

Dementia pugilistica (DP) and Boxing Related Cranial Injuries

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Abstract

Background: The Center for Disease Control and Prevention estimates that 1.6 to 3.8 million of the traumatic brain injuries that occur annually in the United States are sports-related³. Epidemiological studies have suggested a link between cognitive decline in the later stages of adulthood and sports concussions received in earlier stages of adulthood. The repetitive head trauma resulting from the many blows a boxer receives in each match may put professional boxers at increased risk of *dementia pugilistica* (DP) in later life.

Purpose/objectives: A structured literature review was conducted for the purpose of assessing the relationship between boxing-related cranial injuries and dementia in later life.

Methods: The literature search was conducted using the Ovid SP database, using the keywords "concussion", "dementia", "pugilistica", "boxing", and "professional". The search was limited to English text and human research from 2009 to present.

Results: The initial literature search resulted in 15 relevant articles. After careful analysis, only 8 articles were deemed suitable for data extraction.

Conclusions: The evidence suggests that there may be a correlation between repetitive cranial injuries and dementia in boxers, however there is insufficient evidence to answer the research question. As a result, further research should be conducted to include the implementation of a more rigorous standardized set of diagnostic criteria.

Background

Approximately 1.4 million emergency department visits per year are for traumatic brain injuries, which has been thought to underlie a host of problems directly related to neuronal dysfunction or death^{1, 2}. Different types and severities of traumatic brain injuries (TBI) are differentially associated with several neurologic outcomes including seizures, Alzheimer's dementia (AD), parkinsonism, *Dementia pugilistica* (DP), multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), posttraumatic symptoms, ocular and visual disorders, and endocrine disorders². Data indicates that moderate and severe TBIs increase the risk of dementia between 2- and 4-fold³. The terms "punch-drunk" and "slug-nutty" state were first ascribed by Martland *et al.* in 1928 to describe a neurologic disorder that primarily affected boxers who were exposed to the cumulative effects of repetitive, subconcussive blows to the head^{5, 4, 1, 2}. This was successively labeled dementia pugilistica and currently chronic traumatic encephalopathy (CTE), which are a types of dementia associated with the high risk factors acquired from multiple mild TBIs, as experienced by professional boxers⁶. DP is a collection of neurological and neuropsychological symptoms believed to be a result of numerous concussive or subconcussive blows to the head and although most commonly reported in boxers, there have been reports in other sports⁶. DP symptoms emerge anywhere from 7 to 35 years after the beginning of a boxer's career, and manifestations of neurologic decline usually do not present until after a boxer's career has ended, and worsening may progress over decades^{6, 4}. TBI is perhaps the best established environmental risk factor for dementia. Prevalence is greater in males, individuals of low socioeconomic status, alcohol/drug abusers, and new research is suggesting a linkage with the APOE-ε4 allele³.

