memory, delayed recall.

How accurate are sideline cognitive tests such as orientation questions, Maddocks questions, immediate memory word lists and delayed recall for detecting acute sport-related concussion?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 6. 20 passages; 6 unique articles.

SG-4 (Scholar Gateway (Wiley)). Purpose: Pupil, eye tracking, smooth pursuit, saccades, NPC, VOMS.

How accurate are pupil examination, eye tracking, smooth pursuit, saccades, near point of convergence and vestibular ocular motor screening for detecting acute sport-related concussion at the sideline?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 14. 20 passages; 14 unique articles.

SG-5 (Scholar Gateway (Wiley)). Purpose: BESS, tandem gait, Romberg.

How accurate and reliable are balance and gait tests such as the Balance Error Scoring System, tandem gait and Romberg test for detecting acute sport-related concussion?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 16. 20 passages; 16 unique articles.

SG-6 (Scholar Gateway (Wiley)). Purpose: Symptom under-reporting versus examiner-observed signs.

Do boxers and combat sport athletes underreport concussion symptoms, and how should ringside physicians weigh athlete self-report against examiner-observed signs?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 13. 20 passages; 13 unique articles.

SG-7 (Scholar Gateway (Wiley)). Purpose: Red flags: intracranial haemorrhage, skull fracture, cervical spine; emergency management.

What red flags indicate intracranial hemorrhage, skull fracture or cervical spine injury after boxing head trauma, and how should ringside emergency management and transport proceed?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 13. 20 passages; 13 unique articles.

SG-8 (Scholar Gateway (Wiley)). Purpose: Medical suspension and return to competition.

What medical suspension periods and return-to-competition rules follow a knockout or diagnosed concussion in amateur boxing, and what evidence supports their duration?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway

search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 6. 20 passages; 6 unique articles.

SG-9 (Scholar Gateway (Wiley)). Purpose: MACE 2 and SCAT6 reliability, validity and administration time.

What are the reliability, validity and administration time of the Military Acute Concussion Evaluation (MACE 2) and the Sport Concussion Assessment Tool 6 (SCAT6) for acute concussion assessment?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 17. 20 passages; 17 unique articles.

WL-1 (Wiley Scholar Gateway (full text)). Purpose: Neurological examination after knockdown or knockout; referee counts and concussion recognition.

After a knockdown or knockout in boxing, what neurological examination should the ringside physician perform, and how do referee counts and standing counts relate to concussion recognition?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 9. 20 passages; 9 unique articles.

WL-2 (Wiley Scholar Gateway (full text)). Purpose: Youth, junior and female amateur boxers.

What is known about concussion recognition, assessment and outcomes in youth, junior and female amateur boxers?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 4. 20 passages; 4 unique articles.

WL-3 (Wiley Scholar Gateway (full text)). Purpose: Administration time and feasibility of sideline tools under competition conditions.

How long do sideline concussion assessment tools take to administer in real competition settings, and how does time pressure or a noisy environment affect their feasibility and accuracy?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 9. 20 passages; 9 unique articles.

WL-4 (Wiley Scholar Gateway (full text)). Purpose: Delayed neurological deterioration and serial reassessment.

How often does neurological deterioration occur in the hours after a sport-related head injury that initially appeared mild, and what serial observation or reassessment protocol is recommended?

Parameters: 20 passages per query; no date, journal or article-type filter. The platform returns 20 full-text passages per query from the Wiley Online Library corpus; passages are grouped into articles by DOI. Scholar Gateway and Wiley Scholar Gateway search the same Wiley corpus and share one monthly quota (free plan, 30 queries per month; 14 used for this search, 16 remaining, reset 2026-10-01). Date run: 2026-09-30. Returned: 20. Recorded: 12. 20 passages; 12 unique articles.

A.4 SciSpace (10 records per query; no filters)

SS-1 (SciSpace). Purpose: Ringside recognition and incidence in amateur and Olympic-style boxing.

How is concussion recognized and assessed at ringside in amateur and Olympic-style boxing, and what is the incidence of concussion in amateur boxing competition?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Added in the updated search.

SS-2 (SciSpace). Purpose: Observable signs at the moment of impact.

Which observable signs at the moment of head impact (loss of consciousness, tonic posturing, fencing response, motor incoordination, blank stare, slow to get up) predict sport-related concussion?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

SS-3 (SciSpace). Purpose: Orientation, Maddocks questions, immediate memory and delayed recall.

How accurate are orientation questions, Maddocks questions, immediate memory and delayed recall for detecting acute sport-related concussion?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

SS-4 (SciSpace). Purpose: Pupil, eye tracking, smooth pursuit and VOMS.

How accurate are pupil examination, eye tracking, smooth pursuit and vestibular ocular motor screening for detecting acute concussion at the sideline?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

SS-5 (SciSpace). Purpose: BESS and tandem gait.

How accurate are balance and gait tests such as the Balance Error Scoring System and tandem gait for detecting acute sport-related concussion?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

SS-6 (SciSpace). Purpose: Symptom under-reporting versus examiner-observed signs.

