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Amateur boxing and dementia:

Cognitive impairment within the 35-year Caerphilly cohort study

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Acknowledgements

The Caerphilly Prospective Study was conducted by the former MRC Epidemiology Unit (South Wales). The Caerphilly archive is now held in the School of Social and Community Medicine in Bristol University and we thank Professor Yoav Ben Shlomo who maintains the archive. We thank the Medical Research Information service of the National Health Service Information Centre for helping us maintain long term follow-up with the cohort. We most sincerely thank all the men who gave their time to be participants in the study.

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ABSTRACT:

Objective: To examine the long-term effects of amateur boxing in a representative population sample of men.

Design: The sample was examined every 5 years for 35 years. Cognition was assessed repeatedly from the third examination. Previous boxing experience and dementia were assessed at the 5th examination and dementia assessed subsequently through medical records.

Setting: The Caerphilly Prospective Study investigates risk factors for a range of chronic disease of disease. These include life-style and behaviour, together with biological factors relevant to vascular disease.

Subjects: 1,123 adult males aged 45-59 years at baseline, followed for 35 years.

Main outcome measures: cognitive impairment.

Results: Having boxed was associated with a two-fold increase in cognitive impairment (Odds ratio=2.27; 95%CI=1.18-4.38). For amnestic (Alzheimer-like) impairment this rises to OR=2.78 (95% confidence limits 1.37-5.65). Having boxed is associated with an 'advancement' in the onset of the dementia (4.8 years; 95% confidence limits 0.9 to 8.8 years).

Conclusions: Amateur boxing is associated with an increased risk and an earlier onset of cognitive impairment and dementia.

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Key words: Amateur boxing; head injury; vascular disease, cognitive impairment; dementia

INTRODUCTION:

Boxing is a popular sport and used to be seen by many in Wales as a means to rise above the poverty of everyday life. The popularity of the sport has been enhanced by a large number of professional boxers from Wales, amongst whom there have been twelve World Champions and forty-four British champions. Indeed, despite the more recent popularity of rugby in Wales boxing seems still to be integral to regional culture within the province of Wales.

Boxing involves the potential for repeated head trauma which may increase risk of traumatic brain injury, and possibly subsequent and earlier onset dementia.[1] The opportunity was therefore taken in a study of a representative sample of middle-aged men in a typical Welsh town, to study the long-term effects of amateur boxing.

Professional boxers have a risk of developing chronic neurological and physical brain damage, formerly referred to as 'punch drunk' and later 'dementia pugilistica'.[2] Over the years the introduction of increasingly tight control of the amateur sport, with shorter bouts and mandatory headgear means that the chance of serious chronic traumatic brain injury is likely now to be much reduced in amateur boxing.[3] Yet amongst amateur boxers there are still claims of early traumatic brain injury, [4,5] though many studies fail to detect such evidence.[6,7] Most of the published studies were however short-term and whether or not there are clinically measurable long-term brain injury occurs in amateur boxers is uncertain.[7]

The purpose of the present study is to address the question of whether amateur boxing has long term cognitive impact.

METHODS:

The Caerphilly Cohort study began in 1979.[8] Men aged 45-59 years, living in the town of Caerphilly and the surrounding villages in South Wales UK were invited to cooperate in a long-term study of health and disease. Caerphilly was chosen for the study because the distributions of social class and other democratic measures of the community were closely similar to those of the UK. Sustained efforts were made at base-line and throughout the duration of the study to recruit and to maintain a representative population sample of men. Consent was obtained for repeated examination and access to general practice and hospital records.

Extensive social and medical data were collected at baseline (Phase I), and the men were re-questioned and re-examined every five years for the following 35 years. A battery of tests of cognitive function was introduced at the third examination and repeated at the fourth, fifth and seventh examinations. These tested a range of functions and skills including language, praxis, perception, memory, attention, and orientation. The tests and the methods of their administration to the men are described elsewhere.[9] Also at the fifth examination, when the survivors were aged 65-79 years, previous head injury and boxing experience was investigated using the following questions:

> When you were younger did you ever box seriously as a sport?
> Have you ever had a head injury that was severe enough to result in loss of consciousness?
> Have you ever been admitted to hospital due to head injury?

The cognitive tests administered at the seventh examination, when the sample was aged 75-89 years, were used to identify men with cognitive impairment, indicated by either a low score, or a declining score since earlier cognitive tests. Low test scores were used to select for a clinical assessment of dementia by a specialist geriatrician and a neurologist. The clinicians were blinded to boxing status. The assessment of cognitive impairment involved the use of a range of questionnaires and tests which attempted to discern between vascular and non-vascular dementia, and between vascular and non-vascular CIND (cognitive impairment not dementia). In what follows we refer to non-vascular impairment as amnestic or 'Alzheimer's like'. Alzheimer's like CIND may be understood to indicate early stage Alzheimer's disease. Full details of the tests and the diagnostic procedures have been reported elsewhere.[10]

Statistical methods

Odds ratios for the three outcomes: CIND, dementia, and impairment (CIND or dementia) according to boxing or head injury status were obtained by logistic regression using STATA 16. Adjustments were made for confounding using age, BMI, smoking, pre-existing vascular disease, hypertension, diabetes, social class and alcohol consumption due to their known relationships with the outcomes.

