

Online Supplementary Material

Examining Later-in-Life Health Risks Associated with Sport-Related Concussions and Repetitive Head Impacts: A Systematic Review of Case-Control and Cohort Studies

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180 (2021-2; resigned Oct 2022) (paid); (iii) Chair, Therapeutic Use Exemption Fairness Committee
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212

213 The Need for Case-Control and Cohort Studies

214

215 There is a large and steadily growing body of cross-sectional studies on problems with brain
216 health, broadly defined, in former amateur and professional athletes, and these studies have been
217 the focus of multiple prior narrative and systemic reviews [1-28]. Cross-sectional studies, using
218 samples of convenience, are important for searching for associations, generating hypotheses, and
219 providing directions for more definitive causal research. For example, a cross-sectional, also
220 known as a prevalence study or survey, might find that former athletes report greater (or lesser)
221 symptoms of depression than a control sample, and that same study might show an association
222 between depression and chronic pain or depression and a self-reported history of sustaining
223 multiple concussions. However, cross-sectional studies are not sufficient to draw conclusions
224 about the incidence or the risk of depression in former athletes.

225

226 Case series are often the first type of study to appear when investigating new entities that may
227 not have an established clinical diagnostic phenotype in living patients and may only have a
228 pathological definition, such as is currently the case with chronic traumatic encephalopathy
229 neuropathologic change (CTE-NC) [29, 30]. These are important because they raise hypotheses
230 to be investigated in future cohort and case-control studies, and they can be viewed as the first
231 step in causal investigations in medicine. Cross-sectional studies also appear early in the process
232 of examining health risk factors and long-term outcomes because they are cost-effective,
233 feasible, and relatively easy to complete because there is no active follow-up period. However,
234 because they are a snapshot in time, they include only prevalent cases which limits the ability to
235 infer causation [31]. For example, some case series or cross-sectional studies recruit available
236 cases, often from a clinical setting. These prevalent or available cases differ from incident cases
237 used in cohort and case-control studies in that they are missing those that have recovered,
238 emigrated, died, or are lost to follow up for other reasons. Available prevalent cases would have
239 a different and usually worse prognosis than an inception cohort of incident cases. Thus, the
240 factors associated with prevalent cases might clearly differ from those associated with incident
241 cases [32]. Moreover, it can be difficult to place exposures, confounders, and outcomes in an
242 appropriate timeline in cross-sectional studies because they are all measured at the same time.
243 Case series and cross-sectional studies are not designed to examine causal relationships but help
244 direct research efforts to examine these issues in more rigorous study designs [32, 33].

245

246 To more definitively study potential negative long-term effects of concussions and repetitive
247 head impacts, or exposure to contact sports, specific research designs are required. Longitudinal
248 study designs that include an exposed and unexposed group from a population at risk of the
249 outcome are required. Specifically, cohort studies and case control designs are suited for this
250 type of investigation. Implicit in these designs is the careful control of confounding factors, or
251 factors that are associated with or 'travel together' with the exposure of interest and are not
252 intermediate factors directly along the path from cause to effect [34]. This is extremely important
253 when dealing with long lag-times between exposures and outcomes, such as playing a sport
254 during adolescence or young adulthood and determining the cause of dementia many decades
255 later. For example, when studying risk factors for dementia in older adults there are a number of
256 factors of potential importance to try to measure and control for, such as genetic factors, level of
257 education, socioeconomic status and social determinants of health, cognitive reserve,

258 hypertension, diabetes, alcohol misuse, sleep apnea, hearing loss, peripheral vascular disease,
259 and small vessel ischemic disease [35-39].
260
261 Cohort studies inception incident cases and directly measure risk by dividing the incidence of the
262 outcome in the exposed by the incidence of the outcome in the unexposed producing a direct
263 measure of risk or the relative risk (RR). Alternatively, case-control studies estimate the relative
264 risk by comparing the odds of exposure in cases divided by the odds of exposure in controls
265 producing an odds ratio (OR). Care must be taken to ensure that the outcome of interest is an
266 uncommon or rare event in case control studies or the odds ratio will overestimate the relative
267 risk [40]. Case-control studies are retrospective by design and as a rule, cohort studies provide
268 more accurate estimates of risk than case-control studies. The most informative case-control
269 studies are nested in an inception cohort of incident cases.
270

271 **Studies Not Included in this Systematic Review**

272

273 ➤ Numerous postmortem studies relating to chronic traumatic encephalopathy neuropathologic
274 change (CTE-NC) in former athletes have been published over the past 17 years [22, 41-47],
275 as well as many published reviews [4, 14, 16-23, 25-28, 48-63].

276

277 ➤ There is also a body of literature relating to neuroimaging in former athletes [2, 12].

278

279 ➤ None of these postmortem studies or neuroimaging studies were included in this systematic
280 review because they are not case-control or cohort studies that can examine risk.

281

282 ➤ It was decided, a priori, by the author group that planned this systematic review, to identify
283 studies in the world literature that were case-control or cohort studies that might yield
284 evidence relating to inferences about future risk to former athletes.

285

286 ➤ No studies included in this review examined possible long-term effects in women, and thus
287 we can draw no conclusions relating to women.

288

289 ➤ There were also no studies of former university or college-level athletes that met criteria for
290 inclusion in this review.

291

292 ➤ One of our review questions pertained to age of first exposure to contact or collision sports
293 and whether earlier age was associated with worse later in life brain health [15, 64-67]. There
294 were no studies on this topic included in this review, and we cannot draw any conclusions.

295

296 Narrative Review of Studies of Former Amateur Athletes

297

298 There were 10 studies of former amateur athletes [68-77]. Depression, anxiety, or both were
299 included in five studies of former amateur athletes, mostly football players, and none of these
300 studies identified an increased risk for these mental health problems in former contact or
301 collision sport athletes [68-70, 72, 73]. Data from the National Longitudinal Study of Adolescent
302 to Adult Health [78] was used in four of the studies included in this review [69, 70, 72, 73]. This
303 study began during the 1994-1995 school year when the participants were adolescents (Wave I).
304 The studies used survey data from when the participants were a median age of 22 (Wave III,
305 2001-2001; age IQR=20-23), 29 (Wave IV, 2007-2009, age IQR=28-31), and 38 (Wave V,
306 2016-2018, age IQR=36-40). Men who reported the intention to play high school football during
307 their adolescence, when surveyed later in life, at the average age of 29 and 38, did not report a
308 greater lifetime history of anxiety [69, 72] or depression [69, 70, 72, 73], greater mental health
309 treatment in the past year [69, 70], or current symptoms of depression (i.e., within the past seven
310 days) [69, 72]. Moreover, playing high school football was not associated with suicidal ideation
311 at an average age of 22 [70], 29 [70, 72, 73], or 38 [69]. Collectively, none of these studies found
312 an association between high school football participation and risk for future mental health
313 problems or suicidality over course of this 20-25-year longitudinal study. A methodological
314 limitation of these studies is that while in high school the boys were surveyed a single time about
315 their intention to play football; it could not be determined whether they actually did play football,
316 or for how many years, or their positions, or their playing time.

317

318 Deshpande and colleagues [68], using data from the Wisconsin Longitudinal Study, examined
319 the association between playing high school football and the experience of cognitive impairment
320 or depression, decades later, at the age of 65, in a sample of 3,904 men. The primary outcome
321 cognitive functioning was based on neuropsychological testing and the other primary outcome
322 relied on a self-report measure for symptoms of depression. Secondary outcomes, such as anger,
323 anxiety, and heavy use of alcohol, were also examined. They reported that former football
324 players had similar primary outcomes at the age of 65 as those who did not play football, and
325 similar secondary outcomes at ages 54, 65, and 72.

326

327 Two studies examined whether playing high school football was associated with increased risk
328 for later in life neurodegenerative diseases, and these studies noted that playing high school
329 football was not associated with increased risk for dementia, Parkinson's disease, or ALS [74,
330 75]. Savica and colleagues [75] examined the medical records from 438 former athletes who
331 played high school football during the period 1946-1956 for the presence of neurological or
332 neurodegenerative diseases. They were compared to 140 men who did not play sports. There
333 were no significant differences between groups in the proportions with neurological or
334 neurodegenerative diseases. Janssen and colleagues [74] used a similar methodology as Savica et
335 al. and examined the medical records of 296 men who played high school football between 1956-
336 1970. They were compared to 190 men who participated in other sports during high school (i.e.,
337 swimming, basketball, and wrestling). There were no significant differences between groups in
338 the proportions with neurological or neurodegenerative diseases.

339

340 Porter [76] conducted a 9-year longitudinal study of a small sample of amateur boxers compared
341 to age and socioeconomically similar control subjects. The control sample was not allowed to

342 participate in combat sports, but could participate in contact or collision sports. The samples
343 underwent neuropsychological testing on five occasions over 9 years. The boxers did not show
344 evidence of decline in neuropsychological functioning, over the 9 years, in comparison to the
345 controls.

346

347 Valenti and colleagues [77], using a case-control study design, examined the sporting history of
348 300 people who had been clinically diagnosed as having ALS. The patients were identified from
349 10 national (in Italy) centers for the diagnosis and treatment of ALS. The controls were matched
350 on age, sex, and neighborhood in which they lived. There was no association between playing
351 sports in general, and soccer in particular, and having ALS.

352

353 Weiss and colleagues [71] conducted a study of 660 Swedish twins, older than 50 years of age at
354 the time of baseline examination, who were being followed for 19 years with 3-year follow-up
355 examinations with the Mini Mental State Examination (MMSE). Cognitive impairment was
356 defined using a cutoff of 27, with lower scores indicative of more severe impairment. Exposure
357 was based on a single survey question: 'Have you been involved in any sport (e.g., football, ice
358 hockey, or boxing) that may involve a hit on a head?', and 78 (11.8%) of the cohort endorsed
359 this question affirmatively. The authors reported that participation in contact or collision sports
360 during youth was not significantly associated with measured cognitive impairment later in life
361 [71].

362

363 Narrative Review of Studies of Former Professional Athletes

364

365 Eighteen studies involved former or current professional athletes [79-96]. There were nine
366 studies with former NFL players [79, 80, 84, 85, 88, 91-94].

367

368 Mental health was one of the outcomes of interest in eight studies with former professional
369 athletes [79-81, 85, 87, 91, 92, 94]. Two studies of former NFL players found an association
370 between a greater number of past concussions and a greater risk for depression [85, 94]. In
371 contrast, mortality studies, conducted by examining death certificates, revealed that former NFL
372 players are at significantly *lower* risk for death relating to psychiatric disorders [79, 80], and
373 hospitalization for psychiatric problems was *less* common in former professional soccer players
374 [87]. All studies that examined suicide as a manner of death in former NFL players or former
375 professional soccer players reported either significantly lower risk [79, 80, 92] or no difference
376 compared to men in the general population [81, 87].

377

378 Neurological conditions (e.g., dementia) and neurodegenerative diseases (e.g., Alzheimer's
379 disease and ALS) were outcomes in nine studies [79-84, 86, 90, 91, 93], and many of these
380 studies reported worse outcomes for former professional athletes. Greater risk for neurological
381 conditions and neurodegenerative diseases was reported for both former NFL players [93] and
382 former professional soccer players [90]. Six studies reported on ALS as an outcome, and all six
383 found an association with participation in professional sports [81-84, 90, 93]. However, most of
384 these studies were ecological in nature with the exposure-outcome relationship at the group
385 rather than the individual level. Thus, an association between variables at the group level might
386 not be confirmed at the individual level. In addition, these associations are mostly unadjusted
387 with little or no control of individual confounding factors. This makes them susceptible to
388 "ecologic fallacy," a bias that occurs when associations at the group level are not confirmed at
389 the individual level. Ecological studies [97] can raise hypotheses to be tested in more rigorous
390 study designs but cannot address causation at the individual level. Study summaries are provided
391 below.

392

393 Kerr and colleagues [94] followed a cohort of 1,044 former NFL players with surveys that asked
394 about demographic information, number of concussions sustained during their professional
395 football career, physical and mental health, and prevalence of diagnosed conditions. Between the
396 2001 and 2010 surveys, 106 (10.2%) reported being diagnosed as clinically depressed. The
397 authors reported that the 9-year risk of depression diagnosis increased in association with greater
398 self-reported past concussions from 3% in those who reported zero past concussions to 26.8% in
399 the group that reported 10 or more prior concussions. The authors reported that those former
400 players who developed depression, compared to those who did not, were younger, they were
401 retired for fewer years, and they had worse physical health scores when surveyed in 2001. The
402 authors speculated that reduced physical functioning might be associated with a growing sense of
403 hopelessness and less physical independence, contributing to an erosion of mental health.

404

405 Brett and colleagues [85] investigated 333 former NFL players at 3 time points over 19 years as
406 part of the NFL-LONG study (i.e., 2001, 2010, and 2019). Their mean age at the first time point
407 was 49 (SD=9.4 years). Players with a greater history of concussion were more likely to report
408 greater depressive symptoms severity. Years of participation in sports was not associated with

409 symptoms of depression. The number of individuals who reported symptoms of depression that
410 were greater than one SD above the general population mean increased from 6.7% in 2001 to
411 16% in 2019. A decline in physical functioning, but not concussion history or years of football
412 exposure, was an important predictor of worsening depression over time.
413

414 Russell and colleagues conducted a large-scale study of former professional soccer (i.e.,
415 European football) players from Scotland and examined psychiatric hospitalizations [87]. Over
416 an 18-year observation period, 5.1% (388/7,676) of former professional soccer players compared
417 to 6.1% (1,399/23,028) of matched population controls were hospitalized for psychiatric reasons.
418 Regarding specific diagnoses, former professional soccer players had a lower risk of
419 hospitalization for depression (HR=0.64; 95% CI=0.44-0.92), bipolar and affective mood
420 disorders (HR=0.55; 95% CI=0.34-0.88), anxiety and stress related disorders (HR=0.37; 95%
421 CI=0.25-0.55), alcohol use disorders (HR=0.62; 95% CI=0.51-0.76), and drug use disorders
422 (HR=0.39; 95% CI=0.25-0.60) [87]. This study also examined suicide as a manner of death in
423 former professional soccer players [87]. There was no significant difference in the rate of suicide
424 or age of suicide between former professional soccer players and their matched population
425 controls. Of the total sample, 0.25% (19/7,676) of former professional soccer players and 0.40%
426 (93/23,028) of population controls had died as the result of suicide, and of those who had died
427 during the observation period, 1.6% of former soccer players (19/1,180) had suicide as their
428 manner of death compared to 2.4% of population controls (93/3,807) [87].
429

430 Baron and colleagues [79] identified a sample of 3,439 former NFL players who played at least 5
431 seasons in the NFL between 1959 and 1988 through a pension fund database, and reported that
432 334 had died during the observation period of the study (up through 2007). The primary purpose
433 of their study was to examine cardiovascular mortality. However, in Table 2 of that paper they
434 reported that there was no significant increased risk for mortality associated with diseases of the
435 nervous system and sense organs for former NFL players compared to men from the general
436 population. There were 12 documented deaths from diseases of the nervous system and sense
437 organs compared to 9.7 that would be expected from the general population (SMR=1.24; 95%
438 CI, 0.64–2.16). They also reported on psychiatric disorders as a cause of death and suicide as a
439 manner of death. They found a significantly lower risk for death relating to both psychiatric
440 disorders (Standardized Mortality Ratio or SMR=0.34, 95% CI=0.09-0.87) and suicide
441 (SMR=0.41, 95% CI=0.19-0.78) for former NFL players compared to men from the general
442 population.
443

444 Lehman and colleagues [92] examined suicide mortality in former NFL players who played at
445 least 5 seasons in the NFL who were identified through a pension fund database—the same
446 cohort of 3,439 former players studied by Baron and colleagues [79]. The observation period was
447 extended, however, from 2007 to 2013, and 537 former players had died. The authors reported
448 that former NFL players had a significantly reduced risk of mortality from suicide. There were
449 12 documented deaths from suicide compared to 25.6 that would be expected in a comparable
450 sex/race/age sector of the US population (SMR=0.47; 95% CI, 0.24–0.82).
451

452 Lehman and colleagues [93] used the same sample as Baron and colleagues [79] and conducted
453 more narrow and specific analyses relating to ICD codes for neurodegenerative diseases as an
454 underlying or contributing cause of death. The more narrowed analysis thus yielded 10 former

455 players (compared to 12 in Baron et al.) who were identified as having one of these conditions as
456 the underlying cause of death, which was significantly greater than predicted from the general
457 population (SMR=2.83; 95% CI, 1.36-5.21). When considering both underlying and contributing
458 causes of death, they also reported significantly greater mortality associated with dementia
459 (SMR=3.86, 95% CI=1.55-7.95) and ALS (SMR=4.31, 95% CI=1.73-8.87), but not Parkinson's
460 disease (SMR=1.69, 95% CI=0.35-4.94) in former NFL players. However, it is not possible to
461 determine whether these ecological findings would hold up in an individual-level analysis that
462 could control for potential confounding factors. As the authors noted, it is not possible to
463 determine what caused the increased risks in this study.