Do boxers and combat sport athletes underreport concussion symptoms, and how does athlete self-report compare with examiner-observed signs?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Added in the updated search.

SS-7 (SciSpace). Purpose: Red flags: intracranial haemorrhage, skull fracture, ringside emergency management.

What red flags indicate intracranial hemorrhage or skull fracture after boxing head trauma and how should ringside emergency management proceed?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

SS-8 (SciSpace). Purpose: MACE 2 and SCAT6 reliability, validity and administration time.

What are the reliability, validity and administration time of the Military Acute Concussion Evaluation (MACE 2) and Sport Concussion Assessment Tool 6 (SCAT6)?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Added in the updated search.

SS-9 (SciSpace). Purpose: Medical suspension and return to competition.

What medical suspension and return-to-competition rules follow a knockout or concussion in amateur boxing?

Parameters: None. Natural-language question; the platform returns 10 papers per query (page size); no year, journal or type filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Re-run with the query text recorded here; records are those of the re-run.

A.5 ClinicalTrials.gov, preprint servers and alphaXiv

CT-1 (ClinicalTrials.gov). Purpose: Registered studies of concussion or head injury in boxing and combat sports.

(concussion OR "brain concussion" OR "traumatic brain injury" OR "head injury") AND (boxing OR boxer OR "combat sports" OR "mixed martial arts")

Parameters: query term as written; no status, phase, location or date filter; default page size. Date run: 2026-09-30. Returned: 3. Recorded: 3. Added in the updated search.

CT-2 (ClinicalTrials.gov). Purpose: All registered studies mentioning boxing (context; most are exercise interventions).

boxing

Parameters: single term; no filters; default page size. Date run: 2026-09-30. Returned: 22. Recorded: 22. Added in the updated search.

MX-1 (medRxiv). Purpose: Recent preprints (the platform has no keyword search).

medRxiv listing: preprints posted in the 90 days before the run date (first 100); no keyword search available

Parameters: 90-day listing, first 100 records, no category. Date run: 2026-09-30. Returned: 30. Recorded: 30. 0 relevant by title.

BX-1 (bioRxiv). Purpose: Recent neuroscience preprints (the platform has no keyword search).

bioRxiv listing: neuroscience preprints posted in the 90 days before the run date (first 50); no keyword search available

Parameters: neuroscience category, 90-day listing, first 50 records. Date run: 2026-09-30. Returned: 30. Recorded: 30. 0 relevant by title.

AX-1 (alphaXiv (arXiv)). Purpose: Non-biomedical index searched for context only: ringside concussion assessment and observable signs of concussion in boxing and combat sports.

keywords ["boxing", "concussion", "ringside"]; question: ringside concussion assessment and observable signs of concussion in boxing and combat sports

Parameters: keyword and question search, no date filter. Date run: 2026-09-30. Returned: 10. Recorded: 10. Context only.

AX-2 (alphaXiv (arXiv)). Purpose: Non-biomedical index searched for context only: objective sideline concussion screening: eye tracking, balance sensors and video-based detection of visible signs.

keywords ["sideline concussion", "eye tracking", "balance", "video signs"]; question: objective sideline concussion screening: eye tracking, balance sensors and video-based detection of visible signs

Parameters: keyword and question search, no date filter. Date run: 2026-09-30. Returned: 9. Recorded: 9. Context only.

A.6 PubMed DOI look-up runs

Runs DX-1 to DX-17 searched every unique DOI from the Consensus, Scholar Gateway, Wiley and SciSpace record sets in PubMed as Boolean OR combinations of "doi"[doi] terms, at most 21 DOIs per query (322 DOIs in DX-1 to DX-16; DX-17 was a control run for 7 superseded DOIs). Of 311 unique DOIs in the final record sets, 244 were indexed in PubMed (133 already retrieved by the topic queries; 111 added to screening) and 67 were not. The full DOI lists for each run are in Supplementary File S1.

Appendix B. Reports Not Retrieved and Data-Integrity Issues

B.1 Core Reports Not Retrieved (n = 16)

All 16 are title-only records (no abstract in PubMed) that remained unretrieved after every full-text retrieval route. They are listed under reports not retrieved in the PRISMA flow (Figure 1) and contribute no data.