Further adjustments were made to allow for differences in pre-morbid cognitive ability, and early cognitive decline. Pre-morbid cognitive ability was assessed using the results of the National Adult Reading Test (NART)[11] completed by the men 10 years earlier before the clinical assessment. Early cognitive decline was used to adjust for the effects of reverse causation and was assessed using the Camcog questionnaire.

The 'rate advancement' of cognitive impairment and of dementia were also estimated, that is: the difference in age at which a disease or functional outcome appears in a selected group of subjects. For this we used the method devised by Brenner et al (1993).[12]

RESULTS:

At baseline, the enumerated population of men aged 45-59 years in Caerphilly and the surrounding villages was 2,828 of whom 2,517 (89%), consented to join the study. Ethical approval for each examination was obtained from the local (later South East Wales) NHS Ethics Board. Participants were examined at base-line and every five-years thereafter.

Data for this report were obtained from 1123 of the men who were examined, and whose medical records were examined for dementia at ages of 75 years and above. Of these 73 reported boxing seriously when younger, 125 reported loss of consciousness die to head injury and 101 reported being admitted to hospital due to head injury. Of these 196 men reported any one of these sources of head injury.

Table 1 describes the sample. There were slight differences according to boxing status for age, BMI, alcohol consumption, vascular disease, smoking, social class. However only for pre-morbid cognitive ability was the difference statistically significant with 'boxers' showing lower ability scores (p=0.002).

Table 2 shows the data on cognitive impairment according to boxing, loss of consciousness, admission to hospital, and any head injury. Boxing is associated with any impairment (p=0.002), CIND (p=0.003) and Alzheimer's like CIND (p=0.002). Loss of consciousness due to head injury was not associated with impairment. In general, hospitalisation due to head injury was not associated with impairment, although an exception was with vascular dementia (p=0.038). Associations with any head injury reflected those just described. These associations were used to inform more detailed analyses, focussing on boxing, and on any head injury as a surrogate for head injury in general.

Table 3 shows the logistic regression of each outcome on boxing or any head injury. Model 1 adjusts for covariates that are known to affect cognition in later life. Model 2 further adjusts for cognitive confounders using pre-morbid cognitive ability [11] to adjust for differences in cognition prior to boxing and early decline to adjust for differences in cognition due to reverse causation i.e. cognitive decline affecting likelihood of boxing.

In these analyses boxing remain strongly associated with any impairment (model 1: OR=2.21, p=0.009) and CIND (model 1: OR=2.38, p=0.007), these association being largely driven by the association with amnestic CIND (OR=2.68, p=0.003). Any head injury is less strongly associated with any impairment or CIND, but the association with vascular dementia is retained (Model 1: OR=3.17, p=0.035). Further adjustment for premorbid cognitive ability and early cognitive decline does not materially affect the odd's ratios although formal levels of statistical significance are reduced.

Our assessment of the earlier commencement of impairment (rate advancement[12]) in the men who had boxed was 3.5 years (95% CI 2.6 to 4.4) for cognitive impairment and 4.8 years (0.9 to 8.8 years) for amnestic (Alzheimer-like) dementia. The advancements in the men who had not boxed but had had a head injury with loss of consciousness were much smaller and non-significant: 2.0 years (95% CI -0.5 to 4.5 years for cognitive impairment and 2.8 years (95% CI -0.1 to 5.8) years for dementia.

DISCUSSION:

There is a considerable literature on head injury, and its sequelae, both short and long-term, but relatively little of the available evidence is focused on amateur boxing alone. While boxing includes the sustaining and the inflicting of repeated head injury, the training and the conduct of this sport have changed considerably since the 1950s when the men followed in this study will have boxed.[4] In particular, there is evidence of a dramatic decrease in the most serious head injuries, including subdural hematoma, due to changes in rules and closer supervision in amateur boxing.[13]

Perhaps the most important report on head injury in boxers appears to be a paper published in 2007.[7] This describes a systematic review of 36 cohort and case studies which had been identified through the use of the search term 'boxing'. After omission of reports describing professional boxers and including only studies with a follow-up of at least one year, the author reported: 'There is no strong evidence to associate chronic traumatic head injury with amateur boxing.' The use of the word 'chronic' is perhaps unfortunate in this statement because later in the paper the author admits: 'Whether clinically measurable long-term brain injury occurs is a different and more important question'.[7]

The results we present are from a representative population sample of 1,123 men in Wales who were followed for 35-years. About 6.5% of these men stated that they had boxed seriously as a sport when younger. When they were aged 75-89 years, one third of those who had boxed showed evidence of cognitive impairment, compared with about one fifth of the men who had not boxed. When corrected for confounding by relevant factors, including early cognitive ability, there was a significant two-fold difference in cognitive impairment, driven largely by a near three-fold (OR=2.78) increase in Alzheimer's-like CIND. That the amnestic CIND finding was not detected for Alzheimer like dementia is not surprising given the small number of men who boxed. However, Alzheimer's disease is a progressive condition and those who are correctly diagnosed with early stage Alzheimer's disease will develop dementia.