464

465 Lincoln and colleagues [80] examined a cohort that included 9,778 former NFL players, with at
466 least 1 year in the NFL, whose last season was between 1986 and 2012. Two percent (N=227) of
467 the players were deceased during the observation period, and the former players had significantly
468 lower risk for death than the general population (SMR=0.46, 95% CI=0.40-0.52), although those
469 with high body mass indexes during their playing years were at increased risk for overall
470 mortality and cardiovascular disease mortality. The former NFL players did not significantly
471 differ in risk for diseases of the nervous system and sense organs as their cause of death when
472 compared with the general population (SMR=0.65, 95% CI=0.21-1.53). The former players had
473 significantly lower mortality risk for 'mental, psychoneurotic, and personality disorders'
474 (SMR=0.23, 95% CI=0.03-0.82) and suicide (SMR=0.58, 0.35-0.90).

475

476 Nguyen and colleagues [91] used publicly available databases and extracted information on
477 Major League Baseball (MLB) and NFL athletes who played a minimum of one season/game.
478 They compared all-cause mortality between former MLB and former NFL athletes and found
479 that NFL players exhibited greater all cause (HR=1.26; 95% CI, 1.10-1.44), cardiovascular
480 (HR=2.40; 95% CI, 2.03-2.84), and neurodegenerative disease (HR=2.99; 95% CI, 1.64-5.45)
481 mortality rates when compared to MLB players. Neurodegenerative diseases were defined by
482 ICD-9/10 codes and included senile and presenile dementia with or without delusion, depression
483 or delirium, Alzheimer's disease, Parkinson's disease, secondary parkinsonism, and ALS. Nearly
484 all the former NFL players had cardiovascular disease listed on their death certificates (96.3%),
485 compared to half of the former MLB players (52.2%). Neurodegenerative diseases were listed on
486 7.5% of the death certificates of former NFL players compared to 3.7% of former MLB players.
487 The authors noted that they were not able to examine possible cultural, educational,
488 socioeconomic status, genetic, family history, lifestyle, or environmental risk factors that might
489 have contributed to the differences.

490

491 Daneshvar and colleagues [84] examined the incidence of and mortality from ALS in current and
492 former NFL players who debuted between 1960 and 2019 using a publicly available database
493 (N=19,423). They identified 38 men who had received a diagnosis of ALS (0.2%) and 28 who
494 had died during the observation period, which represents a significantly higher incidence of ALS
495 diagnosis (standardized incidence ratio=3.59; 95% CI, 2.58-4.93) and mortality from ALS
496 (SMR=3.94; 95% CI=2.62-5.69) among NFL players compared to men from the general
497 population, after adjusting for age and race. The authors reported that 40% of those cases
498 occurred in the 1960s and the general population control group was taken from 2009-2011. The
499 authors noted that they were unable to identify specific factors that increased the risk of ALS like
500 smoking and exposure to herbicides and pesticides, which may have been more common in the

501 1960s. They also reported that players with ALS had significantly longer careers than those who
502 did not have ALS.

503

504 There were five studies that examined ALS in former professional Italian soccer players, and all
505 reported that former players had greater mortality from ALS than men from the general
506 population [81-83, 95, 96]. Taioli [81] identified a cohort of 5,389 Italian soccer players of
507 whom 63 had died. There were four deaths from ALS, which was significantly greater than
508 expected using the US general population as the reference standard SMR=18.18 (95% CI=5.00–
509 46.55). There was no significant difference in the incidence of death from suicide in the soccer
510 players compared to men from the US general population (SMR=0.81, 95% CI=0.35-1.59). Belli
511 and Vanacore [82] examined causes of death in a cohort of about 24,000 Italian soccer players,
512 of whom 350 had died, with eight having died from ALS and five from other diseases of the
513 nervous system. The soccer players were significantly more likely to die from ALS than men
514 from the Italian general population (Standardized Proportionate Mortality Ratio or SPMR=1,158,
515 95% CI=672-1,998) but not from other diseases of the nervous system (SPMR=93, 95% CI=30-
516 218). These analyses only controlled for age and calendar period by standardization. In this
517 cohort, former soccer players were not more likely to have neurological diseases, separate from
518 ALS, as a cause of death.

519

520 Pupillo et al. [83] examined ALS as a cause of death in a cohort of 23,586 Italian soccer players,
521 and 34 cases of ALS were identified (0.14%). They reported that the mean age of diagnosis was
522 45.0 years compared to 65.2 years in the general population. The incidence rate in soccer players
523 was significantly greater than for men in the general population (Standardized Incidence Ratio or
524 SIR=1.91, 95% CI=1.32–2.67) in the entire sample and more so in subjects under the age of 45
525 (SIR=4.66, 95% CI=2.66–7.57). The authors speculated that ‘repeated traumatic events and
526 heavy physical exercise may be all implicated, but the role of genetic predisposition cannot be
527 likewise excluded’ (page 408) [83]. Only age, level of play, position of play and year starting
528 soccer were controlled in the analysis, which was ecological or at the group rather than the
529 individual level.

530

531 Chio and colleagues undertook an ecological analysis of a cohort of 7,325 male professional
532 soccer players from Italy identifying five cases of ALS. The number of expected cases in was
533 0.77, yielding a standardized morbidity ratio (SMR) of 6.5 (95% CI=2.1-15.1). Their mean age
534 of onset was 43.4 years (SD=9.1, range=33-56). Those who played professionally more than five
535 years had greater risk [95]. In a follow-up study of the same cohort [96], three additional cases
536 were identified, for a total of eight cases. The number of expected cases was 1.24, yielding an
537 SMR of 6.45 (95% CI=2.78-12.70). No cases of ALS were identified in control cohorts of
538 professional basketball players (n=1,973) or road cyclists (n=1,701), but their numbers were
539 smaller than the soccer players. The authors stated that more analyses of other athlete cohorts are
540 needed to draw definitive conclusions about the risk of ALS.

541

542 Mackay and colleagues conducted a large-scale study of former professional soccer players from
543 Scotland that examined neurodegenerative disease mortality [90]. ‘Neurodegenerative disease’
544 was broadly defined based on ICD codes for several conditions. During the follow-up period,
545 15.4% of the former soccer players (1,180/7676) and 16.5% of the matched general population
546 controls (3,807/23,028) had died. Players were individually matched to general population

547 controls on age, sex, socioeconomic status, and competing risks of death from ischemic heart
548 disease and lung cancer. Having any neurodegenerative disease listed as the primary or
549 contributory cause of death occurred for 2.9% (222/7,676) former soccer players compared to
550 1.0% (228/23,028) of matched controls (HR=3.53, 95% CI=2.72-4.57). Dementia 'not otherwise
551 specified' was listed for 2.3% of former soccer players and 0.8% of matched controls (HR=3.87,
552 95% CI=2.86-5.24). Alzheimer's disease was listed for 0.8% of former soccer players (64/7,676)
553 and 0.2% (47/23,028) of matched controls (HR=5.07, 95% CI=2.92-8.82). Parkinson's disease
554 was listed for 0.4% (28/7,676) of former soccer players compared to 0.2% (44/23,028) of
555 matched controls (HR=2.15, 95% CI=1.17-3.96). Motor neuron disease was listed for 0.3%
556 (22/7,676) of former soccer players and 0.1% (17/23,028) of matched controls (HR=4.33, 95%
557 CI=2.05-9.15) [90]. Russell and colleagues [86], using the same population cohorts as Mackay
558 and colleagues, reported that the former professional soccer players were more likely to have
559 neurological diseases than people in the general population, with the risk being highest for
560 former defenders and lowest for former goaltenders. Regarding career length, risk was highest
561 among former soccer players with professional career lengths longer than 15 years (HR=5.20;
562 95% CI, 3.17-8.51).

563 Methodological Considerations and Limitations with the Studies 564 Included in this Review

565

566 The literature on risk studies relating to possible long-term effects of concussions and repetitive
567 head impacts experienced during participation in youth, amateur, and professional sports is
568 limited but evolving. We adopted a low threshold for admissibility. Some of the studies had
569 some control for confounding variables [72, 73, 85-87, 90], with one study controlling for many
570 confounding variables [68]. There was only one study that was rated as having low-medium risk
571 of bias [68]. All other studies were rated as having high risk of bias, primarily because a lack of
572 control for confounding or being an ecologic study with the analysis at the group rather than the
573 individual level. It is important to appreciate that the studies we reviewed did not consider many
574 genetic, lifestyle, or medical factors that could potentially confound associations between later in
575 life adverse health outcomes and earlier in life participation in sports, and some did not consider
576 any confounding factors beyond age or sex. The studies involving amateur athletes yielded,
577 almost entirely, negative results. Negative results in cohort studies are important in this regard
578 because cohort studies provide the most rigorous study design available in this literature, but
579 also, of course, must be interpreted within the context of a variety of methodological limitations
580 that are common in this literature.

581

582 Another methodological consideration is whether the ‘general population’ is a reasonable
583 comparison group for studies involving the brain health of former contact and collision sport
584 athletes. It is unlikely that control subjects from the general population are similar in all risk
585 factors as professional athletes. Comparing to the general population might under or over-
586 estimate certain risks. For example, former athletes are more likely to experience the health
587 benefits from a life of physical exercise. However, they may also experience more chronic pain
588 and be prescribed more medications than controls from the general population. Finding the
589 perfect control group is a challenge and any differences need to be accounted for in the study
590 analyses.

591

592 The number of prior concussions, while playing sports or over the course of life, was estimated
593 in only four [76, 85, 89, 94] of the 28 studies included in this review. For two of those studies,
594 the number of prior injuries were determined based on a self-report survey [85, 94]. There was
595 no information relating to the severity of the injuries or the duration of symptoms following the
596 injuries. Differential recall bias is a systematic error that can occur when subjects are asked to
597 recall health exposures that are linked to poor outcomes. Some of the reviewed studies asked
598 subjects to recall their lifetime exposure to head injuries in sport. Former athletes might over-
599 estimate the number of past concussions depending on their current health state. One study
600 illustrated that concussion reporting in former NFL players, over time, can be influenced by
601 recall bias [98], and approximately one in three former players reported a greater concussion
602 history in 2010 compared to their responses in 2001. Those who reported this greater number,
603 compared to those who reported the same between 2001 and 2010, endorsed worse physical
604 functioning and worse mental health—thus illustrating that recall bias can occur when former
605 athletes with ongoing problems are asked to remember potential causes of their current problems
606 that occurred in their past (such as past concussions). In contrast, unexposed subjects are usually
607 more healthy than the exposed subjects in a study, and they will often recall fewer health
608 exposures.

609

610 One study in this review attempted to document the amount of repetitive head impact exposure
611 experienced by the subjects, and then associate that with all-cause mortality in former NFL
612 players, which was done based on playing position and years of participation [88]. This study
613 was deemed high risk of bias because it did not control for any factors that could confound this
614 association. For example, former linemen were identified as having the greatest repetitive head
615 impact exposure, but there was no control for their known increased risk for cardiovascular
616 disease in the analyses.

617

618 Most studies defined ‘exposure’ simply as the presence or absence of participation in certain
619 sports. This could mean, for example, merely whether or not the person participated in American
620 high school football [68-70, 72-75], professional football [79, 80, 88, 91-93], or professional
621 soccer [81-83, 86, 87, 90, 95, 96]. Most of these studies did not attempt to quantify exposure,
622 such as the total number of years of participation or playing time. Some studies of former
623 professional players, however, included analyses relating to years of exposure [84, 85, 95, 96].

624

625 Some studies relied on surveys and questionnaires completed by former athletes [68-70, 72, 73]
626 [85, 94]. Both sampling bias and attrition bias limit how well the results from those study
627 samples can be generalized to the larger population of former athletes from which they were
628 derived. There are also limitations, of course, relating to the accuracy of self-report and/or proxy
629 report of past health exposures.

630

631 Several studies included in this review relied on data contained in death certificates. Some of
632 these studies have relatively small sample sizes (e.g., fewer than 500 deaths) [79, 80, 93]. In
633 these ecological studies, there is no explicit exposure other than belonging to a group—the
634 exposure is playing a professional sport, such as football. Thus, there is no control of
635 confounding at the individual level. These are, by definition, hypothesis generating studies, not
636 studies that can be used to draw specific causal conclusions. Moreover, errors on death
637 certificates are common, and include the coding of causes of death, comorbidities, and manner of
638 death [99, 100]. Additionally, there is evidence that dementia as a cause of death is under-
639 reported on death certificates [101].

640

641 Chronic Traumatic Encephalopathy (CTE) Narrative Review

642

643 There have been some case series and cross-sectional studies relating to postmortem
644 neuropathological changes in former contact, collision, and combat sport athletes in the past 17
645 years [22, 41-47], and many reviews of the literature relating to CTE have been published in the
646 past few years [4, 14, 16-23, 25-28, 48-63]. The postmortem studies of CTE were not included in
647 this systematic review because they did not meet the *a priori* inclusion criteria for research
648 design. However, given considerable interest in this topic, a review of the neuropathology
649 studies, a summary of gaps in knowledge, and directions for future research is provided below.

650

651 **Historical Background**

652 In 1928, Martland described the ‘punch drunk’ syndrome in boxers as the first clinical
653 description of chronic neurological deficits that were increasingly apparent to lay observers.
654 Martland suggested that the neurological and neurocognitive signs were variably progressive,
655 and in some cases necessitated commitment to an asylum [102]. Millspaugh used the term
656 ‘dementia pugilistica’ in 1937 [103]. Bowman and Blau used the term ‘traumatic encephalopathy
657 of pugilists’ (or punch drunk) in a book chapter that provided a rich description of diverse
658 clinical problems experienced by boxers [104], and then they discussed a single case study of a
659 28-year-old professional boxer with severe neuropsychiatric problems and diagnosed him with
660 ‘chronic traumatic encephalopathy of pugilists’ (p. 345). In 1949 and 1957, Critchley used the
661 term CTE to describe his experience with boxers who had chronic neurological conditions [105,
662 106].

663

664 Diverse gross and microscopic postmortem neuropathology was described by Corsellis and
665 colleagues in 1973 in a sample of 15 boxers [107]. The authors emphasized damage to the
666 septum pellucidum, substantia nigra degeneration, cerebellar tonsillar sclerosis, and
667 neurofibrillary tangles as a relatively stereotyped pattern of structural change in the brain with
668 prolonged boxing exposure. A recent re-examination of the Corsellis series by Goldfinger et al.
669 [108] revealed CTE-NC by modern criteria in 7 of 14 cases. Several cases were diagnosed as
670 having other conditions (e.g., Lewy body dementia, progressive supranuclear palsy, Alzheimer’s
671 disease). In 2005, Omalu and colleagues described postmortem neuropathology in a former
672 American professional football player [109]. The following year, the same research group
673 published a second case [110], depicting some neocortical p-tau as well as tau in the locus
674 ceruleus.

675

676 In 2009, McKee reviewed 48 cases in the literature that had descriptions of postmortem
677 neuropathology and added three more cases in a former professional football player and two
678 former professional boxers [46]. They described gross neuropathology such as atrophy of the
679 cerebral hemispheres, medial temporal lobe, thalamus, mamillary bodies, and brainstem with
680 ventricle enlargement and fenestrated septum pellucidum, and microscopic neuropathology such
681 as extensive tau-immunoreactive neurofibrillary tangles, astrocytic tangles, and spindle-shaped
682 neurites. In 2011, Omalu and colleagues discussed what they described as ‘emerging
683 histomorphologic phenotypes’ in their case series of 14 former professional and 3 high school
684 athletes [45]. In 2013, McKee and colleagues published a large postmortem case series of
685 neuropathology in former contact and collision sport athletes [44]. In that paper, the definition of
686 the pathology was refined, a 1-4 staging system for neuropathological severity was proposed,

687 and it was noted that CTE-NC often co-existed with the pathology of several neurodegenerative
688 diseases, such as Alzheimer's disease.