PMID	Record	Main obstacle	Alternative information
6102629	Cruikshank, Higgins, Gray. Two cases of acute intracranial haemorrhage in young amateur boxers. <i>Lancet</i> . 1980	Publisher paywall; no open copy	Metadata and MeSH only
895120	Blonstein. Care of the amateur boxer. <i>J Sports Med Phys Fitness</i> . 1977	No online archive for 1977	None
4097449	Beaussart, Beaussart-Boulengé. "Experimental" study of cerebral concussion in 123 amateur boxers, by clinical examination and EEG before and immediately after fights	No DOI or online copy	Sample size from the title only; may hold acute mental-status data
17273465	Valovich McLeod et al. Psychometric and measurement properties of concussion assessment tools in youth sports. <i>J Athl Train</i> . 2006	Repository and PubMed Central blocked	Abstract values used in the synthesis as context only
41201314	Cicciù, Barbagallo, Fiorillo. Acute subdural hematoma in professional boxing. <i>J Craniofac Surg</i>	Publisher access denied (402)	None
40127238	Cicciù, Barbagallo, Fiorillo. The fatal consequences of brain trauma in boxing: the tragic case of John Cooney. <i>J Craniofac Surg</i> . 2025	Publisher access denied (402)	News and encyclopedia summaries only; not citable
15742934	Garfield, Samuels. The Watson boxer case: what actually happened? <i>Med Leg J</i> . 2004	Publisher restricted access; judgment host blocked	Secondary and tertiary legal summaries only
12400242	Samuels. A comment upon the paper by Mr Garfield on Watson v British Boxing Board of Control. <i>Med Leg J</i> . 2002	Publisher paywall	Secondary summaries only
14169953	Courville. The mechanism of boxing fatalities: report of an unusual case with severe brain lesions incident to impact of boxer's head against the ropes	No online archive	None
12981335	Hall et al. Acute traumatic subdural hematoma; report of a case with slight trauma from boxing. <i>J Kans Med Soc</i> . 1952	No online archive	None
24539906	Jokl. Acute fatal boxing injuries. <i>Acta Med Orient</i> . 1950	No online archive	None
18103708	Romino. Boxing and intracranial injuries. <i>W V Med J</i> . 1948	No online archive	None
20343264	Jokl. Fatal cerebral injury in boxer. <i>Lancet</i> . 1947	Publisher identifier in the target list resolved to a different letter; no open copy	None
37253484	Rajesh et al. Head injury: assessment and early management, summary of updated NICE guidance. <i>BMJ</i> . 2023	BMJ host rate limit (HTTP 429)	NICE NG232 guideline text read instead (partial, through the NCBI Bookshelf copy)
13396258	Blonstein, Clarke. Further observations on the medical aspects of amateur boxing. <i>Br Med J</i> . 1957	BMJ host rate limit; PubMed Central reCAPTCHA	None
13396259	Paul. A fatal injury at boxing; traumatic decerebrate rigidity. <i>Br Med J</i> . 1957	BMJ host rate limit; PubMed Central reCAPTCHA	None

Priority records that remained abstract-only although the publisher holds the full text include Moriarity 2004 and 2012, Howell 2017, Stojisih 2008 (printed 2010), Doan 2021, Heilbronner 1991, Schmidt-Olsen 1990, Porter 1996, Siewe 2015, Jordan 1988 and 1990, Holzgraefe 1992, Chen 2013, 2014 and 2015, Warden 2001, Bleiberg 2004, Bianco 2005 and 2009, Brennan 1968, Timm 1993, Dande 2021, Constantoyannis 2004, Munshi 2025 and Peek 2026, together with the published versions of Loosemore 2015 and 2017, the tables of Davis 2017 and Butler 1993 (standard deviations), and the Tokyo 2020 and Buenos Aires 2018 Games reports. Their findings are worded as reported in the abstract or attributed to the secondary source.

B.2 Data-Integrity Issues Found in the Sources

Source	Issue	Handling in this review
Loosemore 2015 (Great Britain squad)	The stated rate of 0.53 concussions per 1,000 hours does not match 5 concussions in 6,375 competition minutes (reviewer arithmetic, 47.1 per 1,000 hours); the published version could not be read; the ARP consensus repeats 0.53	Reviewer arithmetic shown alongside the printed figure; neither quoted as an amateur incidence
Porter 1996 (Irish amateur cohort)	The 51.2% "concussion" proportion counted any head blow that stopped the contest, as reported by Mao 2023; the abstract describes predominantly mild concussions	Treated as a stoppage outcome
Timm 1993 (US Olympic Training Center)	A secondary review reports "6.1% concussions"; the PubMed abstract attributes 6.1% to serious injuries	Abstract wording retained; secondary figure not used
Estwanik 1984	The printed 4.38% equals 48 of 1,094 participants, not 48 of 547 bouts	Both figures shown (Table 5)
Donnelly 2023 (review)	Text figures for the Loosemore head-guard study disagree with its own Table 3; the table's rate column is labelled per 1,000 rounds although the arithmetic is per 10,000; the cited 0.33 vs 2.62 concussions per 100 bouts could not be traced to primary sources	Only the table counts used, attributed as secondary; rates and per-bout figures not used
Bianco 2013	A possible column shift in the head-guard column of Table 1 could not be checked against the PDF	Values from the abstract and analysis-stage full text, flagged for checking
Bianco 2005	The abstract counts injuries at 19 of 645 visits; a secondary review lists 20 injuries	Abstract figure retained
Paizante 2024	Abstract balance values conflict with the Results text and figure legend; interaction P values reported as headgear comparisons in the abstract	Results-text values used; described as a balance difference, not a concussion finding
Le Flao 2026	The publisher page and the PubMed abstract report the symptom-change statistic differently	Abstract values used and labelled
ARP headguard statement (deWeber 2024)	"RSCI increased from 2.04% to 0.60%" describes a decrease; a Davis 2018 percentage appears inconsistent	These secondary figures not used
USA Boxing rules	The 2025 Rule Book gives at least 1 year after 3 KOs in 12 months; the Medical Handbook gives 18 months; schedules for repeat events differ; the 2018 schedule reproduced by	Primary documents cited; RACE1 applies the stricter value

