Chobanian & Avedisian School of Medicine

CONCUSSION & CTE FOUNDATION

Chronic Traumatic Encephalopathy Fact Sheet

What is CTE?

1. CTE is a neurodegenerative disease characterized by a unique pattern of abnormal tau deposition in the brain.[1]

2. CTE appears to be progressive in most cases, with tau continuing to accumulate and spread after head impacts stop.[2]

What causes CTE?

3. According to the National Institutes of Health, CTE is a delayed neurodegenerative disorder that research to date suggests is caused in part by repeated traumatic brain injuries.[3]

4. Repeated traumatic brain injuries can be caused by both concussion and nonconcussive head impacts.[4]

5. Current research suggests that CTE risk is related to the number and severity of head impacts sustained over a lifetime.[5]

How do we diagnose CTE?

6. CTE can be definitively diagnosed only postmortem by examining the brain.[6]

7. The NINDS/NIBIB CTE Diagnostic Criteria define CTE as low- and high-stage. In low-stage CTE, pathology is primarily limited to the cortex. In high-stage CTE, pathology is widely distributed throughout the hippocampus, amygdala, entorhinal cortex, thalamus, and brainstem. [7]

How common is CTE?

8. CTE is rarely seen in the general population. All studies with n > 100 published to date have reported a range of 0% to 2.8%. [8] [9] [10] [11] [12] [13] [14]

9. Because CTE cannot be diagnosed during life, it is unknown how many athletes have CTE. One study suggests that at least 10% of individuals who have played in the National Football League (NFL) die with CTE.[15]

Updated January 20, 2026

Who is at risk for CTE?

10. CTE has been now diagnosed in contact and collision sports athletes who participated in football, ice hockey, soccer, boxing, rugby union, boxing, Australian Rules Football, mixed martial arts, lacrosse, amateur wrestling, some extreme sports, and bull riding/rodeo. [16] [17] [18] [19]
11. CTE has been diagnosed in non-athletes exposed to repetitive head impacts, including military veterans, victims of interpersonal violence, stuntpersons, individuals with uncontrolled epilepsy, and individuals with neurodevelopmental abnormalities who engaged in repetitive head banging behavior. [20]

12. While there may be additional causes of CTE beyond RHI, evidence is limited. As of 2023, there are only 16 cases in the scientific literature claiming to have diagnosed CTE in the absence of RHI. In 6 of those cases (Bieniek 2020), families were not contacted for sports participation history, and for an additional 5 (Iverson 2019), sport participation was not properly queried, and the lead authors of the CTE diagnostic criteria have asserted ARTAG was misdiagnosed as CTE.[21] [22]

13. A single concussion in the absence of additional head impacts has not been consistently shown to be a risk factor for CTE. [23] Most individuals diagnosed with CTE were exposed to more than 1,000 head impacts over their lifetime. [24]

14. The youngest athlete diagnosed with CTE was 17 years old when he died.[25]

What are symptoms of CTE?

15. Severe CTE, in the absence of any other degenerative brain disease, is associated with a 4x increased odds of a clinical diagnosis of dementia.[26]

16. Current evidence suggests that CTE can cause cognitive, functional, and certain neurobehavioral symptoms.[27]

17. CTE has been associated with probable rapid eye movement (REM) sleep behavior disorder.[28]

18. One out four individuals diagnosed with CTE developed Parkinsonism.[29]

19. In younger individuals at risk for CTE, it is unclear if presenting symptoms are related to CTE, other types of brain damage from RHI, or unrelated. [30]

How can CTE be prevented?