689

690 In 2015, Bieniek and colleagues [111] conducted a study using an initial sample of 1,721 men
691 from the Mayo Clinic neurodegenerative disorders brain bank, identified 66 who were former
692 athletes, and reported that 31.8% had CTE-NC (i.e., 21/66), based on the 2013 definition. They
693 also studied the brains of 198 age and diseased matched men and women with no known contact
694 sport exposure. There were no cases with a history of a single TBI or who did not participate in
695 contact sports who were identified as having CTE-NC. Athletic participation included a wide
696 variety of sports with differing head impact exposures. The authors did not assess possible
697 clinical correlates of CTE-NC. There was also a wide variety of underlying neurodegenerative
698 diseases among the case material.

699

700 **Consensus Criteria for the Neuropathology of CTE**

701 Preliminary criteria for defining the microscopic neuropathology and establishing the research
702 methodology for case identification were established through a consensus effort convened by the
703 National Institute of Neurological Disorders and Stroke (NINDS) and National Institute of
704 Biomedical Imaging and Bioengineering and published in 2016 [29]. The panel defined a
705 *pathognomonic* lesion based on light microscopic assessment of p-tau immunohistochemical
706 stains as follows: 'p-tau aggregates in neurons, astrocytes, and cell processes around small
707 vessels in an irregular pattern at the depths of the cortical sulci' (page 81). The authors described
708 this as a first step toward the development of validated criteria for CTE-NC and stated that future
709 research would address the (i) validation of the criteria among a broader group of
710 neuropathologists using cases submitted from multiple sources, (ii) identification of CTE-NC
711 when neurodegenerative diseases, such as Alzheimer's disease are present, and (iii) potential
712 contribution of p-tau and other pathologies to clinical signs or symptoms.

713

714 In 2017, Mez and colleagues published a large case series of brain donations and reported that
715 essentially all former professional American football players in their sample had postmortem
716 neuropathology consistent with CTE-NC [42]. Moreover, 91% of former college players and
717 21% of former high school players in this donation program had evidence of CTE-NC [42]. In
718 2020, Bieniek and colleagues published a large case series of postmortem findings former
719 amateur athletes (classified using high school yearbook and obituaries as source data), compared
720 to those who did not participate in sports, and identified CTE-NC in 2.8% of the total sample
721 (21/750), 5.0% (15/300) of those who played sports, 1.3% who did not play sports (6/450), 0%
722 of women (of 273), 4.4% (21/477) of men, 7.9% of men who played football (11/140), and 2.4%
723 (6/245) of men who did not play sports. Those men who had CTE-NC were, on average, 10 years
724 older at the time of death than those who were negative for CTE-NC, and they were much more
725 likely to have Alzheimer's disease neuropathologic change (i.e., 47.6% vs. 20.2%). The authors
726 concluded that participation in football, specifically beyond the high school level, was associated
727 with greater odds of having CTE-NC. The aforementioned studies cannot provide an accurate
728 estimate of risk for, or prevalence of, CTE-NC—but they are important for illustrating presence
729 of the pathology in these groups.

730

731 Recently published large postmortem studies from the Sydney Brain Bank in Australia (N=636)
732 [112] and a community sample in the United States (N=532) [113] have revealed very few cases

733 of CTE-NC (less than 1%), and a large European study (N=310) reported no cases of CTE-NC
734 [114], using ‘strict’ criteria. In a study of 180 consecutive autopsies in Australia, four cases of
735 mild CTE-NC were identified (2.2%) [115]. In a recent study of 225 former military personnel,
736 CTE-NC was identified in 4.4%, and it usually involved minimal microscopic changes on p-tau
737 immunohistochemistry—with half of the identified cases having only a single pathognomonic
738 lesion—and the authors concluding that it is unclear whether the minimal histopathological
739 findings were of clinical significance [116].

740

741 In 2021, updated and revised consensus criteria for CTE-NC were published [30]. The criteria
742 were narrowed such that astrocytic tau was not required. Strict features to better differentiate
743 CTE-NC from age-related neuropathology, specifically aging-related tau astrogliopathy
744 (ARTAG) [117] and primary age-related tauopathy (PART) [118] were proposed. The updated
745 *pathognomonic lesion* for CTE-NC was described as ‘p-tau aggregates in neurons, with or
746 without thorn-shaped astrocytes, at the depth of a sulcus around a small blood vessel, deep in the
747 parenchyma, and not restricted to the subpial or superficial region of the sulcus’ (page 217).
748 Based on their discussions, the panel proposed a minimum threshold for the diagnosis of CTE (a
749 single microscopic lesion), and an algorithm for judging CTE severity as ‘high’ or ‘low,’ based
750 on the presence of a CTE lesion, and the additional presence of one or more neurofibrillary
751 tangles in various brain regions, including the hippocampus, amygdala, entorhinal cortex,
752 thalamus, mamillary bodies, cerebellar dentate nucleus, neocortical layer II not otherwise
753 specified, and cortical areas in the vicinity of the CTE lesion(s). The authors further stated that
754 differentiating CTE-NC from other neurodegenerative pathologies (e.g., Alzheimer’s disease
755 neuropathologic change) and other age-related pathologies (e.g., ARTAG and PART) represents
756 a topic of interest for future studies. The authors did not make assertions about CTE-NC in the
757 presence of canonical neurodegenerative diseases, such as Alzheimer’s disease.

758

759 The authors of the 2021 consensus criteria for CTE-NC emphasized the importance of future
760 research to validate a newly proposed working protocol for CTE-NC and to improve the ability
761 to identify CTE-NC when canonical neurodegenerative diseases, such as Alzheimer’s disease, or
762 aging-related pathologies, such as PART and ARTAG, are present [30]. The consensus group
763 from 2016 [29] and 2021 [30] focused exclusively on criteria for defining CTE-NC; their work
764 did not attempt to define a clinical syndrome or to determine whether there was an association
765 between the neuropathology and specific clinical symptoms or neurological problems during a
766 person’s lifetime.

767

768 A recent narrative review paper [63] examined the issue of association versus causation relating
769 to repetitive head impacts and CTE-NC, which was explored through the lens of the nine
770 viewpoints proposed by Sir Austin Bradford Hill in 1965 [119]. The authors of that review
771 concluded that the evidence supporting repetitive head impacts causing CTE-NC was compelling
772 [63].¹

773

¹ As part of that review, the authors identified six studies that they referred to as case-control studies and calculated odds ratios for an association between sports exposure and CTE-NC. In the present systematic review, we did not consider those six studies to be case-control or cohort studies that were designed to examine risk for CTE-NC or risk for later in life clinical conditions or disorders. In addition, the original authors of most of the studies did not conceptualize them as case-control studies designed to measure risk.

774 **Updated Website by the NINDS about CTE**

775 The NINDS has supported multi-year research programs designed to (i) develop and evaluate
776 expert consensus-based criteria for defining CTE-NC; (ii) create a methodology for case
777 identification; and (iii) develop the first consensus criteria for defining a clinical condition,
778 traumatic encephalopathy syndrome, that might be caused, at least in part, or be associated with,
779 varying degrees of CTE-NC (as well as other types of neuropathology associated with aging and
780 diseases). The web page of the NINDS that described these funded research programs was
781 changed, in the days prior to the 2022 Concussion in Sport Group Consensus Meeting,
782 presumably in response to advocacy efforts, to include a statement about causation. The web
783 page now reads that CTE-NC *'is caused in part by repeated traumatic brain injuries'*
784 [[https://www.ninds.nih.gov/current-research/focus-disorders/focus-traumatic-brain-injury-](https://www.ninds.nih.gov/current-research/focus-disorders/focus-traumatic-brain-injury-research)
785 [research](https://www.ninds.nih.gov/current-research/focus-disorders/focus-traumatic-brain-injury-research) (last accessed November 6, 2022)]. The NINDS neither described the process
786 undertaken, nor the underlying evidence relied upon, for making the wording change in the
787 website article from *'is associated with'* to *'is caused in part by...'* nor for the word choice of
788 *'repeated traumatic brain injuries'* versus *'head impacts'* or some other term implying blows to
789 the head that do not exceed the conventional threshold for defining traumatic brain injury. Our
790 systematic review did not address these mechanisms of injury, differences in terminology, or
791 either odds ratios or relative risks for CTE-NC.

792

793 **Criteria for the Clinical Diagnosis of Traumatic Encephalopathy Syndrome**

794 In 2014, preliminary research criteria for the clinical diagnosis of traumatic encephalopathy
795 syndrome were published [120]. Those criteria were broad, and the core features included
796 depression (e.g., major depressive disorder), anger dyscontrol (e.g., intermittent explosive
797 disorder), and cognitive impairment (e.g., mild cognitive impairment or dementia). Some studies
798 illustrated that the proposed psychiatric features overlapped with primary psychiatric disorders
799 and with mental health symptoms and problems in the general population, raising concerns about
800 misdiagnosis [121-124]. A clinicopathological study in 2021 attempted to validate the 2014
801 criteria and found that they were highly sensitive to the presence of CTE-NC, but they had very
802 low specificity [125]. In other words, the diagnostic criteria could not rule out traumatic
803 encephalopathy syndrome or distinguish it from other disorders.

804

805 The first consensus criteria for traumatic encephalopathy syndrome, sponsored by the NINDS,
806 were published in 2021, and no parts of the preliminary 2014 criteria were retained in their
807 original form [126]. The consensus group made major changes by eliminating major depressive
808 disorder and intermittent explosive disorder as core diagnostic features. They emphasized that
809 the diagnosis required primarily progressive cognitive impairment, with or without
810 neurobehavioral dysregulation.

811

812 **Directions for Future Research in CTE-NC and Traumatic Encephalopathy Syndrome**

813 There are important gaps in knowledge that provide directions for future research. At present, the
814 incidence and prevalence of CTE-NC, or traumatic encephalopathy syndrome, in former athletes,
815 military veterans, and people from the general population is not known. Moreover, it is not
816 known whether small amounts of CTE-NC cause specific neurological or psychiatric problems,
817 the extent to which larger amounts of CTE-NC can be distinguished from aging and AD, or
818 whether the neuropathology is inexorably progressive.

819

820 The NINDS consensus group made numerous important recommendations to address gaps in
821 knowledge relating to CTE-NC and traumatic encephalopathy syndrome [126]. They encouraged
822 researchers to address topics such as determining whether patchy areas of perivascular p-tau
823 deposition at the depths of cerebral sulci and more limited amounts of CTE-NC have direct
824 clinical correlates, and whether more abundant CTE-NC is associated with specific cognitive and
825 neuropsychiatric symptoms. They also encouraged studies relating to the interrater reliability and
826 predictive validity of the new criteria for traumatic encephalopathy syndrome. They emphasized
827 that the new diagnostic criteria are designed for research use, and it is possible that a number of
828 factors unrelated to sporting history might be associated with the clinical features underlying this
829 new diagnosis, including ‘medical and psychosocial variables, such as sleep disorders, vascular
830 risk factors, chronic pain, and racial and associated inequities in social determinants of health’
831 (page 859) [126]. It is recognized that more research is needed to examine a wide range of
832 neuropathology, such as axonopathy, vascular changes including blood brain barrier disruption,
833 and inflammation—to determine the extent to which polypathologies might contribute to clinical
834 signs and symptoms.
835

836 Historical Synopsis of Chronic Traumatic Encephalopathy

837

1928	Martland [102] described the ‘punch drunk’ syndrome in boxers (the first clinical description of chronic neurological deficits).
1937	Millspaugh [103] used the term ‘dementia pugilistica.’
	Bowman and Blau [104] used the term ‘traumatic encephalopathy of pugilists’ and ‘chronic traumatic encephalopathy of pugilists.’
1949	Critchley used the term CTE to describe his experience with boxers who had chronic neurological conditions [106].
1969	Seminal book on chronic traumatic brain injury (traumatic encephalopathy syndrome) in former boxers (by Roberts). He clinically examined 224 former boxers and identified 17% as having the syndrome (i.e., 11% with a mild form of the syndrome and 6% with a severe form of TES) [127].
1973	Diverse gross and microscopic postmortem neuropathology were described in a sample of 15 boxers (Corsellis and colleagues). The authors emphasized damage to the septum pellucidum, substantia nigra degeneration, cerebellar tonsillar sclerosis, and neurofibrillary tangles as a relatively stereotyped pattern of structural change in the brain with prolonged boxing exposure.
1991	P-tau in depths of cortical sulci was identified in a person with autism who had a long history of head banging behavior (Hof and colleagues) [128].
1999	Tau pathology associated with repetitive head injuries might relate to damage to blood vessels or perivascular elements (Geddes et al.) [129]
2000	Jordan reviewed the literature on <i>chronic traumatic brain injury</i> in former boxers and stated that it is not clear whether their clinical deterioration resulted from a progressive neurodegenerative disease, the aging process superimposed on a fixed neurological injury, or both [130].
2005-2006	Omalu and colleagues described postmortem neuropathology in two former American professional football players [109, 110].
2009	McKee and colleagues published a seminal review of the world literature on CTE with a focus on cases studies that had descriptions of postmortem neuropathology [44].
2011	Omalu and colleagues described ‘emerging histomorphologic phenotypes’ in their case series of 14 former professional and 3 high school athletes [45].
2013	McKee and colleagues published a large postmortem case series of neuropathology and clinical features. The definition of the pathology was refined, a 1-4 staging system for neuropathological severity was proposed.
2013	Hazrati and colleagues described the postmortem neuropathology from six former professional Canadian football players and noted that three had CTE-NC and the other three had other neuropathological diagnoses [47].

2014	Preliminary research criteria for the clinical diagnosis of traumatic encephalopathy syndrome were published (Montenigro et al.) [120].
2015	Bieniek and colleagues [111] conducted a study using a neurodegenerative disorders brain bank, identified 66 men who were former athletes, and reported that 31.8% had CTE-NC.
2016*	Preliminary research criteria for defining the microscopic neuropathology and establishing the research methodology for case identification were established through a consensus effort and published by McKee and colleagues [29]. The panel defined a <i>pathognomonic</i> lesion based on light microscopic assessment of p-tau immunohistochemical stains as follows: ‘p-tau aggregates in neurons, astrocytes, and cell processes around small vessels in an irregular pattern at the depths of the cortical sulci’ (page 81).
2016-2017	CTE-NC was examined in case series and brain bank studies of people with schizophrenia (who had undergone leukotomy) [131], temporal lobe epilepsy [132], ALS [133], multiple system atrophy [134], and several other neurodegenerative diseases [135]. A large Canadian study of people under the age of 60 identified CTE-NC in 4.5% of their cases (but also noted that there is no lower bound for classifying CTE-NC, and an additional 30.6% of their sample had some degree of mild CTE-NC-like pathology; Noy et al.) [136].
2017	Mez and colleagues published a large brain donation study and reported that essentially all former professional American football players (99%) in their sample had postmortem neuropathology consistent with CTE-NC [42].
2018	A re-examination of the Corsellis series from the 1970s by Goldfinger et al. [108] revealed CTE-NC in 7 of 14 cases.
2019	Forrest and colleagues published a large postmortem European study (N=310) and reported no cases of CTE-NC [114], using ‘strict’ criteria.
2019	Lee and colleagues examined the brains of former athletes with dementia in combination with their clinical histories to derive an integrated clinicopathological diagnosis for each person [41]. They identified CTE-NC in 5 of the 7 former soccer players and 3 of the 4 former rugby players.
2020	Bieniek and colleagues published a large-scale postmortem study of former amateur athletes (classified using high school yearbook and obituaries as source data), compared to those who did not participate in sports, and identified CTE-NC in 2.8% of the total sample (21/750), 5.0% (15/300) of those who played sports, 1.3% who did not play sports (6/450), 0% of women (of 273), 4.4% (21/477) of men, 7.9% of men who played football (11/140), and 2.4% (6/245) of men who did not play sports.
2020	Researchers reported that the distribution of astroglial pathology in the depths of cortical sulci, alone, and not neuronal pathology, might be more reflective of CTE-NC [137].
2020-2021	Some studies illustrated that the proposed psychiatric features of 2014 criteria for TES overlapped with primary psychiatric disorders and with mental health symptoms

	and problems in the general population, raising concerns about misdiagnosis [121-124].
2021	A clinicopathological study attempted to validate the 2014 criteria and found that they were highly sensitive to the presence of CTE-NC, but they had very low specificity [125].
2021	Schwab and colleagues published a postmortem study of 35 former football and hockey players and reported that 17 (48.6%) had CTE-NC [43].
2021	Postupna and colleagues published large postmortem study using a community sample in the United States (N=532) [113] and identified CTE-NC in fewer than 1%.
2021*	Updated and revised consensus criteria for CTE-NC were published [30]. The criteria were narrowed such that astrocytic tau was not required. Strict features to better differentiate CTE-NC from age-related neuropathology, specifically aging-related tau astroglipathy (ARTAG) [117] and primary age-related tauopathy (PART) [118] were proposed.
2021*	The first consensus criteria for traumatic encephalopathy syndrome, sponsored by the NINDS, were published, and no parts of the preliminary 2014 criteria were retained in their original form [126]. They emphasized that the diagnosis required primarily progressive cognitive impairment, with or without neurobehavioral dysregulation.
2022	In a large postmortem study using the Sydney Brain Bank in Australia (N=636) [112], very few cases of CTE-NC were identified (fewer than 1%). In a study of 180 consecutive autopsies in Australia, four cases of mild CTE-NC were identified (2.2%) [115]. In a study of 225 former military personnel, CTE-NC was identified in 4.4% [116].
2022	One study reported that CTE-NC is more likely to be accurately identified when both neuronal and astroglial tau pathologies can be visualized [138]. Nonetheless, subpial ARTAG is no longer considered to be part of the 2021 consensus research definition of CTE-NC [30] and astrocytic p-tau in general is not required. A recent study emphasized that neuronal tau is more common than astrocytic tau in cases of CTE-NC [139].