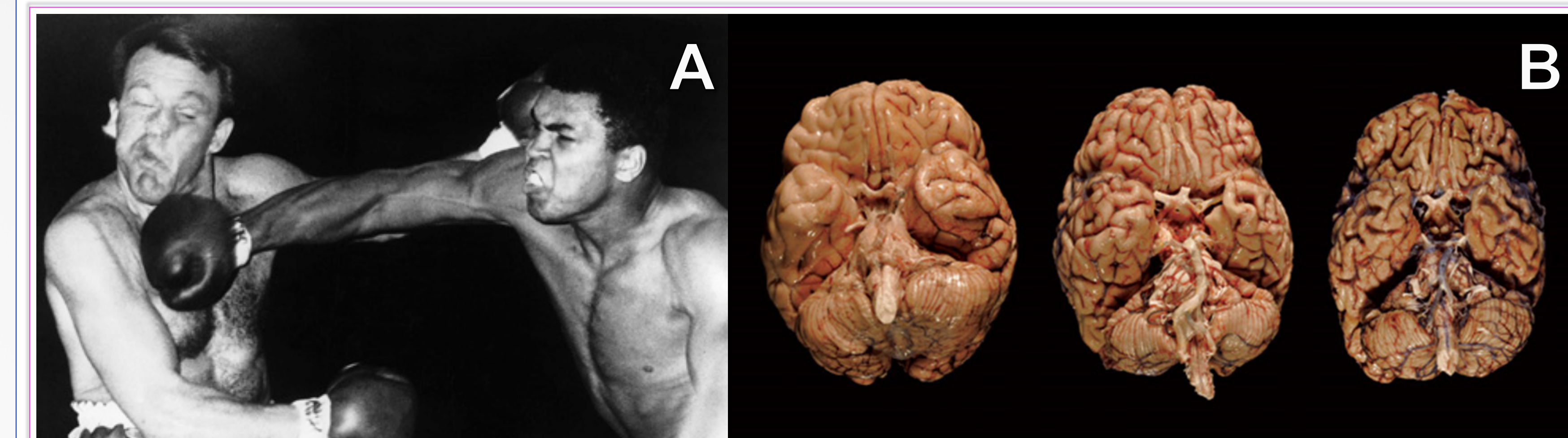


Figure 1A: Famous American professional boxer Muhammad Ali beating Brian London with a knockout punch in 1966⁸.

Figure 1B: Brain deterioration resulting from repetitive hits to the head⁹.

Research Question

Is there an established association or correlation between professional boxing-related cranial injuries and dementia within studies conducted in the past five years?

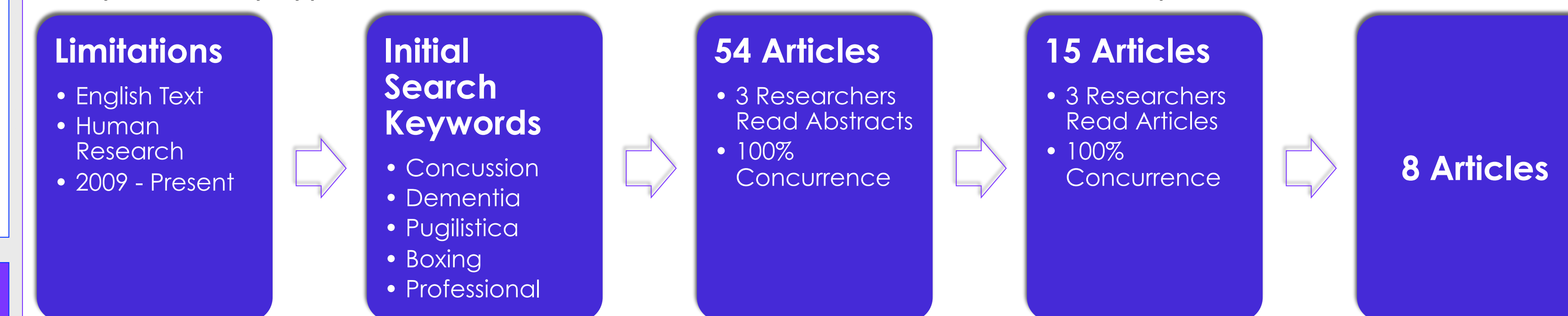
Methodology

➤ **Search Strategy:** A structured literature review was conducted to assess the possible relationship between boxing-related cranial injuries and *dementia pugilistica*. The literature search was conducted using the Medline Ovid SP database.

➤ **Inclusion Criteria:** Articles with human research containing the keywords "concussion", "dementia", "pugilistica", "boxing", and "professional".

➤ **Exclusion Criteria:** Articles published before 2009 were not included in the search and only articles with English text were chosen.

➤ **Analysis:** The abstracts of the resulting 54 articles were reviewed by three raters for relevance to the research question, with 100% concurrence. The resulting 15 articles were then reviewed by the raters for relevance, again with 100% concurrence. In total, 8 articles were included in the present study. All study types were included that were relevant to the research question.