20. Research suggests a reduction in the number and strength of head impacts could reduce the odds of developing CTE.[31]

21. Most individuals diagnosed with CTE were exposed to repetitive head impacts through participation in contact and collision sports. Other primary exposures include military service, interpersonal violence, brain diseases that cause frequent falls, falls secondary to epilepsy, ritualistic head-banging behaviors, and participation in specific types of entertainment in which head impacts can occur. [32]

22. In brain bank studies, the odds of having CTE have been shown to increase with each additional year of participation in football (30%), ice hockey (34%), and rugby (14%).[33] [34] [35]

23. The number of diagnosed or reported concussions does not predict the presence of CTE.[36]

24. While concussion management is important, there is no research that supports the hypothesis that improved concussion management might reduce the risk of developing CTE.

---

[1] Bieniek KF, Cairns NJ, Crary JF, Dickson DW, Folkerth RD, Keene CD, Litvan I, Perl DP, Stein TD, Vonsattel JP, Stewart W, Dams-O'Connor K, Gordon WA, Tripodis Y, Alvarez VE, Mez J, Alosco ML, McKee AC; TBI/CTE Research Group. The Second NINDS/NIBIB Consensus Meeting to Define Neuropathological Criteria for the Diagnosis of Chronic Traumatic Encephalopathy. J Neuropathol Exp Neurol. 2021 Feb 22;80(3):210-219. doi: 10.1093/jnen/nlab001. PMID: 33611507; PMCID: PMC7899277. https://pubmed.ncbi.nlm.nih.gov/33611507/

[2] Alosco ML, Cherry JD, Huber BR, Tripodis Y, Baucom Z, Kowall NW, Saltiel N, Goldstein LE, Katz DI, Dwyer B, Daneshvar DH, Palmisano JN, Martin B, Cantu RC, Stern RA, Alvarez VE, Mez J, Stein TD, McKee AC. Characterizing tau deposition in chronic traumatic encephalopathy (CTE): utility of the McKee CTE staging scheme. Acta Neuropathol. 2020 Oct;140(4):495-512. doi: 10.1007/s00401-020-02197-9. Epub 2020 Aug 11. PMID: 32778942; PMCID: PMC7914059. https://pubmed.ncbi.nlm.nih.gov/32778942/

[3] https://www.ninds.nih.gov/current-research/focus-disorders/focus-traumatic-brain-injury-research

[4] Nowinski CJ, Rhim HC, McKee AC, Zafonte RD, Dodick DW, Cantu RC, Daneshvar DH. 'Subconcussive' is a dangerous misnomer: hits of greater magnitude than concussive impacts may not cause symptoms. Br J Sports Med. 2024 Jul 1;58(14):754-756. doi: 10.1136/bjsports-2023-107413. PMID: 38719575; PMCID: PMC11228231. https://pubmed.ncbi.nlm.nih.gov/38719575/

[5] Daneshvar DH, Nair ES, Baucom ZH, Rasch A, Abdolmohammadi B, Uretsky M, Saltiel N, Shah A, Jarnagin J, Baugh CM, Martin BM, Palmisano JN, Cherry JD, Alvarez VE, Huber BR, Weuve J, Nowinski CJ, Cantu RC, Zafonte RD, Dwyer B, Crary JF, Goldstein LE, Kowall NW, Katz DI, Stern RA, Tripodis Y, Stein TD, McClean MD, Alosco ML, McKee AC, Mez J. Leveraging football accelerometer data to quantify associations between repetitive head impacts and chronic traumatic encephalopathy in males. Nat Commun. 2023 Jun 20;14(1):3470. doi: 10.1038/s41467-023-39183-0. PMID: 37340004; PMCID: PMC10281995. https://pubmed.ncbi.nlm.nih.gov/37340004/

[6] Bieniek KF, Cairns NJ, Crary JF, Dickson DW, Folkerth RD, Keene CD, Litvan I, Perl DP, Stein TD, Vonsattel JP, Stewart W, Dams-O'Connor K, Gordon WA, Tripodis Y, Alvarez VE, Mez J, Alosco ML, McKee AC; TBI/CTE