838 Note: See the online supplementary material for a more complete review this literature. *Consensus criteria
839 published for neuropathological diagnosis and clinical diagnosis. ALS=amyotrophic lateral sclerosis; CTE=chronic
840 traumatic encephalopathy, CTE-NC= chronic traumatic encephalopathy neuropathologic change, and
841 NINDS=National Institute of Neurological Disorders and Stroke.
842

843 Appendix A. Search Strategy

844

845 A draft search was initially developed in Medline, focusing on three main concepts: concussion
846 or repetitive head impact, sports, and residual/long term effects. Search terms for ‘concussion’
847 and ‘sports’ were developed for all systematic reviews written to inform the 6th International
848 Consensus Conference on Concussion in Sport and are described separately in a methodology
849 paper. For this paper specifically, additional search terms for repetitive head impacts were
850 included to capture additional literature regarding exposure to repetitive head impacts and/or
851 contact sport (see the online supplement). The third concept was extensive and comprehensive,
852 including terms relevant to cognitive function/dysfunction, mental and substance abuse
853 disorders, as well as neurological and neurodegenerative diseases, to capture a broad range of
854 possible long-term effects. The author group developed and reviewed the initial search terms for
855 repetitive head impacts and potential residual or long-term effects, inclusion and exclusion
856 criteria, and database selection. Authors also submitted seed articles for the librarian (KAH) to
857 use to verify that the search identified key articles in the field.

858

859 The search was informed by three main resources: search terms suggested by authors, keywords
860 and subject headings informed by analysis of a set of known seed papers, as well as the
861 systematic review on a similar topic conducted as part of the 5th Consensus Statement on
862 Concussion in Sport. The search attempts to be comprehensive (i.e. a sensitive search) and is
863 aimed at retrieving all potentially relevant articles. These supplemental materials include an
864 annotated Ovid Medline search strategy in order to provide a search narrative and the complete
865 search strategies for the other databases searched which includes: Embase (Ovid), Cochrane
866 Central Register of Controlled Trials (Ovid), Cochrane Database of Systematic Reviews (Ovid),
867 CINAHL Plus with Full Text (EBSCO), SPORTDiscus with Full Text (EBSCO), Scopus
868 (Elsevier) and Web of Science Core Collection (including: Science Citation Index-Expanded,
869 Social Sciences Citation Index, Arts & Humanities Citation, Conference Proceedings Citation
870 Index - Science, Conference Proceedings Citation Index - Social Sciences & Humanities, and
871 Emerging Sources Citation Index).

872

873 The search was created by K. Alix Hayden, MLIS MSc PhD (Librarian).

874

875 Study Selection

876

877 A rapid screen was completed by one author (GMS) to remove citations that were clearly
878 irrelevant to the review (i.e., non-human research, opinion papers, conference proceedings, etc.).
879 The title and abstract screenings were then completed by pairs of two authors independently
880 (RJC, JDC, KJS, GMS). Conflicts were settled by a third author. Full texts were obtained and
881 uploaded to Covidence. Prior to initiating the full text screen, authors were asked to review the
882 citations captured for the full text screen to identify any additional citations they felt may meet
883 inclusion criteria. Authors also were encouraged to identify additional possible articles at any
884 stage of the review process, including while reviewing the full text articles. Any additional
885 citations were added to the full text screen. Combinations of two authors independently reviewed
886 the articles for the full text screen (RJC, JDC, GMS). Any disagreements resulted in engagement
887 of a third author who also completed the full text screen and a meeting between the three authors
888 was held to come to a final decision.

889

890 **1. Annotated Medline (via Ovid) Search Strategy as searched March 25, 2022**

891

892 The sports and concussion concepts were collaboratively created by K. Alix Hayden and Zahra
 893 Premji (librarians), and peer reviewed using PRESS by Heather Ganshorn (librarian). The long-
 894 term/residual effects concept was created by K. Alix Hayden, and peer reviewed using PRESS
 895 by Zahra Premji.

896

897 Overview of Ovid Medline syntax:

.tw,kf.	Keyword searching. Searches the following fields: title, abstract, and author-supplied keywords
Exp	Exploded subject heading. Includes more specific (i.e. narrower) subject headings which are nested below the main subject heading
/ (at the end of a term)	Subject heading
*	Truncation operator Retrieves multiple endings for a word. E.g. sport* retrieves: <i>sport, sports, sporting</i>
Adj	Adjacency operator Adj2 means that the two words/phrases will occur within 2 words of each other, in either direction. E.g. return* adj2 play* retrieves return/returned/returning within 2 words in either direction of play*
OR	Boolean operator Used to combine synonyms for the same concept
AND	Boolean operator Used to combine all the relevant concepts: <i>Concussion AND sports AND Long Term Effects</i>

898

899 Database(s): **Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed**
 900 **Citations and Daily**
 901

Concepts	#	Searches	Results	Annotations
Concussion	1	exp Brain Concussion/	10987	Exploded subject heading for concussion (standard concussion search)
	2	Post-Concussion Syndrome/	1423	Exploded subject heading for post-concussive syndrome (standard concussion search)
	3	Craniocerebral Trauma/	23057	Additional subject headings of relevance (standard concussion search)
	4	Brain Injuries/ or Brain Injuries, Traumatic/	63970	
	5	Brain Injury, Chronic/	778	CTE relevant subject headings to capture those articles that do not concussion-related terms
	6	exp Chronic Traumatic Encephalopathy/	317	
	7	Neurodegenerative Diseases/	22062	
	8	(concussion* or concussed or concussive or subconcuss* or sub-concuss*).tw,kf.	11761	
	9	(post-concuss* or postconcuss*).tw,kf.	3589	
	10	(mild adj3 (traumatic brain injur* or tbi*).tw,kf.	7670	
	11	mtbi*.tw,kf.	3606	
	12	(head adj2 (injur* or impact* or trauma*).tw,kf.	36845	
	13	(traumatic brain injur* or tbi*).tw,kf.	52529	
	14	(neurotrauma* or "neuro-trauma").tw,kf.	2453	
	15	(craniocerebral adj2 (trauma* or injur*).tw,kf.	3249	Additional keywords relevant to repetitive head impact, CTE,
	16	((repetitive or multiple or cumulative) adj3 (head injur* or head impact* or concussion* or head trauma)).tw,kf.	1024	
	17	((subconcuss* or sub-concuss*) adj3 (impact* or blow*).tw,kf.	234	
	18	(chronic traumatic encephalopath* or CTE).tw,kf.	3908	
	19	(neurodegenerative adj2 (disease* or disorder*).tw,kf.	87216	
	20	or/1-19	228659	
Sports	21	exp Athletic Injuries/ or exp Athletes/	44656	Subject heading for athletes

22	Sports/ or Return to Sport/ or Sports medicine/	44083	Subject heading for category terms related to sport
23	exp baseball/ or exp basketball/ or exp Bicycling/ or exp boxing/ or exp football/ or exp gymnastics/ or exp hockey/ or exp martial arts/ or exp racquet sports/ or exp skating/ or exp Skiing/ or exp snow sports/ or exp soccer/ or exp Swimming/ or exp Tennis/ or exp "track and field"/ or exp volleyball/ or exp water sports/ or exp wrestling/ or exp youth sports/	74998	Subject headings for the individual sports, as well as youth sports.
24	(athlete* or athletic* or crew or player* or teammate* or team-mate* or varsity).tw,kf.	136483	Keywords related to athletes
25	sport*.tw,kf,jw.	172752	Keyword for sport as a category term and also a keyword in journal title
26	((return* or resum* or "re-ent*" or reent*) adj2 (play* or competition* or sport*)),tw,kf.	7769	Keyword combination for return to sport
27	(baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or "roller derb*" or rollerskat* or rodeo* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball).tw,kf.	105845	Keyword terms for individual sports where concussion is known to occur. This list was created by consulting the list of Olympic sports in addition to all other exploratory methods previously mentioned.
28	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting).tw,kf.	55489	
29	(aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox*	2801	

		or Martial arts or taekwondo or tae kwon do or tai ji).tw,kf.		
	30	(capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*).tw,kf.	957	
	31	(biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*).tw,kf.	32985	Keyword terms relating to the player of the specific sport
	32	or/21-31	411972	Combination line for Sport concept combined with OR
Long term / residual effects Including Psychological Neurobehavioral Neurodegenerative Brain related	33	*Cognitive Dysfunction/	24307	Subject headings / keywords for psychological / neurobehavioral
	34	*Cognition Disorders/	46701	
	35	*Mental Disorders/	136398	
	36	*substance-related disorders/ or *alcohol-related disorders/ or *marijuana abuse/ or *opioid-related disorders/	98213	
	37	((cognitive or memory or executive) adj2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*).tw,kf.	178791	
	38	((drug* or alcohol* or substance) adj2 (dependen* or abuse or disorder*).tw,kf.	118831	
	39	exp Psychotic Disorders/	56032	
	40	Depression/	138881	
	41	Self-Injurious Behavior/	9058	
	42	Suicide/ or Suicide, Attempted/	59656	
	43	Aggression/	35633	
	44	Anxiety/ or Anxiety Disorders/	127267	
	45	exp Anger/	8818	
	46	Mood Disorders/	15403	
	47	((psychiatric or mental* or psychological) adj2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*).tw,kf.	53795	
48	((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) adj2 (impair* or	10524		

	abnormal* or dysfunction* or decline or disturbance* or deteriorat*).tw,kf.		
49	(depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety).tw,kf.	911698	
50	(mood disorder* or psychos?s).tw,kf.	74503	
51	((chronic or persistent) adj2 headache*).tw,kf.	5129	
52	Neurodegenerative Diseases/	22062	Subject headings / keywords for neurodegenerative diseases
53	exp Chronic Traumatic Encephalopathy/	317	
54	Dementia/ or Frontotemporal Dementia/	60925	
55	Alzheimer Disease/	107773	
56	Amyotrophic Lateral Sclerosis/	21533	
57	Motor Neuron Disease/	4613	
58	Parkinson Disease, Secondary/ or Parkinson Disease/	79513	
59	Hypopituitarism/	7377	
60	Seizures/	58809	
61	(chronic traumatic encephalopath* or CTE or traumatic encephalopath*).tw,kf.	4034	
62	((neurodegenerative or neurobehavioral or neurobehavioural) adj2 (disorder* or disease*).tw,kf.	88176	
63	(dementia pugilistica or punch drunk).tw,kf.	126	
64	(alzheimer* or amyotrophic lateral sclerosis or ALS or parkinson*).tw,kf.	328445	
65	(motor neuron adj1 (disease* or disorder*).tw,kf.	6585	
66	hypopituitarism.tw,kf.	5449	
67	((endocrine or hormon* or metabolic) adj2 dysfunction).tw,kf.	7304	
68	seizure*.tw,kf.	134174	
69	White Matter/	11130	Subject headings / keywords for brain-related
70	Tauopathies/	2184	
71	TDP-43 Proteinopathies/	348	
72	*Cerebral Cortex/	79683	
73	Septum Pellucidum/	3036	
74	(white matter or taupath* or tau or tap-43 or septum pellucid*).tw,kf.	112765	
75	(cortical adj2 (thick* or thin*).tw,kf.	11247	
76	((longterm or long term or permanent or cumulative or chronic or residual) adj2 (consequences or effects or outcome* or sequela* or prognosis or damage*).tw,kf.	215957	Keywords for long term / residualeffects

	77	or/33-76	2309799	Combination line for long term/residual concept combined with OR
	78	20 and 32 and 77	4244	Final combination line: Concussion AND Sports AND Long Term/Residual Effects
	79	(address or autobiography or bibliography or biography or congress or dataset or dictionary or directory or editorial or "expression of concern" or festschrift or government document or interactive tutorial or interview or lecture or legal case or legislation or letter or news or newspaper article or overall or patient education handout or periodical index or personal narrative or portrait or webcasts).pt.	2325495	Publication types
	80	78 not 79	4122	Excludes above publication types from search
	81	limit 80 to "humans only (removes records about animals)"	3661	Limiting to humans only
	82	limit 81 to english language	3580	Limiting to English language only
	83	limit 82 to yr="2001 - 2022"	3385	Date limit

902
903
904

Embase (via OVID) as searched March 25, 2022

#	Searches	Results
1	brain concussion/	6584
2	concussion/	7419
3	postconcussion syndrome/	2775
4	traumatic brain injury/	57267
5	brain injury/	92179
6	exp chronic traumatic encephalopathy/	1196
7	degenerative disease/	62650
8	(concussion* or concussed or concussive or subconcuss* or sub-concuss*).tw,kf.	15681
9	(post-concuss* or postconcuss*).tw,kf.	5068
10	(mild adj3 (traumatic brain injur* or tbi*).tw,kf.	11469
11	mtbi*.tw,kf.	5817
12	(head adj2 (injur* or impact* or trauma*).tw,kf.	47983
13	(traumatic brain injur* or tbi*).tw,kf.	81182
14	(neurotrauma* or "neuro-trauma").tw,kf.	3745
15	(craniocerebral adj2 (trauma* or injur*).tw,kf.	3738
16	((repetitive or multiple or cumulative) adj3 (head injur* or head impact* or concussion* or head trauma)).tw,kf.	1488

17	((subconcuss* or sub-concuss*) adj3 (impact* or blow*).tw,kf.	315
18	(chronic traumatic encephalopathy* or CTE).tw,kf.	3097
19	(neurodegenerative adj2 (disease* or disorder*).tw,kf.	116189
20	or/1-19	354133
21	athlete/ or basketball player/ or body builder/ or boxer/ or cyclist/ or football player/ or hockey player/ or judoka/ or skier/ or soccer player/ or triathlete/ or wrestler/	61342
22	sport/ or aquatic sport/ or exp athletics/ or baseball/ or basketball/ or body building/ or boxing/ or exp combat sport/ or contact sport/ or "cricket (sport)"/ or cycling/ or diving/ or endurance sport/ or extreme sport/ or football/ or hockey/ or horseback riding/ or ice hockey/ or martial art/ or mountaineering/ or exp racquet sport/ or rock climbing/ or roller skating/ or rowing/ or rugby/ or skateboarding/ or skating/ or skiing/ or soccer/ or swimming/ or team sport/ or exp tennis/ or "track and field"/ or volleyball/ or water skiing/ or winter sport/ or wrestling/ or youth sport/	145402
23	sport injury/	32548
24	sports medicine/	18183
25	return to sport/	4368
26	(athlete* or athletic* or crew or player* or teammate* or team-mate* or varsity).tw,kf.	164308
27	sport*.tw,kf,jx.	204507
28	((return* or resum* or "re-ent*" or reent*) adj2 (play* or competition* or sport*).tw,kf.	9519
29	(baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or "roller derb*" or rollerskat* or rodeo* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball).tw,kf.	123107
30	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting).tw,kf.	70435
31	(aikido or judo or jiujitsu or "ju-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji").tw,kf.	3379
32	(capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*").tw,kf.	1489
33	(biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*).tw,kf.	37063
34	or/21-33	498805
35	20 and 34	17286
36	cognitive defect/ or mild cognitive impairment/	215242
37	mental disease/ or confusion/ or emotional disorder/ or memory disorder/ or thought disorder/	329250
38	substance abuse/ or exp drug dependence/	295874