Source	Issue	Handling in this review
	the ARP is superseded	
World Boxing Medical Handbook 2025	The mapping of the 30-day and 90-day suspensions to LOC status in section 8.1 was ambiguous and conflicted between extractions; question wording paraphrased in the web-page text extraction	Periods and wording not quoted
NICE NG232	Recommendations 1.2.2 and 1.2.3 were returned paraphrased; section 1.3 not obtained	Only verbatim recommendations (1.2.4 onward and CT criteria) used
CRT6	Item lists read from an adapted ski-federation copy	Items described, not quoted
Siewe 2015	Secondary sources disagree on whether the cohort was amateur or professional	Abstract figure reported with the disagreement stated
Welch 1986	A secondary table (294 injuries, 48% to the head) conflicts with the abstract rate below 4% of about 2,100 cadets	Not used numerically
Junge 2009	Training and competition boxing injuries in Table 3 do not sum to the extracted total of 42	Concussion count (2 of 281) used; all-injury total not used
Chen 2012	Motion sickness in 8 of 15 boxers in the abstract and 7 of 15 in the Results and Table 1	Results figure used
Galetta 2011	The abstract describes 39 boxers and MMA fighters; the same group's meta-analysis lists 42 amateur boxers	Retained as combat-sport context, not reclassified
Stewart 2026	The synthesis summary and the extraction record give different proportions of strikes followed by observable signs	No proportion quoted
Screening workbook and synthesis (Breton 1991)	Recorded as excluded (E4) among targeted-search records but listed among amateur studies in the orientation and memory synthesis	Not cited; noted in section 3.11
Sethi 2022b (ARP neuroimaging)	A 2022 table of commission licensure imaging lists the Alabama Athletic Commission as having no requirement; the author is a commissioner	Reported with disclosure; not checked against current rules
Al-Awady 2025; Adkitte 2016; Lystad 2014; Dande 2021; Hohmann 2023	Age-range, issue, volume, identifier and publication-year discrepancies in citation metadata	Corrected at citation verification

Appendix C. RACE1 Ringside Acute Concussion Examination Cards (Edition 4) for Review

Guidance, not authority. The RACE1 cards are intended to give the ringside clinician structured guidance after the bout. They do not supersede the authority, clinical judgment or decisions of the ringside physician or any other licensed ringside clinician, and they do not replace the rules or medical requirements of the governing body. Whether to stop a bout, whether to transport, and whether and when an athlete is cleared remain decisions of the ringside physician.

The 18 standardized cards (20 half-letter pages, including the reverse sides of Cards 5 and 18) are reproduced below exactly as issued in edition 4 for review and comment. RACE1 is used only after the bout, against a pre-bout baseline where possible; it is never used during a bout, between rounds, or to permit return to participation the same day or in the same competition. A normal result is not a clearance. Items and score bands are provisional and have not been validated in any sport. Reviewers are asked to send comments on the wording, order, scoring and layout of any card to editor@searspublishing.net, citing the card number.

CARD 1 of 18 Instructions and Exam Sequence**Purpose**

RACE1 is a standardized post-bout screen for suspected concussion, used after the bout has ended (knockout, stoppage, retirement, or final bell). It applies to amateur and professional bouts. Where possible, the same items are recorded at the pre-bout examination as the fighter's baseline.

RACE1 does not diagnose or exclude concussion, and it never clears a fighter. It records standardized findings to assist the ringside physician, who decides clearance after a mandatory multimodal evaluation (for example, SCAT6 or MACE 2). Never use RACE1 during a bout, between rounds, or to permit return to participation the same day or in the same competition. Items and score bands are provisional and unvalidated.

Examiner

Licensed healthcare professional: the ringside physician, or a clinician working under the ringside physician's direction.

Materials

This card deck, pen, penlight, watch or timer, examination gloves, and the fighter's pre-bout baseline (Card 18, Section A).

Rules that apply at every card

- A red flag found at any point ends the exam. Go to Card 3 and follow its action.
- Complete Card 5 (cervical spine, fractures, eyes) before any standing task or eye test.
- Word lists: List A at the pre-bout baseline, List B after the bout, List C for a re-test, in the fighter's preferred language.
- Mark a test U (unreliable) when an injury on Card 5 prevents a valid result. U scores 0.
- Exertion degrades balance: repeat Cards 10 to 14 after a short rest before the final disposition.
- Screen winners as well as losers after a knockout, a stoppage, or suspected concussion.
- When in doubt, do not clear.