Research Group. The Second NINDS/NIBIB Consensus Meeting to Define Neuropathological Criteria for the Diagnosis of Chronic Traumatic Encephalopathy. J Neuropathol Exp Neurol. 2021 Feb 22;80(3):210-219. doi: 10.1093/jnen/nlab001. PMID: 33611507; PMCID: PMC7899277. https://pubmed.ncbi.nlm.nih.gov/33611507/

[7] Bieniek KF, Cairns NJ, Crary JF, Dickson DW, Folkerth RD, Keene CD, Litvan I, Perl DP, Stein TD, Vonsattel JP, Stewart W, Dams-O'Connor K, Gordon WA, Tripodis Y, Alvarez VE, Mez J, Alosco ML, McKee AC; TBI/CTE Research Group. The Second NINDS/NIBIB Consensus Meeting to Define Neuropathological Criteria for the Diagnosis of Chronic Traumatic Encephalopathy. J Neuropathol Exp Neurol. 2021 Feb 22;80(3):210-219. doi: 10.1093/jnen/nlab001. PMID: 33611507; PMCID: PMC7899277. https://pubmed.ncbi.nlm.nih.gov/33611507/

[8] Forrest SL, Kril JJ, Wagner S, Hönigschnabl S, Reiner A, Fischer P, Kovacs GG. Chronic Traumatic Encephalopathy (CTE) Is Absent From a European Community-Based Aging Cohort While Cortical Aging-Related Tau Astrogliopathy (ARTAG) Is Highly Prevalent. J Neuropathol Exp Neurol. 2019 May 1;78(5):398-405. doi: 10.1093/jnen/nlz017. PMID: 30939193. https://pubmed.ncbi.nlm.nih.gov/30939193/

[9] McCann H, Bahar AY, Burkhardt K, Gardner AJ, Halliday GM, Iverson GL, Shepherd CE. Prevalence of chronic traumatic encephalopathy in the Sydney Brain Bank. Brain Commun. 2022 Aug 1;4(4):fcac189. doi: 10.1093/braincomms/fcac189. PMID: 35950093; PMCID: PMC9356727. https://pubmed.ncbi.nlm.nih.gov/35950093/

[10] Adams JW, Alvarez VE, Mez J, Huber BR, Tripodis Y, Xia W, Meng G, Kubilus CA, Cormier K, Kiernan PT, Daneshvar DH, Chua AS, Svirsky S, Nicks R, Abdolmohammadi B, Evers L, Solomon TM, Cherry JD, Aytan N, Mahar I, Devine S, Auerbach S, Alosco ML, Nowinski CJ, Kowall NW, Goldstein LE, Dwyer B, Katz DI, Cantu RC, Stern RA, Au R, McKee AC, Stein TD. Lewy Body Pathology and Chronic Traumatic Encephalopathy Associated With Contact Sports. J Neuropathol Exp Neurol. 2018 Sep 1;77(9):757-768. doi: 10.1093/jnen/nly065. PMID: 30053297; PMCID: PMC6097837. https://pubmed.ncbi.nlm.nih.gov/30053297/

[11] Postupna N, Rose SE, Gibbons LE, Coleman NM, Hellstern LL, Ritchie K, Wilson AM, Cudaback E, Li X, Melief EJ, Beller AE, Miller JA, Nolan AL, Marshall DA, Walker R, Montine TJ, Larson EB, Crane PK, Ellenbogen RG, Lein ES, Dams-O'Connor K, Keene CD. The Delayed Neuropathological Consequences of Traumatic Brain Injury in a Community-Based Sample. Front Neurol. 2021 Mar 16;12:624696. doi: 10.3389/fneur.2021.624696. PMID: 33796061; PMCID: PMC8008107. https://pubmed.ncbi.nlm.nih.gov/33796061/

[12] Bieniek KF Blessing MM Heckman MG Diehl NN Serie AM Paolini MA et al . Association between contact sports participation and chronic traumatic encephalopathy: a retrospective cohort study. *Brain Pathol.* (2020) 30:63–74. 10.1111/bpa.12757 https://pmc.ncbi.nlm.nih.gov/articles/PMC6916416/