39	((cognitive or memory or executive) adj2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*).tw,kf.	265479
40	((drug* or alcohol* or substance) adj2 (dependen* or abuse or disorder*).tw,kf.	168851
41	exp psychosis/	298779
42	depression/ or agitated depression/ or atypical depression/ or chronic depression/ or major depression/ or minor depression/ or "mixed anxiety and depression"/ or "mixed depression and dementia"/	475077
43	automutilation/	21020
44	suicide attempt/ or suicide/	88168
45	aggression/ or aggressiveness/ or hostility/	79363
46	anxiety disorder/ or anxiety/ or generalized anxiety disorder/	323805
47	anger/ or rage/	21303
48	mood disorder/	47710
49	((psychiatric or mental* or psychological) adj2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*).tw,kf.	71902
50	((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) adj2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*).tw,kf.	15806
51	(depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety).tw,kf.	1236556
52	(mood disorder* or psychos?s).tw,kf.	101186
53	((chronic or persistent) adj2 headache*).tw,kf.	8546
54	degenerative disease/	62650
55	exp chronic traumatic encephalopathy/	1196
56	dementia/ or frontotemporal dementia/	142633
57	Alzheimer disease/	223738
58	amyotrophic lateral sclerosis/	42962
59	motor neuron disease/	11175
60	Parkinson disease/	172147
61	hypopituitarism/	12252
62	seizure/	159730
63	(chronic traumatic encephalopath* or CTE or traumatic encephalopath*).tw,kf.	3212
64	((neurodegenerative or neurobehavioral or neurobehavioural) adj2 (disorder* or disease*).tw,kf.	117490
65	(dementia pugilistica or punch drunk).tw,kf.	169
66	(alzheimer* or amyotrophic lateral sclerosis or ALS or parkinson*).tw,kf.	450191
67	(motor neuron adj1 (disease* or disorder*).tw,kf.	9843
68	hypopituitarism.tw,kf.	6957
69	((endocrine or hormon* or metabolic) adj2 dysfunction).tw,kf.	10577
70	seizure*.tw,kf.	202981
71	white matter/	72759
72	tauopathy/	6631
73	TDP 43 proteinopathy/	1477
74	*brain cortex/	42734

75	septum pellucidum/	4851
76	(white matter or taupath* or tau or tap-43 or septum pellucid*).tw,kf.	157033
77	(cortical adj2 (thick* or thin*)).tw,kf.	17623
78	((longterm or long term or permanent or cumulative or chronic or residual) adj2 (consequences or effects or outcome* or sequela* or prognosis or damage*)).tw,kf.	312745
79	or/36-78	3474720
80	35 and 79	7023
81	limit 80 to conference abstracts	1704
82	80 not 81	5319
83	limit 82 to (books or chapter or conference abstract or editorial or letter or note or tombstone)	396
84	82 not 83	4923
85	limit 84 to "humans only (removes records about animals)"	4247
86	limit 85 to english language	4111
87	limit 86 to yr="2001 - 2022"	3895

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Cochrane Central Register of Controlled Trials (via OVID) as searched March 25, 2022

#	Searches	Results
1	exp Brain Concussion/	442
2	Post-Concussion Syndrome/	164
3	Cranio cerebral Trauma/	338
4	Brain Injuries/ or Brain Injuries, Traumatic/	2310
5	Brain Injury, Chronic/	36
6	exp Chronic Traumatic Encephalopathy/	36
7	Neurodegenerative Diseases/	102
8	(concussion* or concussed or concussive or subconcuss* or sub-concuss*).tw,kw.	891
9	(post-concuss* or postconcuss*).tw,kw.	530
10	(mild adj3 (traumatic brain injur* or tbi*)).tw,kw.	888
11	mtbi*.tw,kw.	429
12	(head adj2 (injur* or impact* or trauma*)).tw,kw.	2500
13	(traumatic brain injur* or tbi*).tw,kw.	5843
14	(neurotrauma* or "neuro-trauma").tw,kw.	131
15	(cranio cerebral adj2 (trauma* or injur*)).tw,kw.	143
16	((repetitive or multiple or cumulative) adj3 (head injury* or head impact* or concussion* or head trauma)).tw,kw.	50
17	((subconcuss* or sub-concuss*) adj3 (impact* or blow*)).tw,kw.	22
18	(chronic traumatic encephalopathy or CTE).tw,kw.	104
19	(neurodegenerative adj2 (disease* or disorder*)).tw,kw.	1525
20	or/1-19	10693
21	exp Athletic Injuries/ or exp Athletes/	1804
22	Sports/ or Return to Sport/ or Sports medicine/	1099
23	exp baseball/ or exp basketball/ or exp Bicycling/ or exp boxing/ or exp football/ or exp gymnastics/ or exp hockey/ or exp martial arts/ or exp racquet sports/ or exp skating/ or	4565

	exp Skiing/ or exp snow sports/ or exp soccer/ or exp Swimming/ or exp Tennis/ or exp "track and field"/ or exp volleyball/ or exp water sports/ or exp wrestling/ or exp youth sports/	
24	(athlete* or athletic* or crew or player* or teammate* or team-mate* or varsity).tw,kw.	12054
25	sport*.tw,kw,jw.	20165
26	((return* or resum* or "re-ent*" or reent*) adj2 (play* or competition* or sport*)).tw,kw.	631
27	(baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or "roller derb*" or rollerskat* or rodeo* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball).tw,kw.	8820
28	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampoline* or "water polo" or "weight lifting" or windsurfing or yachting).tw,kw.	2405
29	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampoline* or "water polo" or "weight lifting" or windsurfing or yachting).tw,kw.	2405
30	(capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*").tw,kw.	164
31	(biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*).tw,kw.	3349
32	or/21-31	35828
33	*Cognitive Dysfunction/	0
34	*Cognition Disorders/	0
35	*Mental Disorders/	0
36	*substance-related disorders/ or *alcohol-related disorders/ or *marijuana abuse/ or *opioid-related disorders/	17
37	((cognitive or memory or executive) adj2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*)).tw,kw.	23412
38	((drug* or alcohol* or substance) adj2 (dependen* or abuse or disorder*)).tw,kw.	19653
39	exp Psychotic Disorders/	3166
40	Depression/	13498
41	Self-Injurious Behavior/	343
42	Suicide/ or Suicide, Attempted/	1111
43	Aggression/	1249
44	Anxiety/ or Anxiety Disorders/	12147
45	exp Anger/	478
46	Mood Disorders/	878

47	((psychiatric or mental* or psychological) adj2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*)).tw,kw.	7148
48	((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) adj2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)).tw,kw.	1239
49	(depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety).tw,kw.	134358
50	(mood disorder* or psychos?s).tw,kw.	9466
51	((chronic or persistent) adj2 headache*).tw,kw.	972
52	Neurodegenerative Diseases/	102
53	exp Chronic Traumatic Encephalopathy/	36
54	Dementia/ or Frontotemporal Dementia/	2640
55	Alzheimer Disease/	3674
56	Amyotrophic Lateral Sclerosis/	610
57	Motor Neuron Disease/	297
58	Parkinson Disease, Secondary/ or Parkinson Disease/	4673
59	Hypopituitarism/	170
60	Seizures/	967
61	(chronic traumatic encephalopath* or CTE or traumatic encephalopath*).tw,kw.	111
62	((neurodegenerative or neurobehavioral or neurobehavioural) adj2 (disorder* or disease*)).tw,kw.	1586
63	(dementia pugilistica or punch drunk).tw,kw.	1
64	(alzheimer* or amyotrophic lateral sclerosis or ALS or parkinson*).tw,kw.	26664
65	(motor neuron adj1 (disease* or disorder*)).tw,kw.	211
66	hypopituitarism.tw,kw.	207
67	((endocrine or hormon* or metabolic) adj2 dysfunction).tw,kw.	453
68	seizure*.tw,kw.	9241
69	White Matter/	117
70	Tauopathies/	9
71	TDP-43 Proteinopathies/	1
72	*Cerebral Cortex/	21
73	Septum Pellucidum/	1
74	(white matter or taupath* or tau or tap-43 or septum pellucid*).tw,kw.	7626
75	(cortical adj2 (thick* or thin*)).tw,kw.	663
76	((longterm or long term or permanent or cumulative or chronic or residual) adj2 (consequences or effects or outcome* or sequela* or prognosis or damage*)).tw,kw.	32074
77	or/33-76	239846
78	20 and 32 and 77	140
79	limit 78 to english language	88
80	limit 79 to yr="2001 - 2022"	86

908
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APA PsycInfo (via OVID) as searched March 25, 2022

#	Searches	Results
1	Traumatic Brain Injury/	19931

2	Brain Concussion/	2809
3	head injuries/ or brain injuries/	5591
4	exp Encephalopathies/	5255
5	neurodegenerative diseases/	6968
6	(concussion* or concussed or concussive or subconcuss* or sub-concuss*).tw,id.	4254
7	(post-concuss* or postconcuss*).tw,id.	2036
8	(mild adj3 (traumatic brain injur* or tbi*).tw,id.	4508
9	mtbi*.tw,id.	2254
10	(head adj2 (injur* or impact* or trauma*).tw,id.	8690
11	(traumatic brain injur* or tbi*).tw,id.	20603
12	(craniocerebral adj2 (trauma* or injur*).tw,id.	204
13	((repetitive or multiple or cumulative) adj3 (head injur* or head impact* or concussion* or head trauma)).tw,id.	375
14	((subconcuss* or sub-concuss*) adj3 (impact* or blow*).tw,id.	105
15	(chronic traumatic encephalopath* or CTE).tw,id.	682
16	(neurodegenerative adj2 (disease* or disorder*).tw,id.	17717
17	or/1-16	56507
18	sports/	21221
19	baseball/ or basketball/ or extreme sports/ or football/ or judo/ or martial arts/ or soccer/ or swimming/ or tennis/ or weightlifting/	10581
20	athletes/ or athletic participation/ or athletic performance/ or athletic training/ or college athletes/ or competition/	35755
21	sports medicine/	185
22	(athlete* or athletic* or crew or player* or teammate* or team-mate* or varsity).tw,id.	44912
23	sport*.tw,id,jx.	47192
24	((return* or resum* or "re-ent*" or reent*) adj2 (play* or competition* or sport*).tw,id.	605
25	(baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or net ball or racquet sport* or racquetball or ringette or rodeo* or "roller derb*" or rugby or skateboard* or skating or skiing or snowboard* or snow sport* or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball).tw,id.	30440
26	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or "roller derb*" or rollerskat* or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampoline* or "water polo" or "weight lifting" or windsurfing or yachting).tw,id.	5078
27	(aikido or judo or jiu-jitsu or "ju-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji").tw,id.	1224
28	(capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*).tw,id.	197
29	(biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*).tw,id.	8306

30	or/18-29	109618
31	*cognitive impairment/ or Cognitive ability/ or exp Cognitive Processes/	866518
32	mental disorders/ or exp neurocognitive disorders/ or exp personality disorders/ or exp "stress and trauma related disorders"/ or exp thought disturbances/	265885
33	"substance use disorder"/ or "substance related and addictive disorders"/ or addiction/ or "alcohol use disorder"/ or drug abuse/ or drug dependency/ or "opioid use disorder"/ or drug addiction/ or "Cannabis Use Disorder"/	87650
34	((cognitive or memory or executive) adj2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*)).tw,id.	109047
35	((drug* or alcohol* or substance) adj2 (dependen* or abuse or disorder*)).tw,id.	104863
36	exp Psychosis/	123272
37	exp "Depression (Emotion)"/ or exp Major Depression/	171291
38	exp Self-Destructive Behavior/ or exp Self-Injurious Behavior/ or exp Self-Mutilation/	45240
39	exp Attempted Suicide/ or exp Suicide/	37929
40	exp Aggressive Behavior/ or exp Aggressiveness/	176805
41	Anxiety Disorders/ or Anxiety/	87306
42	exp anger/ or anger control/	16317
43	affective disorders/	15161
44	((psychiatric or mental* or psychological) adj2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*)).tw,id.	61781
45	((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) adj2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)).tw,id.	6691
46	(depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety).tw,id.	597569
47	(mood disorder* or psychos?s).tw,id.	75768
48	((chronic or persistent) adj2 headache*).tw,id.	2005
49	exp neurodegenerative diseases/	88002
50	encephalopathies/	3383
51	exp Dementia/ or exp Dementia with Lewy Bodies/	85254
52	alzheimer's disease/	51424
53	Amyotrophic Lateral Sclerosis/	4220
54	nervous system disorders/	17084
55	exp parkinson's disease/	27095
56	hypopituitarism/	170
57	seizures/	12029
58	(chronic traumatic encephalopath* or CTE or traumatic encephalopath*).tw,id.	709
59	((neurodegenerative or neurobehavioral or neurobehavioural) adj2 (disorder* or disease*)).tw,id.	18254
60	(dementia pugilistica or punch drunk).tw,id.	56
61	(alzheimer* or amyotrophic lateral sclerosis or ALS or parkinson*).tw,id.	116374
62	(motor neuron adj1 (disease* or disorder*)).tw,id.	1333
63	hypopituitarism.tw,id.	164
64	((endocrine or hormon* or metabolic) adj2 dysfunction).tw,id.	706

65	seizure*.tw,id.	33552
66	White Matter/	10165
67	*Cerebral Cortex/	14906
68	(white matter or taupath* or tau or tap-43 or septum pellucid*).tw,id.	31480
69	(cortical adj2 (thick* or thin*)).tw,id.	3719
70	((longterm or long term or permanent or cumulative or chronic or residual) adj2 (consequences or effects or outcome* or sequela* or prognosis or damage*)).tw,id.	36699
71	or/31-70	1991111
72	17 and 30 and 71	1686
73	limit 72 to peer reviewed journal	1319
74	limit 73 to yr="2001 - 2022"	1265

911
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Cochrane Database of Systematic Reviews (via OVID) as searched March 25, 2022

#	Searches	Results
1	(concussion* or concussed or concussive or subconcuss* or sub-concuss*).ti,ab,ct.	2
2	(post-concuss* or postconcuss*).ti,ab,ct.	3
3	(mild adj3 (traumatic brain injur* or tbi*)).ti,ab,ct.	6
4	mtbi*.ti,ab,ct.	1
5	(head adj2 (injur* or impact* or trauma*)).ti,ab,ct.	19
6	(traumatic brain injur* or tbi*).ti,ab,ct.	64
7	(neurotrauma* or "neuro-trauma*").ti,ab,ct.	0
8	(craniocerebral adj2 (trauma* or injur*)).ti,ab,ct.	0
9	((repetitive or multiple or cumulative) adj3 (head injury* or head impact* or concussion* or head trauma)).ti,ab,ct.	0
10	((subconcuss* or sub-concuss*) adj3 (impact* or blow*)).ti,ab,ct.	0
11	(chronic traumatic encephalopathy or CTE).ti,ab,ct.	0
12	(neurodegenerative adj2 (disease* or disorder*)).ti,ab,ct.	14
13	or/1-12	88
14	sport*.ti,ab,ct.	101
15	((return* or resum* or "re-ent*" or reent*) adj2 (play* or competition* or sport*)).ti,ab,ct.	9
16	(baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or "roller derb*" or rollerskat* or rodeo* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball).ti,ab,ct.	31
17	(archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting).ti,ab,ct.	9
18	(capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*").ti,ab,ct.	0

19	(biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*).ti,ab,ct.	7
20	or/14-19	140
21	((cognitive or memory or executive) adj2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*).ti,ab,ct.	209
22	((drug* or alcohol* or substance) adj2 (dependen* or abuse or disorder*).ti,ab,ct.	83
23	((psychiatric or mental* or psychological) adj2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*).ti,ab,ct.	99
24	((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) adj2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*).ti,ab,ct.	4
25	(depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety).ti,ab,ct.	1037
26	(mood disorder* or psychos?s).ti,ab,ct.	158
27	((chronic or persistent) adj2 headache*).ti,ab,ct.	7
28	(chronic traumatic encephalopath* or CTE or traumatic encephalopath*).ti,ab,ct.	0
29	((neurodegenerative or neurobehavioral or neurobehavioural) adj2 (disorder* or disease*).ti,ab,ct.	14
30	(dementia pugilistica or punch drunk).ti,ab,ct.	0
31	(alzheimer* or amyotrophic lateral sclerosis or ALS or parkinson*).ti,ab,ct.	234
32	(motor neuron adj1 (disease* or disorder*).ti,ab,ct.	28
33	hypopituitarism.ti,ab,ct.	0
34	((endocrine or hormon* or metabolic) adj2 dysfunction).ti,ab,ct.	5
35	seizure*.ti,ab,ct.	220
36	(white matter or taupath* or tau or tap-43 or septum pellucid*).ti,ab,ct.	88
37	(cortical adj2 (thick* or thin*).ti,ab,ct.	1
38	((longterm or long term or permanent or cumulative or chronic or residual) adj2 (consequences or effects or outcome* or sequela* or prognosis or damage*).ti,ab,ct.	729
39	or/21-38	2335
40	13 and 20 and 39	1