Sequence

Cards	Content
2 to 5	Incident, red flags, consciousness and memory, confounding injuries
6 to 9	Seated: orientation, immediate memory, pupils, eye tracking
10 to 14	Standing: stand and mouthpiece, guard, resistance, lateral movement, mouthpiece removal
15 to 18	Delayed recall (seated); speech and comprehension (observed throughout); scoring and disposition

CARD 2 of 18 Incident, Bout Details, and Observable Signs

Fighter: _____

Opponent: _____

Event, venue, and date: _____

Round and time of injury: _____

A. Bout details

Contest: ☐ Amateur ☐ Professional Headgear: ☐ None ☐ Worn

Governing rule set: ☐ USA Boxing ☐ World Boxing ☐ Other amateur body
☐ State commission (professional) ☐ Other: _____

Result: ☐ Won ☐ Lost ☐ Draw or no decision Language: _____

Interpreter: ☐

B. Mechanism of injury

Record the event as described by the fighter, referee, corner, or a witness, or as seen on video.

Description (for example, left hook to the chin; head struck the canvas): _____

C. Bout status

- ☐ Knockout
- ☐ Referee stoppage (RSC / TKO); head blows: ☐ Yes ☐ No
- ☐ Standing count
- ☐ Stoppage on physician advice
- ☐ Corner retirement
- ☐ Bout went the distance

D. Observable signs at the time of injury or since

Source: ☐ Examiner ☐ Referee ☐ Corner ☐ Video

- ☐ Loss of consciousness or unresponsiveness (also a red flag: go to Card 3)
- ☐ Seizure or convulsion (also a red flag: go to Card 3)
- ☐ Lying motionless
- ☐ Motor incoordination: stumbling, staggering, or unsteady on the feet
- ☐ No protective action when falling (floppy)
- ☐ Tonic posturing
- ☐ Disorientation or confusion
- ☐ Blank or vacant look
- ☐ Slow to get up (prompts the exam; not a sign on its own)
- ☐ None observed

Any sign rules out "No deficit detected" (Card 18). RSC, TKO, or a standing count triggers this exam; it is not a diagnosis.

CARD 3 of 18 Red Flags: Stop and Activate the Emergency Plan

If ANY red flag is present at ANY point in the exam: stop RACE1, do not clear the fighter, obtain immediate ringside physician evaluation, and activate EMS under the commission's emergency action plan.

- ☐ Glasgow Coma Scale score below 15
 - ☐ Loss of consciousness or unresponsiveness of any duration. Duration: ☐ under 1 minute ☐ 1 minute or longer ☐ unknown
 - ☐ Seizure or convulsion
 - ☐ Deteriorating or fluctuating level of consciousness
 - ☐ Increasing confusion, agitation, or combativeness
 - ☐ Neck pain, midline neck tenderness, or painful or restricted neck movement (Card 5A)
 - ☐ Weakness, numbness, tingling, or paralysis in any limb
 - ☐ New focal neurological deficit (for example, facial droop or loss of eye movement in one direction)
 - ☐ Severe or increasing headache
 - ☐ Vomiting more than once
 - ☐ Persistent double vision
 - ☐ Unequal pupils, or a sluggish or non-reactive pupil, not explained by an eye injury (Card 5C)
 - ☐ Spontaneous or sustained nystagmus
 - ☐ Signs of skull fracture: bruising behind the ear (Battle's sign), bruising around both eyes (raccoon eyes), blood or clear fluid from the ears or nose, or a palpable skull deformity
 - ☐ Ataxia after a knockout, progressive loss of balance, or unable to stand or walk without assistance
-

Unconscious or unresponsive fighter: assume a cervical spine injury. Do not move the head or neck. Protect the airway.

Result

- ☐ No red flags: continue to Card 4
- ☐ Red flag present: STOP. Record the time and go to Card 18 (Emergency).

Time: _____

GCS threshold source: SCAT6 (2023); Association of Ringside Physicians neuroimaging consensus (2022); NICE NG232 (2023). Repeat this red-flag check before the fighter leaves the venue: deterioration can follow a lucid interval.

CARD 4 of 18 Consciousness, Memory, and Symptoms

A. Alteration of consciousness

Did the fighter appear dazed, confused, or slow to respond immediately after the impact ("bell rung")?

☐ Yes ☐ No ☐ Unknown

B. Memory of the event

Ask open, neutral questions. Do not suggest answers.

Before the impact: "What is the last thing you remember before you were hit?"

☐ Gap in memory ☐ No gap ☐ Unknown

After the impact: "What is the first thing you remember after you were hit?"

☐ Gap in memory ☐ No gap ☐ Unknown

C. Symptoms reported by the fighter (not scored)

Pre-bout baseline symptoms: ☐ None ☐ Present: _____ ☐ Not recorded

Interpret after the Card 5 eye check. "How do you feel right now? Do you have any of these?"

- ☐ Headache or pressure in the head
- ☐ Dizziness
- ☐ Nausea
- ☐ Blurred vision
- ☐ Sensitivity to light or noise
- ☐ Ringing in the ears
- ☐ Feeling slowed down or foggy
- ☐ "Don't feel right"
- ☐ None reported

Fighters may not recognise or may not report symptoms. Observed findings take priority over self-report.