[13] Del Bigio MR, Krawitz S, Sinha N. Chronic traumatic encephalopathy-neuropathologic change in a routine neuropathology service: 7-year follow-up. J Neuropathol Exp Neurol. 2023 Oct 20;82(11):948-957. doi: 10.1093/jnen/nlad079. PMID: 37846159; PMCID: PMC10588000. https://pubmed.ncbi.nlm.nih.gov/37846159/

[14] Suter CM, Affleck AJ, Lee M, Davies D, Burns AL, Sy J, I'Ons B, Buckland ME. Chronic Traumatic Encephalopathy in a Routine Neuropathology Service in Australia. J Neuropathol Exp Neurol. 2022 Sep 19;81(10):790-795. doi: 10.1093/jnen/nlac071. PMID: 35947764; PMCID: PMC10622321. https://pubmed.ncbi.nlm.nih.gov/35947764/

[15] Binney ZO, Bachynski KE. Estimating the prevalence at death of CTE neuropathology among professional football players. Neurology. 2019 Jan 1;92(1):43-45. doi: 10.1212/WNL.0000000000006699. Epub 2018 Nov 28. PMID: 30487144.

[16] McKee AC, Stein TD, Huber BR, Crary JF, Bieniek K, Dickson D, Alvarez VE, Cherry JD, Farrell K, Butler M, Uretsky M, Abdolmohammadi B, Alosco ML, Tripodis Y, Mez J, Daneshvar DH. Chronic traumatic encephalopathy (CTE): criteria for neuropathological diagnosis and relationship to repetitive head impacts. Acta Neuropathol. 2023 Apr;145(4):371-394. doi: 10.1007/s00401-023-02540-w. Epub 2023 Feb 10. PMID: 36759368; PMCID: PMC10020327. https://link.springer.com/article/10.1007/s00401-023-02540-w

[17] McKee AC, Stern RA, Nowinski CJ, Stein TD, Alvarez VE, Daneshvar DH, Lee HS, Wojtowicz SM, Hall G, Baugh CM, Riley DO, Kubilus CA, Cormier KA, Jacobs MA, Martin BR, Abraham CR, Ikezu T, Reichard RR, Wolozin BL, Budson AE, Goldstein LE, Kowall NW, Cantu RC. The spectrum of disease in chronic traumatic

encephalopathy. Brain. 2013 Jan;136(Pt 1):43-64. doi: 10.1093/brain/aws307. Epub 2012 Dec 2. Erratum in: Brain. 2013 Oct;136(Pt 10):e255. PMID: 23208308; PMCID: PMC3624697. https://pubmed.ncbi.nlm.nih.gov/23208308/

[18] Suter CM, Affleck AJ, Lee M, Pearce AJ, Iles LE, Buckland ME. Chronic traumatic encephalopathy in Australia: the first three years of the Australian Sports Brain Bank. Med J Aust. 2022 Jun 6;216(10):530-531. doi: 10.5694/mja2.51420. Epub 2022 Feb 10. PMID: 35144312; PMCID: PMC9305557. https://pubmed.ncbi.nlm.nih.gov/35144312/

[19] Keene CD, Latimer CS, Steele LM, Mac Donald CL. First confirmed case of chronic traumatic encephalopathy in a professional bull rider. Acta Neuropathol. 2018 Feb;135(2):303-305. doi: 10.1007/s00401-017-1801-z. Epub 2017 Dec 28. PMID: 29285625; PMCID: PMC5773642. https://pmc.ncbi.nlm.nih.gov/articles/PMC5773642/