914
915

916 CINAHL Plus With Full Text (via Ebsco) as searched March 25, 2022

917

#	Query	Limiters/Expanders	Results
S1	(MH "Sports") OR (MH "Horseback Riding") OR (MH "Animal Sports") OR (MH "Amateur Sports") OR (MH "Aquatic Sports") OR (MH "Diving") OR (MH "Rowing") OR (MH "Swimming") OR (MH "Athletic Performance") OR (MH "Athletic Training") OR (MH "Athletic Training Programs") OR (MH "Sport Specific Training") OR (MH "Body Building") OR (MH "College Sports") OR (MH "Contact Sports") OR (MH "Boxing") OR (MH "Football") OR (MH "Martial Arts") OR (MH "Rugby") OR (MH "Wrestling") OR (MH "Cycling") OR (MH "Endurance Sports") OR (MH "Extreme Sports") OR (MH "Fencing") OR (MH "Golf") OR (MH "Gymnastics") OR (MH "Handball") OR (MH "Mountaineering") OR (MH "Professional Sports") OR (MH "Racquet Sports") OR (MH "Tennis") OR (MH "Rock Climbing") OR (MH "Skating") OR (MH "Ice Skating") OR (MH "Skateboarding") OR (MH "Skiing") OR (MH "Snow Skiing") OR (MH "Sporting Events") OR (MH "Sports, Disabled") OR (MH "Sports Participation") OR (MH "Target Sports") OR (MH "Archery") OR (MH "Baseball") OR (MH "Team Sports") OR (MH "Basketball") OR (MH "Cricket (Sports)") OR (MH "Hockey") OR (MH "Soccer") OR (MH "Softball") OR (MH "Volleyball") OR (MH "Track and Field") OR (MH "Weight Lifting") OR (MH "Winter Sports") OR (MH "Snowboarding") OR (MH "Cross Country Skiing")	Search modes - Find all my search terms	74,606
S2	(MH "Athletic Injuries") OR (MH "Aquatic Sports Injuries") OR (MH "Skiing Injuries") OR (MH "Swimming Injuries") OR (MH "Baseball Injuries") OR (MH "Basketball Injuries") OR (MH "Boxing Injuries") OR (MH "Cricket Injuries") OR (MH "Cycling Injuries") OR (MH "Fencing Injuries") OR (MH "Football Injuries") OR (MH "Golf Injuries") OR (MH "Gymnastics Injuries") OR (MH "Hockey Injuries") OR (MH "Martial Arts Injuries") OR (MH "Mountaineering Injuries") OR (MH "Racquet Sports Injuries") OR (MH "Tennis Injuries") OR (MH "Rock Climbing Injuries") OR (MH "Rugby Injuries") OR (MH "Skateboarding Injuries") OR (MH "Soccer Injuries") OR (MH "Volleyball Injuries") OR (MH "Winter Sports Injuries") OR (MH "Snowboarding Injuries")	Search modes - Find all my search terms	23,090
S3	(MH "Sports Re-Entry") OR (MH "Sports Medicine")	Search modes - Find all my search terms	9,111
S4	(MH "Athletes+")	Search modes - Find all my search terms	31,956
S5	TI sport* OR AB sport* OR SO sport* OR SU sport*	Search modes - Find all my search terms	142,592

S6	TI (((return* or resum* or "re-ent*" or reent*) N2 (play* or competition* or sport*))) OR AB (((return* or resum* or "re-ent*" or reent*) N2 (play* or competition* or sport*)))	Search modes - Find all my search terms	5,444
S7	TI ((baseball or basketball or biking or bicycling* or bmx or boxing or bullrid* or "bull rid*" or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or rodeo* or "roller derb*" or rollerskat* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball)) OR AB ((baseball or basketball or biking or bicycling* or bmx or boxing or bullrid* or "bull rid*" or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or rodeo* or "roller derb*" or rollerskat* or rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball))	Search modes - Find all my search terms	40,199
S8	TI ((archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting)) OR AB ((archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting))	Search modes - Find all my search terms	9,370
S9	TI ((aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji")) OR AB ((aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji"))	Search modes - Find all my search terms	1,638
S10	TI ((capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*")) OR AB ((capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*"))	Search modes - Find all my search terms	192
S11	TI ((athlete* or athletic* or crew or player* or teammate* or "team-mate*" or varsity or biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or	Search modes - Find all my search terms	71,458

	divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*) OR AB (athlete* or athletic* or crew or player* or teammate* or "team-mate*" or varsity or biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*)		
S12	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11	Search modes - Find all my search terms	206,135
S13	(MH "BRAIN concussion") OR (MH "POSTCONCUSSION syndrome") OR (MH "BRAIN injuries")	Search modes - Find all my search terms	31,272
S14	TI ((concussion* or concussed or concussive or subconcuss* or "sub-concuss*")) OR AB ((concussion* or concussed or concussive or subconcuss* or "sub-concuss*"))	Search modes - Find all my search terms	6,195
S15	TI (("post-concuss*" or postconcuss*) OR AB (("post-concuss*" or postconcuss*)	Search modes - Find all my search terms	1,665
S16	TI ((mild N3 ("traumatic brain injur*" or tbi*))) OR AB ((mild N3 ("traumatic brain injur*" or tbi*)))	Search modes - Find all my search terms	3,334
S17	TI mtbi* OR AB mtbi*	Search modes - Find all my search terms	1,294
S18	TI ((head N2 (injur* or impact* or trauma*))) OR AB ((head N2 (injur* or impact* or trauma*)))	Search modes - Find all my search terms	11,498
S19	TI (("traumatic brain injur*" or tbi*)) OR AB (("traumatic brain injur*" or tbi*))	Search modes - Find all my search terms	19,512
S20	TI ((neurotrauma* or "neuro-trauma*") OR (craniocerebral N2 (trauma* OR injur*))) OR AB ((neurotrauma* or "neuro-trauma*") OR (craniocerebral N2 (trauma* OR injur*)))	Search modes - Find all my search terms	679
S21	(MH "Chronic Traumatic Encephalopathy")	Search modes - Find all my search terms	65
S22	(MH "Neurodegenerative Diseases")	Search modes - Find all my search terms	4,887
S23	TI (((subconcuss* or sub-concuss*) N3 (impact* or blow*))) OR AB (((subconcuss* or sub-concuss*) N3 (impact* or blow*)))	Search modes - Find all my search terms	94
S24	TI (((repetitive or multiple or cumulative) N3 ("head injur*" or "head impact*" or concussion* or "head trauma*))) OR AB (((repetitive or multiple or cumulative) N3 ("head	Search modes - Find all my search terms	370

	injur*" or "head impact*" or concussion* or "head trauma"))		
S25	TI (("chronic traumatic encephalopath*" or CTE)) OR AB (("chronic traumatic encephalopath*" or CTE))	Search modes - Find all my search terms	440
S26	TI ((neurodegenerative N2 (disease* or disorder*))) OR AB ((neurodegenerative N2 (disease* or disorder*)))	Search modes - Find all my search terms	8,986
S27	S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26	Search modes - Find all my search terms	58,285
S28	S12 AND S27	Search modes - Find all my search terms	6,939
S29	(MH "Cognition Disorders")	Search modes - Find all my search terms	32,546
S30	(MH "Mental Disorders")	Search modes - Find all my search terms	64,240
S31	(MH "Substance Use Disorders") or (MH "Substance Abuse") OR (MH "Alcohol-Related Disorders") OR (MH "Alcohol Abuse") OR (MH "Alcoholism")	Search modes - Find all my search terms	100,979
S32	TI (((cognitive or memory or executive) N2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*))) OR AB (((cognitive or memory or executive) N2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*)))	Search modes - Find all my search terms	58,749
S33	TI (((drug* or alcohol* or substance) N2 (dependen* or abuse or disorder*))) OR AB (((drug* or alcohol* or substance) N2 (dependen* or abuse or disorder*)))	Search modes - Find all my search terms	50,576
S34	(MH "Psychotic Disorders+")	Search modes - Find all my search terms	137,948
S35	(MH "Depression")	Search modes - Find all my search terms	121,097
S36	(MH "Self-Injurious Behavior")	Search modes - Find all my search terms	4,723
S37	(MH "Suicide") OR (MH "Suicide, Attempted")	Search modes - Find all my search terms	26,967
S38	(MH "Aggression")	Search modes - Find all my search terms	11,938
S39	(MH "Anxiety") or (MH "Anxiety Disorders") OR (MH "Generalized Anxiety Disorder")	Search modes - Find all my search terms	62,774
S40	(MH "Anger")	Search modes - Find all my search terms	6,109
S41	(MH "Affective Disorders")	Search modes - Find all my search terms	8,167

S42	TI (((psychiatric or mental* or psychological) N2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*))) OR AB (((psychiatric or mental* or psychological) N2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*)))	Search modes - Find all my search terms	31,135
S43	TI (((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) N2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*))) OR AB (((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) N2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)))	Search modes - Find all my search terms	2,995
S44	TI ((depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety)) OR AB ((depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety))	Search modes - Find all my search terms	290,709
S45	TI ((“mood disorder*” or psychos?s)) OR AB ((“mood disorder*” or psychos?s))	Search modes - Find all my search terms	20,010
S46	TI (((chronic or persistent) N2 headache*)) OR AB (((chronic or persistent) N2 headache*))	Search modes - Find all my search terms	2,585
S47	(MH "Neurodegenerative Diseases")	Search modes - Find all my search terms	4,887
S48	(MH "Chronic Traumatic Encephalopathy")	Search modes - Find all my search terms	65
S49	(MH "Dementia+")	Search modes - Find all my search terms	80,699
S50	(MH "Alzheimer's Disease")	Search modes - Find all my search terms	35,802
S51	(MH "Amyotrophic Lateral Sclerosis")	Search modes - Find all my search terms	4,492
S52	(MH "Motor Neuron Diseases")	Search modes - Find all my search terms	1,438
S53	(MH "Parkinson Disease")	Search modes - Find all my search terms	24,503
S54	(MH "Hypopituitarism")	Search modes - Find all my search terms	619
S55	(MH "Seizures")	Search modes - Find all my search terms	11,869
S56	TI ((“chronic traumatic encephalopath*” or CTE or “traumatic encephalopath*”) OR AB ((“chronic traumatic encephalopath*” or CTE or “traumatic encephalopath*”)	Search modes - Find all my search terms	464
S57	TI (((neurodegenerative or neurobehavioral or neurobehavioural) N2 (disorder* or disease*))) OR AB (((neurodegenerative or neurobehavioral or neurobehavioural) N2 (disorder* or disease*)))	Search modes - Find all my search terms	9,211

S58	TI ((“dementia pugilistica” or “punch drunk”)) OR AB ((“dementia pugilistica” or “punch drunk”))	Search modes - Find all my search terms	20
S59	TI ((alzheimer* or “amyotrophic lateral sclerosis” or ALS or parkinson*)) OR AB ((alzheimer* or “amyotrophic lateral sclerosis” or ALS or parkinson*))	Search modes - Find all my search terms	77,933
S60	TI ((“motor neuron” N1 (disease* or disorder*))) OR AB ((“motor neuron” N1 (disease* or disorder*)))	Search modes - Find all my search terms	907
S61	TI hypopituitarism OR AB hypopituitarism	Search modes - Find all my search terms	523
S62	TI (((endocrine or hormon* or metabolic) N2 dysfunction)) OR AB (((endocrine or hormon* or metabolic) N2 dysfunction))	Search modes - Find all my search terms	1,634
S63	TI seizure* OR AB seizure*	Search modes - Find all my search terms	22,270
S64	(MH "White Matter")	Search modes - Find all my search terms	566
S65	(MM "Cerebral Cortex")	Search modes - Find all my search terms	5,377
S66	TI ((“white matter” or taupath* or tau or “tap-43” or “septum pellucid**”)) OR AB ((“white matter” or taupath* or tau or “tap-43” or “septum pellucid**”))	Search modes - Find all my search terms	18,367
S67	TI ((cortical N2 (thick* or thin*))) OR AB ((cortical N2 (thick* or thin*)))	Search modes - Find all my search terms	2,387
S68	TI (((longterm or “long term” or permanent or cumulative or chronic or residual) N2 (consequences or effects or outcome* or sequela* or prognosis or damage*))) OR AB (((longterm or “long term” or permanent or cumulative or chronic or residual) N2 (consequences or effects or outcome* or sequela* or prognosis or damage*)))	Search modes - Find all my search terms	64,164
S69	S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67 OR S68	Search modes - Find all my search terms	795,018
S70	S28 AND S69	Search modes - Find all my search terms	1,451
S71	S28 AND S69	Limiters - Scholarly (Peer Reviewed) Journals Search modes - Find all my search terms	1,277
S72	S28 AND S69	Limiters - Published Date: 20010101-20221231; Scholarly (Peer Reviewed) Journals	1,241

		Search modes - Find all my search terms	
S73	S28 AND S69	Limiters - Published Date: 20010101-20221231; Scholarly (Peer Reviewed) Journals Search modes - Find all my search terms	1,241
S74	S28 AND S69	Limiters - Published Date: 20010101-20221231; Scholarly (Peer Reviewed) Journals Narrow by Language: - english Search modes - Find all my search terms	1,234

918
919
920

SportDiscus with Full Text (via Ebsco) as searched March 25, 2022

#	Query	Limiters/Expanders	Results
S1	(DE "BRAIN concussion" OR DE "POSTCONCUSSION syndrome") OR (DE "BRAIN injuries")	Search modes - Find all my search terms	6,067
S2	DE "BRAIN concussion prevention"	Search modes - Find all my search terms	185
S3	DE "BRAIN concussion diagnosis"	Search modes - Find all my search terms	385
S4	DE "CHRONIC traumatic encephalopathy"	Search modes - Find all my search terms	110
S5	DE "DEGENERATION (Pathology)"	Search modes - Find all my search terms	453
S6	TI ((concussion* or concussed or concussive or subconcuss* or "sub-concuss*")) OR AB ((concussion* or concussed or concussive or subconcuss* or "sub-concuss*")) OR KW ((concussion* or concussed or concussive or subconcuss* or "sub-concuss*"))	Search modes - Find all my search terms	5,595
S7	TI (("post-concuss*" or postconcuss*) OR AB (("post-concuss*" or postconcuss*) OR KW (("post-concuss*" or postconcuss*))	Search modes - Find all my search terms	907
S8	TI ((mild N3 ("traumatic brain injur*" or tbi*))) OR AB ((mild N3 ("traumatic brain injur*" or tbi*))) OR KW ((mild N3 ("traumatic brain injur*" or tbi*)))	Search modes - Find all my search terms	1,285
S9	TI mtbi* OR AB mtbi* OR KW mtbi*	Search modes - Find all my search terms	394
S10	TI ((head N2 (injur* or impact* or trauma*))) OR AB ((head N2 (injur* or impact* or trauma*))) OR KW ((head N2 (injur* or impact* or trauma*)))	Search modes - Find all my search terms	3,729