Results

	CTE	AD
Clinical		
Short-term memory deficits early in the course	+	+++
Depression early in the course	+++	+
Abrupt mood swings and explosive rage	++	±
Substance abuse	++	-
Parkinsonism late in the course	+++	±
Suicidal behaviors	++	-
Pathologic		
Global cerebral atrophy	±	++
Fenestrated cavum septum pellucidum	+	-
Neuritic plaques and β-amyloid deposits	±	+++
Neurofibrillary tangles in the neocortex	+++	+++
	Predominant layers II and III	Predominant layers V and VI
Neurofibrillary tangles in the hippocampus and parahippocampal gyrus	+++	+++
	All sections of the Ammon horn	Predominantly in CA1
Neurofibrillary tangles in the substantia nigra and locus ceruleus	++	±
Neurofibrillary tangles surrounding small blood vessels	+++	-

Table 1: Association between *dementia pugilistica* (DP) and boxing related cranial injuries. Summary of studies reviewed in literature review and findings of the presence of an association between boxing and dementia. Upon analysis, an association was evident in seven out of eight articles.

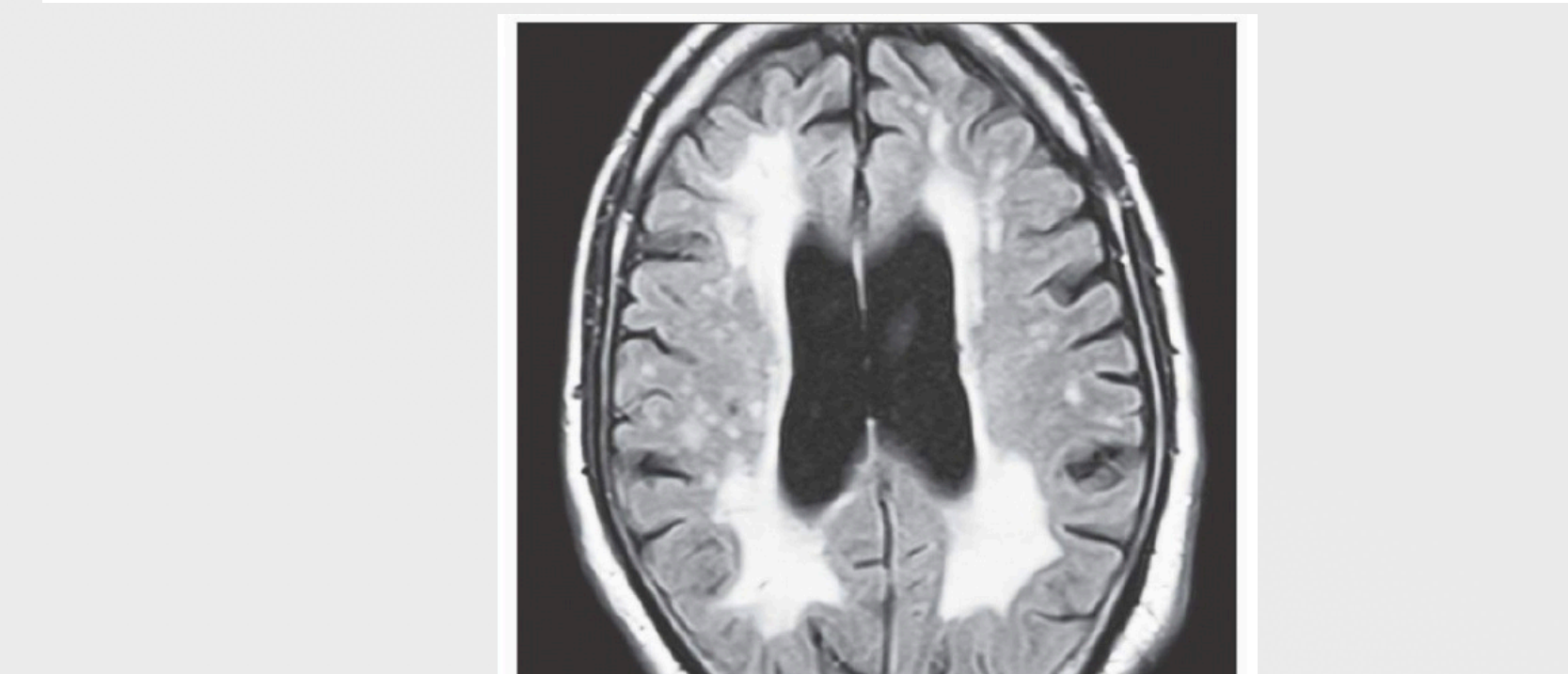


Figure 2: Axial FLAIR (Fluid Attenuated Inversion Recovery) scan in a middle-aged former professional athlete with early-onset dementia. This magnetic resonance imaging shows diffuse bihemispheric volume loss, confluent and punctuate white matter hyperintensities¹¹.

- Anderson *et al.* found that 16.67% of concussions were classified as mild, 54.76% were moderate and 28.57% were classified as severe⁵.
- Another study revealed that 10-18% of mild concussion cases, 25% of moderate cases and 33% of severe cases developed dementia-like symptoms².
- A retrospective study revealed that 29% of dementia patients reported a history of TBI, when compared to only 3% in the control group⁵.

Discussion

➤ Results from multiple studies provide data to indicate a link between suffering multiple concussions, regardless of severity, and the development of dementia or dementia-like symptoms. Despite certain studies proposing that concussions induce early-onset of dementia, these results could not be found to be replicable in other studies.

➤ The results of this literature review are not surprising because the study findings have been replicated in a variety of other contact sports. Though the skull is naturally designed to protect the brain, it is not built to withstand multiple hard impacts to the head¹⁰.

➤ Although analysis methods for the degree of injury in each study varied, they all came to the same result.

➤ Based on the results and regarding policy implications, there may be a need in modifying regulations to minimize the opportunities for injuries. Safeguards such as mandatory resting and specialized protective gear for the head should be considered.