[20] McKee AC, Stein TD, Huber BR, Crary JF, Bieniek K, Dickson D, Alvarez VE, Cherry JD, Farrell K, Butler M, Uretsky M, Abdolmohammadi B, Alosco ML, Tripodis Y, Mez J, Daneshvar DH. Chronic traumatic encephalopathy (CTE): criteria for neuropathological diagnosis and relationship to repetitive head impacts. Acta Neuropathol. 2023 Apr;145(4):371-394. doi: 10.1007/s00401-023-02540-w. Epub 2023 Feb 10. PMID: 36759368; PMCID: PMC10020327. https://link.springer.com/article/10.1007/s00401-023-02540-w

[21] Iverson GL, Luoto TM, Karhunen PJ, Castellani RJ. Mild Chronic Traumatic Encephalopathy Neuropathology in People With No Known Participation in Contact Sports or History of Repetitive Neurotrauma. J Neuropathol Exp Neurol. 2019 Jul 1;78(7):615-625. doi: 10.1093/jnen/nlz045. PMID: 31169877; PMCID: PMC6581557.

[22] McKee AC, Stein TD, Crary JF, Bieniek KF, Cantu RC, Kovacs GG. Practical Considerations in the Diagnosis of Mild Chronic Traumatic Encephalopathy and Distinction From Age-Related Tau Astrogliopathy. J Neuropathol Exp Neurol. 2020 Aug 1;79(8):921-924. doi: 10.1093/jnen/nlaa047. PMID: 32688381; PMCID: PMC7395709.

[23] Bieniek KF, Ross OA, Cormier KA, Walton RL, Soto-Ortolaza A, Johnston AE, DeSaro P, Boylan KB, Graff-Radford NR, Wszolek ZK, Rademakers R, Boeve BF, McKee AC, Dickson DW. Chronic traumatic encephalopathy pathology in a neurodegenerative disorders brain bank. Acta Neuropathol. 2015 Dec;130(6):877-89. doi: 10.1007/s00401-015-1502-4. Epub 2015 Oct 30. PMID: 26518018; PMCID: PMC4655127. https://pubmed.ncbi.nlm.nih.gov/26518018/

[24] Daneshvar DH, Nair ES, Baucom ZH, Rasch A, Abdolmohammadi B, Uretsky M, Saltiel N, Shah A, Jarnagin J, Baugh CM, Martin BM, Palmisano JN, Cherry JD, Alvarez VE, Huber BR, Weuve J, Nowinski CJ, Cantu RC, Zafonte RD, Dwyer B, Crary JF, Goldstein LE, Kowall NW, Katz DI, Stern RA, Tripodis Y, Stein TD, McClean MD, Alosco ML, McKee AC, Mez J. Leveraging football accelerometer data to quantify associations between repetitive head impacts and chronic traumatic encephalopathy in males. Nat Commun. 2023 Jun 20;14(1):3470. doi: 10.1038/s41467-023-39183-0. PMID: 37340004; PMCID: PMC10281995. https://pubmed.ncbi.nlm.nih.gov/37340004/

[25] McKee AC, Mez J, Abdolmohammadi B, Butler M, Huber BR, Uretsky M, Babcock K, Cherry JD, Alvarez VE, Martin B, Tripodis Y, Palmisano JN, Cormier KA, Kubilus CA, Nicks R, Kirsch D, Mahar I, McHale L, Nowinski C, Cantu RC, Stern RA, Daneshvar D, Goldstein LE, Katz DI, Kowall NW, Dwyer B, Stein TD, Alosco ML. Neuropathologic and Clinical Findings in Young Contact Sport Athletes Exposed to Repetitive Head Impacts. JAMA Neurol. 2023 Oct 1;80(10):1037-1050. doi: 10.1001/jamaneurol.2023.2907. PMID: 37639244; PMCID: PMC10463175. https://pubmed.ncbi.nlm.nih.gov/37639244/

[26] Layden RM, Groh JR, Alosco ML et al. CTE Neuropathology Alone Associated with Dementia and Cognitive Symptoms. Alzheimer's & Dementia: The Journal of the Alzheimer's Association. In Press