S11	TI (("traumatic brain injur*" or tbi*)) OR AB (("traumatic brain injur*" or tbi*)) OR KW (("traumatic brain injur*" or tbi*))	Search modes - Find all my search terms	5,268
S12	TI ((neurotrauma* or "neuro-trauma*") OR (craniocerebral N2 (trauma* OR injur*)) OR AB ((neurotrauma* or "neuro-trauma*") OR (craniocerebral N2 (trauma* OR injur*)) OR KW ((neurotrauma* or "neuro-trauma*") OR (craniocerebral N2 (trauma* OR injur*)))	Search modes - Find all my search terms	178
S13	TI (((subconcuss* or sub-concuss*) N3 (impact* or blow*))) OR AB (((subconcuss* or sub-concuss*) N3 (impact* or blow*))) OR KW (((subconcuss* or sub-concuss*) N3 (impact* or blow*)))	Search modes - Find all my search terms	70
S14	TI (((repetitive or multiple or cumulative) N3 ("head injur*" or "head impact*" or concussion* or "head trauma"))) OR AB (((repetitive or multiple or cumulative) N3 ("head injur*" or "head impact*" or concussion* or "head trauma"))) OR KW (((repetitive or multiple or cumulative) N3 ("head injur*" or "head impact*" or concussion* or "head trauma")))	Search modes - Find all my search terms	214
S15	TI (("chronic traumatic encephalopath*" or CTE)) OR AB (("chronic traumatic encephalopath*" or CTE)) OR KW (("chronic traumatic encephalopath*" or CTE))	Search modes - Find all my search terms	189
S16	TI ((neurodegenerative N2 (disease* or disorder*))) OR AB ((neurodegenerative N2 (disease* or disorder*))) OR KW ((neurodegenerative N2 (disease* or disorder*)))	Search modes - Find all my search terms	737
S17	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16	Search modes - Find all my search terms	14,596
S18	DE "SPORTS" OR DE "AMATEUR sports" OR DE "AQUATIC sports" OR DE "BALL games" OR DE "COLLEGE sports" OR DE "CONTACT sports" OR DE "ENDURANCE sports" OR DE "EXTREME sports" OR DE "INDIVIDUAL sports" OR DE "MILITARY sports" OR DE "OLYMPIC Games" OR DE "PROFESSIONAL sports" OR DE "RECREATIONAL sports" OR DE "SCHOOL sports" OR DE "SPORTS competitions" OR DE "TEAM sports" OR DE "VIOLENCE in sports" OR DE "WINTER sports" OR DE "SPORTS camps" OR DE "SPORTS events" OR DE "SPORTS medicine" OR DE "SPORTS participation"	Search modes - Find all my search terms	218,565
S19	DE "ATHLETICS" OR DE "BASEBALL" OR DE "BASKETBALL" OR DE "BICYCLE motocross" OR DE "BICYCLE racing" OR DE "BICYCLE racing training" OR DE "BOXING" OR DE "CYCLING" OR DE "CHEERLEADING" OR DE "ROCK climbing" OR DE "CRACK climbing" OR DE "FACE climbing" OR DE "FREE climbing" OR DE "INDOOR rock climbing" OR	Search modes - Find all my search terms	414,453

<p>DE "CRICKET (Sport)" OR DE "CRICKET competitions" OR DE "INDOOR cricket" OR DE "TWENTY20 cricket" OR DE "ACROBATIC diving" OR DE "SPRINGBOARD diving" OR DE "HORSE sports" OR DE "EQUESTRIAN accidents" OR DE "DRESSAGE tests" OR DE "EVENTING (Horsemanship)" OR DE "GAMES on horseback" OR DE "HORSE racing" OR DE "SHOW jumping" OR DE "SHOW riding" OR DE "VAULTING (Horsemanship)" OR DE "FOOTBALL" OR DE "CANADIAN football" OR DE "COLLEGE football" OR DE "HIGH school football" OR DE "MINOR league football" OR DE "PROFESSIONAL football" OR DE "ARENA football" OR DE "RUGBY football" OR DE "COLLEGE rugby football" OR DE "FLORENTINE football" OR DE "PROFESSIONAL rugby football" OR DE "RUGBY League football" OR DE "RUGBY Union football" OR DE "RUGBY competitions" OR DE "SEVEN-a-side rugby football" OR DE "AUSTRALIAN football" OR DE "TACKLING (Rugby)" OR DE "GOLF" OR DE "COLLEGE golf" OR DE "PROFESSIONAL golf" OR DE "SNOW golf" OR DE "GYMNASTICS" OR DE "ARTISTIC gymnastics" OR DE "SWEDISH gymnastics" OR DE "TEAM aerobics" OR DE "TUMBLING" OR DE "HANDBALL" OR DE "TEAM handball" OR DE "HOCKEY" OR DE "COLLEGE hockey" OR DE "FIELD hockey" OR DE "INDOOR hockey" OR DE "LAWN hockey" OR DE "MINOR league hockey" OR DE "ROLLER hockey" OR DE "BALL hockey" OR DE "PROFESSIONAL hockey" OR DE "LACROSSE" OR DE "MOUNTAINEERING" OR DE "NETBALL" OR DE "RACKET games" OR DE "RACQUETBALL" OR DE "RINGETTE (Game)" OR DE "RODEOS" OR DE "BRONC riding" OR DE "BULL riding" OR DE "CALF roping" OR DE "CHUCKWAGON racing" OR DE "STEER roping" OR DE "STEER wrestling" OR DE "TEAM penning" OR DE "TEAM roping" OR DE "TRICK roping" OR DE "SKATEBOARDING" OR DE "SNOW skating" OR DE "SKATING" OR DE "FIGURE skating" OR DE "FREE skating" OR DE "ICE dancing" OR DE "PROFESSIONAL skating" OR DE "SPEED skating" OR DE "ROLLER skating" OR DE "SKI acrobatics" OR DE "SKI cross" OR DE "SKI mountaineering" OR DE "SKI racing" OR DE "SKIS & skiing" OR DE "SLALOM canoeing" OR DE "SLALOM racing" OR DE "SLALOM skiing" OR DE "SNOWBOARDING" OR DE "BACKCOUNTRY snowboarding" OR DE "SLOPESTYLE snowboarding" OR DE "SKIBOARDING" OR DE "SOCCER" OR DE "COLLEGE soccer" OR DE "HIGH school soccer" OR DE "INDOOR soccer" OR DE "PROFESSIONAL soccer" OR</p>		
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	DE "SOFTBALL" OR DE "SLOW pitch softball" OR DE "YOUTH league softball" OR DE "SQUASH (Game)" OR DE "SWIMMING" OR DE "SWIMMING competitions" OR DE "SYNCHRONIZED swimming" OR DE "TENNIS" OR DE "COLLEGE tennis" OR DE "COURT tennis" OR DE "PROFESSIONAL tennis" OR DE "TABLE tennis" OR DE "TENNIS leagues" OR DE "TENNIS tournaments" OR DE "TENNIS training" OR DE "TRACK & field" OR DE "ALL-around (Track & field)" OR DE "COLLEGE track & field" OR DE "HURDLING (Track & field)" OR DE "INDOOR track & field" OR DE "JUMPING" OR DE "STEEPLECHASING (Track & field)" OR DE "VAULTING" OR DE "VOLLEYBALL" OR DE "BEACH volleyball" OR DE "COLLEGE volleyball" OR DE "PROFESSIONAL volleyball" OR DE "VOLLEYBALL competitions" OR DE "WRESTLING" OR DE "COLLEGE wrestling" OR DE "FREESTYLE wrestling" OR DE "HIGH school wrestling" OR DE "PROFESSIONAL wrestling" OR DE "SAMBO wrestling" OR DE "SUMO"		
S20	DE "AIKIDO" OR DE "JUDO" OR DE "SAN-jitsu" OR DE "JIU-jitsu" OR DE "KARATE" OR DE "TAE kwon do" OR DE "KICKBOXING" OR DE "MARTIAL arts" OR DE "CAPOEIRA (Dance)" OR DE "MIXED martial arts" OR DE "ARCHERY" OR DE "BADMINTON (Game)" OR DE "BADMINTON tournaments" OR DE "BADMINTON training" OR DE "CANOE racing" OR DE "CROSS-country ski racing" OR DE "NORDIC combined" OR DE "SPORT fencing" OR DE "FENCING" OR DE "KAYAKING" OR DE "KAYAKING training" OR DE "ICE luge racing" OR DE "SHOOTING contests" OR DE "ROWING" OR DE "SAILING" OR DE "SKELETON" OR DE "SKI jumping" OR DE "SLEDDING" OR DE "SURFING" OR DE "BODYBOARDING" OR DE "KITE surfing" OR DE "STAND-up paddle surfing" OR DE "WINDSURFING" OR DE "TRAMPOLINING" OR DE "WATER polo" OR DE "WEIGHT lifting" OR DE "YACHTING"	Search modes - Find all my search terms	59,827
S21	DE "ATHLETES" OR DE "ATHLETES' health" OR DE "ARCHERS" OR DE "BADMINTON players" OR DE "BASEBALL players" OR DE "BASKETBALL players" OR DE "BOBSLEDDERS" OR DE "BODYBUILDERS" OR DE "BOXERS (Sports)" OR DE "BULLFIGHTERS" OR DE "CANOEISTS" OR DE "COLLEGE athletes" OR DE "CRICKET players" OR DE "CYCLISTS" OR DE "DIVERS" OR DE "ELITE athletes" OR DE "ENDURANCE athletes" OR DE "FENCERS" OR DE "FOOTBALL players" OR DE "GOLFERS" OR DE "GYMNASTS" OR DE "HANDBALL players" OR DE "HIGH school athletes" OR DE "HOCKEY players" OR	Search modes - Find all my search terms	290,236

	DE "JUNIOR high school athletes" OR DE "LACROSSE players" OR DE "MALE athletes" OR DE "MARTIAL artists" OR DE "MIDDLE school athletes" OR DE "MOUNTAINEERS" OR DE "NETBALL players" OR DE "OFFENSIVE players" OR DE "OLDER athletes" OR DE "OLYMPIC athletes" OR DE "PROFESSIONAL athletes" OR DE "ROWERS" OR DE "RUGBY football players" OR DE "RUGBY football teams" OR DE "SKATEBOARDERS" OR DE "SKATERS" OR DE "SKIERS" OR DE "SNOWBOARDERS" OR DE "SOCCER players" OR DE "SOFTBALL players" OR DE "SQUASH players" OR DE "SURFERS" OR DE "SWIMMERS" OR DE "TABLE tennis players" OR DE "TEAM handball players" OR DE "TENNIS players" OR DE "TRACK & field athletes" OR DE "TRIATHLETES" OR DE "VOLLEYBALL players" OR DE "WATER polo players" OR DE "WEIGHT lifters" OR DE "WINDSURFERS (Persons)" OR DE "WOMEN athletes" OR DE "WRESTLERS"		
S22	DE "MARTIAL artists" OR DE "ARCHERS" OR DE "BADMINTON players" OR DE "CANOEISTS" OR DE "KAYAKERS" OR DE "SAILORS" OR DE "SURFERS" OR DE "TRAMPOLINISTS" OR DE "WATER polo players" OR DE "WEIGHT lifters"	Search modes - Find all my search terms	7,029
S23	DE "SPORTS medicine" OR DE "PEDIATRIC sports medicine" OR DE "SPORTS emergencies" OR DE "SPORTS nutrition" OR DE "SPORTS ophthalmology" OR DE "SPORTS physical therapy" OR DE "SPORTS injuries" OR DE "AQUATIC sports injuries" OR DE "BASEBALL injuries" OR DE "BASKETBALL injuries" OR DE "BOXING injuries" OR DE "CRICKET injuries" OR DE "DIVING injuries" OR DE "DIVING accidents" OR DE "EQUESTRIAN accidents" OR DE "FOOTBALL injuries" OR DE "GOLF injuries" OR DE "GYMNASTICS injuries" OR DE "HOCKEY injuries" OR DE "HORSE sports injuries" OR DE "IN-line skating injuries" OR DE "JUDO injuries" OR DE "KARATE injuries" OR DE "MARTIAL arts injuries" OR DE "MOTORSPORTS injuries" OR DE "NETBALL injuries" OR DE "RACKET game injuries" OR DE "RUGBY football injuries" OR DE "SKATEBOARDING injuries" OR DE "SKIING injuries" OR DE "SKIING accidents" OR DE "SOCCER injuries" OR DE "TENNIS injuries" OR DE "VAULTING injuries" OR DE "VOLLEYBALL injuries" OR DE "WINTER sports injuries" OR DE "JUDO injuries" OR DE "KARATE injuries" OR DE "MARTIAL arts injuries" OR DE "CANOEING accidents" OR DE "YACHTING accidents"	Search modes - Find all my search terms	34,396

S24	TI ((athlete* or athletic* or crew or player* or teammate* or "team-mate*" or varsity)) OR AB ((athlete* or athletic* or crew or player* or teammate* or "team-mate*" or varsity)) OR KW ((athlete* or athletic* or crew or player* or teammate* or "team-mate*" or varsity))	Search modes - Find all my search terms	373,513
S25	TI sport* OR AB sport* OR KW sport* OR SO sport*	Search modes - Find all my search terms	790,292
S26	TI (((return* or resum* or "re-ent*" or reent*) N2 (play* or competition* or sport*))) OR AB (((return* or resum* or "re-ent*" or reent*) N2 (play* or competition* or sport*))) OR KW (((return* or resum* or "re-ent*" or reent*) N2 (play* or competition* or sport*)))	Search modes - Find all my search terms	6,482
S27	TI ((baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or rodeo* or "roller derb*" or rollerskat* rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball)) OR AB ((baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or rodeo* or "roller derb*" or rollerskat* rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball)) OR KW ((baseball or basketball or biking or bicycling* or bmx or boxing or "bull rid*" or bullrid* or cheerleading or "cheer leading" or climbing or cricket or diving or equestrian or football or golf or gymnastics or handball or "horse* riding" or hockey or lacrosse or mountaineering or netball or "net ball" or "racquet sport*" or racquetball or ringette or rodeo* or "roller derb*" or rollerskat* rugby or skateboard* or skating or skiing or snowboard* or "snow sport*" or soccer or softball or squash or swimming or tennis or "track and field" or wrestling or volleyball))	Search modes - Find all my search terms	573,584
S28	TI ((archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting)) OR AB ((archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or	Search modes - Find all my search terms	54,011

	rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting)) OR KW ((archery or badminton or bobsled* or bobsleigh* or canoe* or "cross country" or fencing or kayak* or luge or rifle or rowing or sailing or skeleton or "ski jump*" or sledding or surfing or trampolin* or "water polo" or "weight lifting" or windsurfing or yachting))		
S29	TI ((aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji")) OR AB ((aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji")) OR KW ((aikido or judo or jiu-jitsu or "jiu-jitsu" or jujitsu or "ju jitsu" or karate or kickbox* or "Martial art*" or taekwondo or "tae kwon do" or "tai ji"))	Search modes - Find all my search terms	14,911
S30	TI ((capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*")) OR AB ((capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*")) OR KW ((capoeira or "Dim mak" or kenpo or "kung fu" or "pencak silat" or pitfight* or savate or "submission fight*" or UFC or "ultimate fighting champion*"))	Search modes - Find all my search terms	1,743
S31	TI ((biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*)) OR AB ((biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*)) OR KW ((biker* or boxer* or "cheer leader*" or cheerleader* or climber* or cyclist* or diver or divers or fencer* or fighter* or footballer* or goalie* or golfer* or gymnast or gymnasts or "horse* rider*" or jockey* or judoka* or mountaineer* or rower* or sailor* or skater* or skier* or sledder* or snowboarder* or surfer* or swimmer* or "weight lifter*" or wrestler*))	Search modes - Find all my search terms	149,848
S32	S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31	Search modes - Find all my search terms	1,478,336

S33	S17 AND S32	Search modes - Find all my search terms	7,261
S34	DE "COGNITION disorders"	Search modes - Find all my search terms	1,282
S35	DE "MENTAL illness"	Search modes - Find all my search terms	2,466
S36	DE "SUBSTANCE abuse" OR DE "ADDICTIONS" OR DE "ALCOHOLISM" OR DE "DRUG abuse"	Search modes - Find all my search terms	13,981
S37	TI (((cognitive or memory or executive) N2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*))) OR AB (((cognitive or memory or executive) N2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*))) OR KW (((cognitive or memory or executive) N2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline or disturbance* or deteriorat* or decrement* or sequela*)))	Search modes - Find all my search terms	5,358
S38	TI (((drug* or alcohol* or substance) N2 (dependen* or abuse or disorder*))) OR AB (((drug* or alcohol* or substance) N2 (dependen* or abuse or disorder*))) OR KW (((drug* or alcohol* or substance) N2 (dependen* or abuse or disorder*)))	Search modes - Find all my search terms	10,668
S39	DE "MENTAL depression"	Search modes - Find all my search terms	6,552
S40	DE "SELF-destructive behavior"	Search modes - Find all my search terms	74
S41	DE "SUICIDE"	Search modes - Find all my search terms	799
S42	DE "AGGRESSION (Psychology)"	Search modes - Find all my search terms	1,132
S43	DE "ANXIETY"	Search modes - Find all my search terms	7,609
S44	DE "AFFECTIVE disorders"	Search modes - Find all my search terms	759
S45	TI (((psychiatric or mental* or psychological) N2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*))) OR AB (((psychiatric or mental* or psychological) N2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*))) OR KW (((psychiatric or mental* or psychological) N2 (illness or impair* or abnormal* or dysfunction* or deficit* or decline or deteriorat*)))	Search modes - Find all my search terms	2,222
S46	TI (((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) N2 (impair* or	Search modes - Find all my search terms	241

	abnormal* or dysfunction* or decline or disturbance* or deteriorat*)) OR AB (((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) N2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)) OR AB (((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive) N2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)))		
S47	TI ((depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety)) OR AB ((depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety)) OR KW ((depress* or suicide or suicidal or aggression or aggressive or anger or angry or rage or anxiety))	Search modes - Find all my search terms	40,915
S48	TI (("mood disorder*" or psychos?s)) OR AB (("mood disorder*" or psychos?s)) OR KW (("mood disorder*" or psychos?s))	Search modes - Find all my search terms	1,250
S49	TI (((chronic or persistent) N2 headache*)) OR AB (((chronic or persistent) N2 headache*)) OR KW (((chronic or persistent) N2 headache*))	Search modes - Find all my search terms	838
S50	DE "DEGENERATION (Pathology)"	Search modes - Find all my search terms	453
S51	DE "CHRONIC traumatic encephalopathy"	Search modes - Find all my search terms	110
S52	DE "DEMENTIA"	Search modes - Find all my search terms	860
S53	DE "ALZHEIMER'S disease"	Search modes - Find all my search terms	1,070
S54	DE "AMYOTROPHIC lateral sclerosis"	Search modes - Find all my search terms	353
S55	DE "PARKINSON'S disease"	Search modes - Find all my search terms	1,732
S56	TI (("chronic traumatic encephalopath*" or CTE or "traumatic encephalopath*") OR AB (("chronic traumatic encephalopath*" or CTE or "traumatic encephalopath*")) OR KW (("chronic traumatic encephalopath*" or CTE or "traumatic encephalopath*"))	Search modes - Find all my search terms	202
S57	TI (((neurodegenerative or neurobehavioral or neurobehavioural) N2 (disorder* or disease*))) OR AB (((neurodegenerative or neurobehavioral or neurobehavioural) N2 (disorder* or disease*))) OR KW (((neurodegenerative or neurobehavioral or neurobehavioural) N2 (disorder* or disease*)))	Search modes - Find all my search terms	772