➤ An outstanding finding was the APOE-ε4 gene, which predisposes an individual to a higher risk of developing dementia pugilistica. The presence of this gene creates a confounding effect as most of the studies utilized qualitative methods that analyzed cases and controls and disregarded genetic history.

➤ Ethical considerations for boxers include pre-test scanning for the gene of APOE-ε4 to assess if there is a heightened risk of contracting DP.

Bias And Limitations:

➤ The literature search was limited to only English text articles from the Medline OVID SP search engine, therefore other supporting or opposing articles were ultimately not factored into the conclusion of the findings. Furthermore, there appears to be an absence of a standardized study measure in assessing TBIs which may have varied the findings from article to article. Among all the possible literature to assess, grey literature were omitted due to the difficulty in acquiring them within the time constraint.

➤ The term "Traumatic Brain Injuries" or "TBI" had multiple synonyms such as Dementia Pugilistica, and Chronic Traumatic Encephalopathy (CTE). Since the literature search was confined to "dementia" and "pugilistica", some instances of CTE may have been omitted due to the changing of terms throughout time. "Pugilistica" was in fact, the older term used to define TBIs, but was utilized as such to address literature searches conducted by each paper. The variation in terminology could present a source of information bias in our search strategy.

➤ Although samples were chosen on the basis of having TBI, each article addressed different confounding factors or failed to address extraneous factors that may have caused bias in selecting the samples.

Conclusions And Future Direction

➤ The evidence strongly suggests that there is indeed an association between cranial injuries and dementia, but the limitations within all the studies makes it impossible to reach a definitive conclusion. Therefore, the insufficient data is unable to answer the research question. This indicates that to establish correlation, future work should be conducted to include more recent high quality experimental studies as well as the review of grey literature.

➤ Moreover, since all the studies reviewed were biased and limited, guidelines should be established to standardize diagnostic criteria and measurements within studies. For future studies to achieve statistically significant results, the use of larger sample sizes in longitudinal prospective studies are required as well as more comprehensive procedures for analyzing patients. The appearance of a strong correlation gives rise to implications for reassessing regulations and improving the safety of boxers and other contact sports.

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