[27] Alosco ML, White M, Bell C, Faheem F, Tripodis Y, Yhang E, Baucom Z, Martin B, Palmisano J, Dams-O'Connor K, Crary JF, Goldstein LE, Katz DI, Dwyer B, Daneshvar DH, Nowinski C, Cantu RC, Kowall NW, Stern RA, Alvarez VE, Huber BR, Stein TD, McKee AC, Mez J. Cognitive, functional, and neuropsychiatric correlates of regional tau pathology in autopsy-confirmed chronic traumatic encephalopathy. Mol Neurodegener. 2024 Feb 6;19(1):10. doi: 10.1186/s13024-023-00697-2. PMID: 38317248; PMCID: PMC10845638. https://pubmed.ncbi.nlm.nih.gov/38317248/

[28] Adams JW, Alosco ML, Mez J, Alvarez VE, Huber BR, Tripodis Y, Adler CH, Kubilius C, Cormier KA, Mathais R, Nicks R, Kelley HJ, Saltiel N, Uretsky M, Nair E, Aytan N, Cherry JD, Nowinski CJ, Kowall NW, Goldstein LE,

Dwyer B, Katz DI, Cantu RC, Stern RA, McKee AC, Stein TD. Association of probable REM sleep behavior disorder with pathology and years of contact sports play in chronic traumatic encephalopathy. Acta Neuropathol. 2020 Dec;140(6):851-862. doi: 10.1007/s00401-020-02206-x. Epub 2020 Sep 17. PMID: 32939646; PMCID: PMC7669574.

[29] Adams JW, Kirsch D, Calderazzo SM, Tuz-Zahra F, Tripodis Y, Mez J, Alosco ML, Alvarez VE, Huber BR, Kubilus C, Cormier KA, Nicks R, Uretsky M, Nair E, Kuzyk E, Aytan N, Cherry JD, Crary JF, Daneshvar DH, Nowinski CJ, Goldstein LE, Dwyer B, Katz DI, Cantu RC, Stern RA, McKee AC, Stein TD. Substantia Nigra Pathology, Contact Sports Play, and Parkinsonism in Chronic Traumatic Encephalopathy. JAMA Neurol. 2024 Sep 1;81(9):916-924. doi: 10.1001/jamaneurol.2024.2166. PMID: 39008284; PMCID: PMC11250391.

[30] McKee AC, Mez J, Abdolmohammadi B, Butler M, Huber BR, Uretsky M, Babcock K, Cherry JD, Alvarez VE, Martin B, Tripodis Y, Palmisano JN, Cormier KA, Kubilus CA, Nicks R, Kirsch D, Mahar I, McHale L, Nowinski C, Cantu RC, Stern RA, Daneshvar D, Goldstein LE, Katz DI, Kowall NW, Dwyer B, Stein TD, Alosco ML. Neuropathologic and Clinical Findings in Young Contact Sport Athletes Exposed to Repetitive Head Impacts. JAMA Neurol. 2023 Oct 1;80(10):1037-1050. doi: 10.1001/jamaneurol.2023.2907. PMID: 37639244; PMCID: PMC10463175.

[31] Daneshvar DH, Nair ES, Baucom ZH, Rasch A, Abdolmohammadi B, Uretsky M, Saltiel N, Shah A, Jarnagin J, Baugh CM, Martin BM, Palmisano JN, Cherry JD, Alvarez VE, Huber BR, Weuve J, Nowinski CJ, Cantu RC, Zafonte RD, Dwyer B, Crary JF, Goldstein LE, Kowall NW, Katz DI, Stern RA, Tripodis Y, Stein TD, McClean MD, Alosco ML, McKee AC, Mez J. Leveraging football accelerometer data to quantify associations between repetitive head impacts and chronic traumatic encephalopathy in males. Nat Commun. 2023 Jun 20;14(1):3470. doi: 10.1038/s41467-023-39183-0. PMID: 37340004; PMCID: PMC10281995. https://pubmed.ncbi.nlm.nih.gov/37340004/