A Yes or Unknown in A, a gap in B, or any symptom in C means the fighter cannot be classed "No deficit detected" on Card 18.

CARD 5 of 18 Confounding Injuries and Test Reliability

Complete Sections A to C before any standing task (Cards 10 to 14) and before interpreting Cards 4C, 8, and 9.

A. Cervical spine screen

- ☐ Neck pain at rest
- ☐ Midline tenderness on palpation
- ☐ Pain or restriction on active neck rotation (only if no pain at rest and no tenderness)
- ☐ Arm or leg weakness, numbness, or tingling
- ☐ All normal

Any abnormal finding is a red flag (Card 3): immobilize and transport; do not perform standing tasks.

B. Fracture suspicion

- ☐ Skull fracture signs (Card 3 red flag)
- ☐ Facial or jaw fracture (deformity, malocclusion, step-off)
- ☐ Orbital fracture (eye movement restriction, numb cheek, enophthalmos)
- ☐ None

Suspected facial, jaw, or orbital fracture: transfer for CT. Normal radiographs do not exclude orbital fracture.

C. Eye and periocular screen

- ☐ Hyphema, globe injury, or eye swollen shut
- ☐ Sudden loss or reduction of vision, flashes, or floaters
- ☐ Laceration of the eyelid or around the eye
- ☐ None

Any finding: emergent ophthalmology referral (Association of Ringside Physicians eye-conditions statement). After an in-competition eye injury, defer the penlight test briefly; mark Cards 8 and 9 U if the eye cannot be examined validly.

CARD 5 of 18 (reverse) Test Reliability and Context

D. Injuries that make tests unreliable

Injury present	Tests marked U
☐ Eye injury (Section C, orbital fracture)	Card 8 pupils; Card 9 eye tracking
☐ Ear injury (perforated eardrum, severe ear trauma)	Cards 10, 11, 13 balance items, if hearing or balance is affected
☐ Upper-limb injury (hand, wrist, arm, shoulder)	Card 10 mouthpiece item; Cards 11, 12, 14
☐ Lower-limb injury (hip, knee, ankle, foot)	Card 10 standing item; Card 13
☐ Facial, jaw, or dental injury affecting speech or mouthpiece use	Card 10 mouthpiece item; Card 14; Card 16
☐ Laceration or bleeding obscuring vision	Card 9 eye tracking, if vision is obscured
☐ No confounding injury identified	None

E. Context (record; never used to dismiss a suspected concussion)

Time since end of bout (minutes): _____

- ☐ Exhaustion or recent maximal exertion ☐ Rapid weight loss before the bout ☐ Anticoagulant or antiplatelet use ☐ Alcohol or drugs suspected
- ☐ Previous concussion ☐ Migraine or headache disorder ☐ ADHD, learning, or mood disorder ☐ Motion sickness

Other injury or history: _____

Rules

- An abnormal pupil is managed as a red flag (Card 3) unless the ringside physician attributes it to a direct eye injury.
- Exhaustion is recorded but is not used to explain an abnormal finding without a physician re-test after rest.
- Any U result means the fighter cannot be classed “No deficit detected” on Card 18.

CARD 6 of 18 Orientation (Seated)

Seat the fighter. Ask each question as written. Do not offer choices. Score 1 for each correct answer.

Question	Correct (1)	Incorrect (0)
1. "About what time of day is it?" (morning, afternoon, evening, or night is correct)	☐	☐
2. "Where are we right now?" (venue name or city is correct)	☐	☐
3. "Who did you fight tonight?" (opponent's name)	☐	☐
4. "What was the last round you fought?"	☐	☐

Not scored: "How did the bout end?" ☐ Correct ☐ Incorrect ☐ Not known to examiner

ORIENTATION SCORE: _____ / 4

Bout-specific questions follow USA Boxing Medical Handbook 5.4.2 and World Boxing Medical Handbook 5.3.

CARD 7 of 18 Immediate Memory (Seated)

Use List A at the pre-bout baseline, List B for the post-bout exam, and List C for a re-test. Give the words in the fighter's preferred language, using an adapted list (not a literal translation) where one is available.

List A	List B	List C
Window	Anchor	Rocket
Tiger	Pillow	Blanket
Bottle	Carrot	Lemon

List used: ☐ A ☐ B ☐ C Language: _____

Script

"I am going to say three words. Repeat them back to me when I finish. Try to remember them, because I will ask for them again later."

Procedure

- Say the three words at about one word per second.
- Score Trial 1: 1 point for each word repeated correctly, in any order.
- If any word is missed, repeat all three words until the fighter repeats all three (maximum 3 trials). This makes sure the words were registered before the delayed recall test.

Trials needed to register all three words (1, 2, 3, or not registered): _____

Time words given (needed for Card 15): _____

IMMEDIATE MEMORY SCORE (Trial 1): _____ / 3

A three-word list is brief and many fighters will score full marks (ceiling effect); a full score does not exclude concussion.

CARD 8 of 18 Pupil Response (Seated)

Check Card 5C first. After an in-competition eye injury, wait briefly before the penlight test.