S58	TI ((“dementia pugilistica” or “punch drunk”)) OR AB ((“dementia pugilistica” or “punch drunk”)) OR KW ((“dementia pugilistica” or “punch drunk”))	Search modes - Find all my search terms	39
S59	TI ((alzheimer* or “amyotrophic lateral sclerosis” or ALS or parkinson*)) OR AB ((alzheimer* or “amyotrophic lateral sclerosis” or ALS or parkinson*)) OR KW ((alzheimer* or “amyotrophic lateral sclerosis” or ALS or parkinson*))	Search modes - Find all my search terms	9,108
S60	TI ((“motor neuron” N1 (disease* or disorder*))) OR AB ((“motor neuron” N1 (disease* or disorder*))) OR KW ((“motor neuron” N1 (disease* or disorder*)))	Search modes - Find all my search terms	63
S61	TI hypopituitarism OR AB hypopituitarism OR KW hypopituitarism	Search modes - Find all my search terms	100
S62	TI (((endocrine or hormon* or metabolic) N2 dysfunction)) OR AB (((endocrine or hormon* or metabolic) N2 dysfunction)) OR KW (((endocrine or hormon* or metabolic) N2 dysfunction))	Search modes - Find all my search terms	275
S63	TI seizure* OR AB seizure* OR KW seizure*	Search modes - Find all my search terms	1,269
S64	DE "CEREBRAL cortex"	Search modes - Find all my search terms	533
S65	TI ((“white matter” or taupath* or tau or “tap-43” or “septum pellucid**”)) OR AB ((“white matter” or taupath* or tau or “tap-43” or “septum pellucid**”)) OR KW ((“white matter” or taupath* or tau or “tap-43” or “septum pellucid**”))	Search modes - Find all my search terms	955
S66	TI ((cortical N2 (thick* or thin*))) OR AB ((cortical N2 (thick* or thin*))) OR KW ((cortical N2 (thick* or thin*)))	Search modes - Find all my search terms	421
S67	TI (((longterm or “long term” or permanent or cumulative or chronic or residual) N2 (consequences or effects or outcome* or sequela* or prognosis or damage*))) OR AB (((longterm or “long term” or permanent or cumulative or chronic or residual) N2 (consequences or effects or outcome* or sequela* or prognosis or damage*))) OR KW (((longterm or “long term” or permanent or cumulative or chronic or residual) N2 (consequences or effects or outcome* or sequela* or prognosis or damage*)))	Search modes - Find all my search terms	9,125
S68	S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67	Search modes - Find all my search terms	89,721
S69	S33 AND S68	Search modes - Find all my search terms	1,071

S70	S33 AND S68	Limiters - Scholarly (Peer Reviewed) Journals Search modes - Find all my search terms	827
S71	S33 AND S68	Limiters - Published Date: 20010101-20221231; Scholarly (Peer Reviewed) Journals Search modes - Find all my search terms	782
S72	S33 AND S68	Limiters - Published Date: 20010101-20221231; Scholarly (Peer Reviewed) Journals Narrow by Language: - english Search modes - Find all my search terms	750

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922

923 **Scopus (Eslevier) as searched March 25, 2022**

924
 925 ((TITLE-ABS-KEY ((concussion* OR concussed OR concussive OR subconcuss* OR sub-concuss*))
 926 OR TITLE-ABS-KEY (mild W/3 ("traumatic brain injur*" OR tbi*)) OR TITLE-ABS-KEY (post-
 927 concuss* OR postconcuss*) OR TITLE-ABS-KEY (head W/2 (injur* OR impact* OR trauma*)) OR
 928 TITLE-ABS-KEY (("traumatic brain injur*" OR tbi* OR mtbi* OR neurotrauma* OR "neuro-
 929 trauma*")) OR TITLE-ABS-KEY (craniocerebral W/2 (trauma* OR injur*)) OR TITLE-ABS-
 930 KEY ((repetitive OR multiple OR cumulative) W/3 ("head injur*" OR "head impact*" OR concussion*
 931 OR "head trauma")) OR TITLE-ABS-KEY ((subconcuss* OR sub-concuss*) W/3 (impact* OR
 932 blow*)) OR TITLE-ABS-KEY (("chronic traumatic encephalopath*" OR cte)) OR TITLE-ABS-
 933 KEY (neurodegenerative W/2 (disease* OR disorder*)))
 934 AND
 935 (((SRCTITLE (sport*) OR TITLE-ABS-KEY (athlete* OR athletic* OR crew OR player* OR
 936 teammate* OR team-mate* OR varsity OR sport*) OR TITLE-ABS-KEY ((return* OR resum* OR
 937 "re-ent*" OR reent*) W/2 (play* OR competition* OR sport*)))) OR ((TITLE-ABS-
 938 KEY (baseball OR basketball OR biking OR bicycling* OR bmx OR boxing OR "bull rid*" OR bullrid*
 939 OR cheerleading OR "cheer leading" OR climbing OR cricket OR diving OR equestrian OR football OR
 940 golf OR gymnastics OR handball OR "horse* riding" OR hockey OR lacro) OR TITLE-ABS-
 941 KEY ("horse* riding" OR hockey OR lacrosse OR mountaineering OR netball OR "net ball" OR
 942 "racquet sport*" OR racquetball OR ringette OR "roller derb*" OR rollerskat* OR rodeo*) OR TITLE-
 943 ABS-KEY (rugby OR skateboard* OR skating OR skiing OR snowboard* OR "snow sport*" OR soccer
 944 OR softball OR squash OR swimming OR tennis OR "track and field" OR wrestling OR volleyball) OR
 945 TITLE-ABS-KEY (archery OR badminton OR bobsled* OR bobsleigh* OR canoe* OR "cross country"
 946 OR fencing OR kayak* OR luge OR rifle) OR TITLE-ABS-KEY (rowing OR sailing OR skeleton OR
 947 "ski jump*" OR sledding OR surfing OR trampolin* OR "water polo" OR "weight lifting" OR
 948 windsurfing OR yachting))) OR ((TITLE-ABS-KEY (aikido OR judo OR jiujitsu OR "jiu-jitsu" OR
 949 jujitsu OR "ju jitsu" OR karate OR kickbox* OR "Martial art*" OR taekwondo OR "tae kwon do" OR "tai
 950 ji") OR TITLE-ABS-KEY (capoeira OR "Dim mak" OR kenpo OR "kung fu" OR "pencak silat" OR
 951 pitfight* OR savate OR "submission fight*" OR ufc OR "ultimate fighting champion*") OR TITLE-
 952 ABS-KEY (biker* OR boxer* OR "cheer leader*" OR cheerleader* OR climber* OR cyclist* OR diver
 953 OR divers OR fencer* OR fighter* OR footballer* OR goalie*) OR TITLE-ABS-KEY (golfer* OR
 954 gymnast OR gymnasts OR "horse* rider*" OR jockey* OR judoka* OR mountaineer* OR rower* OR
 955 sailor* OR skater* OR skier* OR sledder* OR snowboarder* OR surfer* OR swimmer* OR "weight
 956 lifter*" OR wrestler*)))))
 957 AND
 958 (((TITLE-ABS-KEY (((cognitive OR memory OR executive) W/2 (impair* OR abnormal* OR
 959 dysfunction* OR deficit* OR disorder* OR disabilit* OR decline OR disturbance* OR deteriorat* OR
 960 decrement* OR sequela*))) OR TITLE-ABS-KEY (((drug* OR alcohol* OR substance) W/2
 961 (dependen* OR abuse OR disorder*))) OR TITLE-ABS-KEY (((psychiatric OR mental* OR
 962 psychological) W/2 (illness OR impair* OR abnormal* OR dysfunction* OR deficit* OR decline OR
 963 deteriorat*))))) OR (TITLE-ABS-KEY (((neuropsychological OR neurophysiological OR
 964 neuropsychiatric OR neurocognitive) W/2 (impair* OR abnormal* OR dysfunction* OR decline OR
 965 disturbance* OR deteriorat*)))) OR (TITLE-ABS-KEY ((depress* OR suicide OR suicidal OR
 966 aggression OR aggressive OR anger OR angry OR rage OR anxiety OR "mood disorder*" OR
 967 psychos?s))) OR (TITLE-ABS-KEY (((chronic OR persistent) W/2 headache*))) OR ((TITLE-
 968 ABS-KEY ("chronic traumatic encephalopath*" OR cte OR "traumatic encephalopath*" OR "dementia
 969 pugilistica" OR "punch drunk" OR alzheimer* OR "amyotrophic lateral sclerosis" OR als OR
 970 parkinson*) OR TITLE-ABS-KEY (hypopituitarism OR seizure* OR "white matter" OR taupath* OR
 971 tau OR tap-43 OR "septum pellucid*") OR TITLE-ABS-KEY (((neurodegenerative OR
 972 neurobehavioral OR neurobehavioural) W/2 (disorder* OR disease*))))) OR (TITLE-ABS-
 973 KEY (("motor neuron" W/1 (disease* OR disorder*)))) OR (TITLE-ABS-KEY (((endocrine OR

974 hormon* OR metabolic) W/2 dysfunction)) OR (TITLE-ABS-KEY ((cortical W/2 (thick* OR
975 thin*)))) OR (TITLE-ABS-KEY ((longterm OR "long term" OR permanent OR cumulative OR
976 chronic OR residual) W/2 (consequences OR effects OR outcome* OR sequela* OR prognosis OR
977 damage*)))) AND NOT DBCOLL (medl) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-
978 TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR
979 LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR ,
980 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-
981 TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR
982 LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR ,
983 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-
984 TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR
985 LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001)) AND (LIMIT-
986 TO (LANGUAGE , "English"))
987 Note: Excluded Medline records, limited by date and English
988 **Web of Science as searched March 25, 2022**
989 ((concussion* OR concussed OR concussive OR subconcuss* OR sub-concuss*) OR (post-concuss* OR
990 postconcuss*) OR (mild NEAR/3 ("traumatic brain injur*" OR tbi*) OR (head NEAR/2 (injur* OR
991 impact* OR trauma*)) OR ("traumatic brain injur*" OR tbi* OR mtbi* OR neurotrauma* OR "neuro-
992 trauma*") OR (craniocerebral NEAR/2 (trauma* OR Injur*)) OR ((repetitive * OR multiple * OR
993 cumulative) W/3 ("head injur*" * OR "head impact*" * OR concussion* * OR "head trauma")) OR ((
994 subconcuss* * OR sub-concuss*) W/3 (impact* * OR blow*)) OR ("chronic traumatic
995 encephalopath*" * OR CTE) OR (neurodegenerative NEAR/2 (disease* * OR disorder*))
996
997 **AND**
998
999 ((sport*) OR (athlete* OR athletic* OR crew OR player* OR teammate* OR team-mate* OR varsity OR
1000 sport*) OR ((return* OR resum* OR "re-ent*" OR reent*) NEAR/2 (play* OR competition* OR sport*))
1001 OR (baseball OR basketball OR biking OR bicycling* OR bmx OR boxing OR "bull rid*" OR bullrid*
1002 OR cheerleading OR "cheer leading" OR climbing OR cricket OR diving OR equestrian OR football OR
1003 golf OR gymnastics OR handball OR "horse* riding" OR hockey OR lacrosse OR mountaineering OR
1004 netball OR "net ball" OR "racquet sport*" OR racquetball OR ringette OR "roller derb*" OR rollerskat*
1005 OR rodeo* OR rugby OR skateboard* OR skating OR skiing OR snowboard* OR "snow sport*" OR
1006 soccer OR softball OR squash OR swimming OR tennis OR "track and field" OR wrestling OR
1007 volleyball OR archery OR badminton OR bobsled* OR bobsleigh* OR canoe* OR "cross country" OR
1008 fencing OR kayak* OR luge OR rifle OR rowing OR sailing OR skeleton OR "ski jump*" OR sledding
1009 OR surfing OR trampoline* OR "water polo" OR "weight lifting" OR windsurfing OR yachting) OR
1010 (aikido OR judo OR jujitsu OR "jiu-jitsu" OR jujitsu OR "ju jitsu" OR karate OR kickbox* OR "Martial
1011 art*" OR taekwondo OR "tae kwon do" OR "tai ji") OR (capoeira OR "Dim mak" OR kenpo OR "kung
1012 fu" OR "pencak silat" OR pitfight* OR savate OR "submission fight*" OR ufc OR "ultimate fighting
1013 champion*") OR (biker* OR boxer* OR "cheer leader*" OR cheerleader* OR climber* OR cyclist* OR
1014 diver OR divers OR fencer* OR fighter* OR footballer* OR goalie* OR golfer* OR gymnast OR
1015 gymnasts OR "horse* rider*" OR jockey* OR judoka* OR mountaineer* OR rower* OR sailor* OR
1016 skater* OR skier* OR sledder* OR snowboarder* OR surfer* OR swimmer* OR "weight lifter*" OR
1017 wrestler*))
1018 **AND**
1019 (longterm OR "long term" OR permanent OR cumulative OR chronic OR residual) NEAR/2 (consequences OR
1020 effects OR outcome* OR sequela* OR prognosis OR damage*) OR (cortical NEAR/2 (thick* OR thin*)) OR
1021 ("white matter" OR taupath* OR tau OR "tap-43" OR "septum pellucid*") OR seizure* OR ((endocrine OR
1022 hormon* OR metabolic) NEAR/2 dysfunction) OR hypopituitarism OR (("motor neuron") NEAR/1
1023 (disease* OR disorder*)) OR (alzheimer* OR "amyotrophic lateral sclerosis" OR ALS OR parkinson*) OR
1024 ("dementia pugilistica" OR "punch drunk") OR ((neurodegenerative OR neurobehavioral OR

1025 neurobehavioural) NEAR/2 (disorder* or disease*) OR (“chronic traumatic encephalopath*” or CTE or
1026 “traumatic encephalopath*”) OR ((chronic or persistent) NEAR/2 headache*) OR (“mood disorder*” or
1027 psychosis or psychoses) OR (depress* or suicide or suicidal or aggression or aggressive or anger or angry
1028 or rage or anxiety) OR ((neuropsychological or neurophysiological or neuropsychiatric or neurocognitive)
1029 NEAR/2 (impair* or abnormal* or dysfunction* or decline or disturbance* or deteriorat*)) OR ((drug* or
1030 alcohol* or substance) NEAR/2 (dependen* or abuse or disorder*)) OR ((cognitive or memory or
1031 executive) NEAR/2 (impair* or abnormal* or dysfunction* or deficit* or disorder* or disabilit* or decline
1032 or disturbance* or deteriorat* or decrement* or sequela*))

1033

1034 Limited to 2001 – 2022

1035

English

1036

1037

1038 Appendix B. References²

1039

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² This reference list is larger than the list in the published article because this supplement includes a more comprehensive review of the literature on chronic traumatic encephalopathy neuropathologic change and traumatic encephalopathy syndrome.

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