[32] McKee AC, Stein TD, Huber BR, Crary JF, Bieniek K, Dickson D, Alvarez VE, Cherry JD, Farrell K, Butler M, Uretsky M, Abdolmohammadi B, Alosco ML, Tripodis Y, Mez J, Daneshvar DH. Chronic traumatic encephalopathy (CTE): criteria for neuropathological diagnosis and relationship to repetitive head impacts. Acta Neuropathol. 2023 Apr;145(4):371-394. doi: 10.1007/s00401-023-02540-w. Epub 2023 Feb 10. PMID: 36759368; PMCID: PMC10020327. https://link.springer.com/article/10.1007/s00401-023-02540-w

[33] Mez J, Daneshvar DH, Abdolmohammadi B, Chua AS, Alosco ML, Kiernan PT, Evers L, Marshall L, Martin BM, Palmisano JN, Nowinski CJ, Mahar I, Cherry JD, Alvarez VE, Dwyer B, Huber BR, Stein TD, Goldstein LE, Katz DI, Cantu RC, Au R, Kowall NW, Stern RA, McClean MD, Weuve J, Tripodis Y, McKee AC. Duration of American Football Play and Chronic Traumatic Encephalopathy. Ann Neurol. 2020 Jan;87(1):116-131. doi: 10.1002/ana.25611. Epub 2019 Nov 23. PMID: 31589352; PMCID: PMC6973077. https://pubmed.ncbi.nlm.nih.gov/31589352/

[34] Stewart W, Buckland ME, Abdolmohammadi B, Affleck AJ, Alvarez VE, Gilchrist S, Huber BR, Lee EB, Lyall DM, Nowinski CJ, Russell ER, Stein TD, Suter CM, McKee AC. Risk of chronic traumatic encephalopathy in rugby union is associated with length of playing career. Acta Neuropathol. 2023 Dec;146(6):829-832. doi: 10.1007/s00401-023-02644-3. Epub 2023 Oct 24. PMID: 37872234; PMCID: PMC10627955.

[35] bdolmohammadi B, Tuz-Zahra F, Uretsky M, Nicks R, Mosaheb S, Labonte J, Yhang E, Durape S, Martin B, Palmisano J, Nowinski C, Cherry JD, Alvarez VE, Huber BR, Dams-O'Connor K, Crary J, Dwyer B, Daneshvar DH, Goldstein LE, Au R, Katz DI, Kowall NW, Cantu RC, Stern RA, Alosco ML, Stein TD, Tripodis Y, McKee AC, Mez J. Duration of Ice Hockey Play and Chronic Traumatic Encephalopathy. JAMA Netw Open. 2024 Dec 2;7(12):e2449106. doi: 10.1001/jamanetworkopen.2024.49106. PMID: 39630446; PMCID: PMC11618473. https://pubmed.ncbi.nlm.nih.gov/39630446/

[36] Daneshvar DH, Nair ES, Baucom ZH, Rasch A, Abdolmohammadi B, Uretsky M, Saltiel N, Shah A, Jarnagin J, Baugh CM, Martin BM, Palmisano JN, Cherry JD, Alvarez VE, Huber BR, Weuve J, Nowinski CJ, Cantu RC, Zafonte RD, Dwyer B, Crary JF, Goldstein LE, Kowall NW, Katz DI, Stern RA, Tripodis Y, Stein TD, McClean MD, Alosco ML, McKee AC, Mez J. Leveraging football accelerometer data to quantify associations between repetitive head impacts and chronic traumatic encephalopathy in males. Nat Commun. 2023 Jun 20;14(1):3470. doi: 10.1038/s41467-023-39183-0. PMID: 37340004; PMCID: PMC10281995. https://pubmed.ncbi.nlm.nih.gov/37340004/