Pre-bout baseline (from the pre-bout examination): ☐ Equal ☐ Unequal
(record): _____ ☐ Not recorded

Shade the eyes if the venue lighting is bright. Shine the penlight into each eye in turn.

Normal

- ☐ Pupils equal in size (or unchanged from the pre-bout baseline)
- ☐ Both pupils constrict briskly to light

Abnormal

- ☐ Unequal pupils, new since the pre-bout baseline
- ☐ Sluggish or non-reactive pupil

An abnormal pupil is a red flag: stop and go to Card 3, unless the ringside physician attributes it to a direct eye injury (Card 5C).

PUPIL SCORE: 1 (normal) / 0 (abnormal) / U (Card 5): _____

CARD 9 of 18 Eye Tracking (Seated)

Check Card 5C first. Hold a finger at arm's length. Ask the fighter to keep the head still and follow the finger with the eyes only. Move it slowly left, right, up, and down (H pattern). Ask about double vision at each end position.

Normal

- ☐ Eyes follow the target smoothly in all directions
- ☐ No double vision
- ☐ Eyes focused, not glassy

Abnormal

- ☐ Jerky or broken tracking
- ☐ Nystagmus away from the far ends of gaze (a few beats at the far end of gaze can be normal)
- ☐ Glassy or unfocused gaze

Persistent double vision, spontaneous or sustained nystagmus, or loss of eye movement in one direction is a red flag: stop and go to Card 3, and check Card 5C for an eye or orbital injury.

EYE TRACKING SCORE: 1 (normal) / 0 (abnormal) / U (Card 5):

CARD 10 of 18 Stand Up and Insert Mouthpiece

Only after Card 5A is normal. Command: "Stand up and put your mouthpiece in." The examiner wears gloves when handling the mouthpiece.

Surface: ☐ Ring canvas ☐ Floor Footwear: ☐ Boxing shoes ☐ Other

Stance: feet shoulder-width apart

Item 1: Standing (1 point)

- ☐ Normal: stands up steadily without losing balance
- ☐ Abnormal: sways, stumbles, or needs a corrective step or support

Item 2: Mouthpiece (1 point)

- ☐ Normal: inserts the mouthpiece correctly on the first attempt without fumbling
- ☐ Abnormal: fumbles, drops it, inserts it reversed or upside down, or asks for the instruction again

If no mouthpiece is available, mark Item 2 as U.

STAND UP SCORE: Item 1 _____ + Item 2 _____ = _____ / 2

CARD 11 of 18 Hands Up: Guard Position (Standing)

Command: "Put your hands up." (the fighter's normal defensive guard)

Normal

- ☐ Raises both hands promptly into a proper guard covering the face and chin
- ☐ Holds the stance steadily

Abnormal

- ☐ Hands low or uneven
- ☐ Unsteady while raising the arms
- ☐ Delayed response, or needs the command repeated

Keep the fighter in guard for Card 12.

GUARD SCORE: 1 (normal) / 0 (abnormal) / U (Card 5): _____

CARD 12 of 18 Resistance Test (Standing, in Guard)

Script: "I am going to press down on your arms. Keep your hands up and resist me."

Apply moderate downward pressure on both forearms at the same time for about 2 seconds.

Normal

- ☐ Both arms hold strongly and equally
- ☐ Keeps stance and footing
- ☐ Understands and performs the task

Abnormal

- ☐ One or both arms give way, or strength is unequal
- ☐ Loses footing, stumbles, or takes a large corrective step
- ☐ Does not resist, drops the hands, or misunderstands the task

New weakness in one limb is a red flag: go to Card 3.

RESISTANCE SCORE: 1 (normal) / 0 (abnormal) / U (Card 5): _____

CARD 13 of 18 Lateral Movement and Return (Standing)

Step 1: "Take two steps to your right."

Step 2: "Now come back to me."

Normal

- ☐ Moves promptly to the correct side
- ☐ Takes two smooth steps and returns steadily
- ☐ Keeps balance while moving and turning

Abnormal

- ☐ Stumbles, shuffles, drags a foot, or crosses the feet awkwardly
- ☐ Goes the wrong way or takes the wrong number of steps
- ☐ Sways or nearly trips

Stand close enough to steady the fighter. Ataxia after a knockout or progressive loss of balance is a red flag: go to Card 3.

LATERAL MOVEMENT SCORE: 1 (normal) / 0 (abnormal) / U (Card 5):

**CARD 14 of 18 Remove and Hand Over Mouthpiece
(Standing)**

Command, given once: "Take out your mouthpiece and hand it to me."

Normal

- ☐ Removes the mouthpiece promptly and smoothly
- ☐ Hands it to the examiner (completes both parts of the command)

Abnormal

- ☐ Fumbles, shakes, or drops the mouthpiece
- ☐ Completes only the first part (for example, removes it but does not hand it over)
- ☐ Hesitates or needs a prompt

If Card 10 Item 2 was U, mark this card U.

MOUTHPIECE REMOVAL SCORE: 1 (normal) / 0 (abnormal) / U (Card 5): _____

Repeat Cards 10 to 14 after a short rest (record the time on Card 18) before the final disposition: exertion and fatigue can degrade balance for about 20 minutes.

CARD 15 of 18 Delayed Recall (Seated)

Seat the fighter. At least 5 minutes must have passed since the words were given on Card 7. If fewer than 5 minutes have passed, wait.

Time of recall: _____

Script: "What were the three words I asked you to remember?" Do not give hints. Score 1 for each word recalled, in any order.

Word (from the list used on Card 7)	Recalled (1)	Not recalled (0)
Word 1: _____	☐	☐
Word 2: _____	☐	☐
Word 3: _____	☐	☐

DELAYED RECALL SCORE: _____ / 3

CARD 16 of 18 Speech Fluency (Observed Throughout)

Score from the fighter's speech during Cards 4 to 15, in the fighter's preferred language (Card 2).

Normal

- ☐ Clear, fluent speech; answers and acknowledgements are appropriate

Abnormal

- ☐ Slurred or incoherent speech
- ☐ Slow, altered, or repetitive speech
- ☐ Difficulty finding words
- ☐ Silent or does not respond when spoken to

Mark U if a facial, jaw, or dental injury (Card 5) or a language barrier prevents a valid judgement.

SPEECH SCORE: 1 (normal) / 0 (abnormal) / U (Card 5): _____

CARD 17 of 18 Comprehension and Processing (Observed Throughout)

Score from how the fighter followed instructions during Cards 6 to 15. Give instructions in the fighter's preferred language.

Normal

- ☐ Follows commands promptly; normal facial expression and response time

Abnormal

- ☐ Slowed processing: asks for instructions again or seems unsure what to do
- ☐ Blank or vacant stare
- ☐ Misunderstands instructions, cannot respond appropriately to questions, or does something inappropriate

COMPREHENSION SCORE: 1 (normal) / 0 (abnormal): _____

CARD 18 of 18 Scoring, Disposition, and Signatures**A. Score summary**

Domain and card	Max	Pre-bout baseline	Post-bout exam	Re-test
Orientation (Card 6)	4			
Immediate memory (Card 7)	3			
Delayed recall (Card 15)	3			
Cognition subtotal	10			
Pupils (Card 8)	1			
Eye tracking (Card 9)	1			
Oculomotor subtotal	2			
Stand up and mouthpiece (Card 10)	2			
Guard (Card 11)	1			
Resistance (Card 12)	1			
Lateral movement (Card 13)	1			
Mouthpiece removal (Card 14)	1			
Motor and balance subtotal	6			
Speech (Card 16)	1			
Comprehension (Card 17)	1			
Speech and comprehension subtotal	2			
TOTAL	20			

Pre-bout baseline items not recordable before the bout (opponent, last round) are left blank. A finding absent at baseline and present after the bout is new.

Tests marked U: _____ Word list: Baseline ____ Post-bout ____
 Re-test ____ Motor re-test time: _____

Loss of consciousness: ☐ None ☐ Under 1 minute ☐ 1 minute or longer
☐ Unknown

Signatures

Examiner name and credential: _____

Signature: _____

Ringside physician: _____

Signature: _____

Exam start and finish times: _____

Re-test times: _____

CARD 18 of 18 (reverse) Disposition, Restriction, and Signatures**B. Disposition (apply the first category that fits)**

Category	Criteria	Action
EMERGENCY	Any red flag (Card 3) at any time, including GCS below 15	Activate EMS. Transport to the pre-identified trauma centre (CT, neurosurgery). Cervical precautions when indicated.
NOT CLEARED	Total below 20; or any observable sign (Card 2); or altered consciousness, memory gap, or symptom (Card 4); or any test marked U	No return to participation. Mandatory multimodal physician evaluation (e.g., SCAT6, MACE 2). Re-test every 15 to 30 min with a new word list; if worse, EMERGENCY. Apply Section C.
NO DEFICIT DETECTED	Total 20, with none of the findings above	Not a clearance and no same-day return: no clearance until the physician completes a mandatory multimodal evaluation; mandated restrictions still apply. Repeat Cards 3 and 4C before the fighter leaves. Signs can appear later.

The score bands are provisional and have not been validated against clinical diagnosis. A total of 20 does not exclude concussion.

C. Restriction (governing body minimum; physician may extend)

Rule set (Card 2): _____ Minimum restriction under that rule set: _____ days

Where the governing body's documents conflict, apply the stricter value.

Physician extension: ☐ None ☐ Extended to _____ days ☐ Indefinite suspension pending further evaluation

Reason for extension: _____

D. Written instructions given to the fighter and a responsible adult

- ☐ Do not stay alone tonight; do not drink alcohol; do not drive
- ☐ Seek emergency care for worsening headache, neck stiffness, vomiting, confusion, drowsiness, weakness, seizure, or any new symptom in the following days
- ☐ Written medical clearance is required before any return to training or competition

E. Final disposition

☐ Emergency transport ☐ Not cleared ☐ No deficit detected

Physician decision after multimodal evaluation: ☐ Released from venue with instructions and restriction ☐ Transport