As the focus of the analysis is on boxing prior to recruitment to the study, whether adjusting for early decline and pre-morbid ability post-boxing is over adjustment i.e. removing a potential effect of boxing, is moot. Both models are presented. Of interest is that boxing remained a strong predictor of impairment independent of any early effects. This confirms the importance of long-term follow-up in studies of head injury.

The onset of dementia was almost five years earlier in the men who had boxed, compared with those who had not participated in the sport provides a tangible metric of impact that can be readily understood in the community. A similar advanced onset of Alzheimer's

disease of eight years was also shown in a population study of patients whose hospital records showed that they had had a prior traumatic brain injury.[14]

Perhaps surprisingly, there is no evidence of any association with vascular dementia for boxing. This however was the expectation expressed by a number of authors.[15-17] Franzblau et al[18] however hypothesize that vessel damage in head injury may be a major pathway between head injury and Alzheimer's disease, the injury causing damage to vascular integrity, facilitating the formation of plaques. Anything that increases cerebral blood flow may therefore be helpful in reducing plaque formation.

The strengths of our study include the fact that it is based on a representative population sample, and the measurement of the outcomes was long after the boxing had taken place. While the inclusion of 'serious' in the question about boxing is somewhat vague, it certainly will have eliminated men who toyed casually with the sport, and although the identification of men who had boxed was retrospective, serious boxing is not a sport which is likely to have been forgotten. A further strength of our study is the wealth of evidence on possible confounding factors available for the subjects in this study, many of which have been incorporated in the analyses.

On the other hand, a major limitation is the small numbers of 'serious' boxers – only 73 men. However, population-based long-term follow-up of amateur boxers is rare. These data provide some of the best evidence available on the cognitive impact of amateur boxing. Nevertheless, an unfortunate limitation in the study is that potential psycho-social benefits of engaging in an organised sport such as boxing were not measured.

Conclusions:

Participation in amateur boxing is associated with clinically measurable long-term brain injury, manifested as earlier onset Alzheimer's like impairment.

What is already known on the topic

Professional boxing is known to cause chronic traumatic brain injury. There is controversy in the literature as to whether or not amateur boxing is associated with long-term brain injury.

What the study adds

Estimates of long-term Alzheimer's like impaimentive impairment, and Alzheimers-like dementia following serious involvement in amateur boxing, in a representative population sample of men.

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Authors contributions

The idea was suggested by PCE; the Caerphilly Study was led by PCE and JG. LH collected many of the survey data, the cognitive assessments and the diagnoses were by JG and AB, JP and JG conducted statistical analyses, LH, GM and AW helped write the report.

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Table 1: population sample according to boxing status

variable	Boxers (n=73)	Non boxers (n=1049)	p
Age (years) : mean (SD)	56.4 (4.2)	56.6 (4.3)	0.39
BMI: mean (SD)	27.8 (3.8)	26.6 (3.3)	0.99
NART[1] score: mean (SD)	23.3 (12.7)	27.4 (11.7)	0.002
Alcohol consumption (g/wk): (%>27g/wk)	14 (21%)	179 (18%)	0.55
Previous vascular disease: (% positive)	3 (4%)	61 (6%)	0.55
Social class: (% manual)	46 (68%)	601 (60%)	0.19
Smoking (% never smoked)	20 (29%)	239 (24%)	0.29

1. National Adult Reading Test[11]

Table 2: Cognitive outcomes according to report of boxing or head injury

Cognitive Impairment	Boxing			Loss of consciousness			Hospitalisation			Any head injury		
	Yes (n=73)	No (n=1037)	p	Yes (n=125)	No (n=985)	p	Yes (n=101)	No (n=1009)	p	Yes (n=196)	No (n=914)	p
Any impairment	24 (33%)	189 (18%)	0.002	26 (21%)	187 (19%)	0.6	24 (24%)	189 (19%)	0.2	50 (26)	163 (18%)	0.013
Dementia	5 (9%)	47 (5%)	0.2	7 (7%)	45 (5%)	0.6	7 (8%)	45 (5%)	0.2	13 (8)	39 (4%)	0.1
Vascular dementia	3 (6%)	21 (2%)	0.1	4 (4%)	20 (2%)	0.4	5 (6%)	19 (2%)	0.038	8 (5)	16 (2%)	0.027
Amnestic dementia	2 (4%)	26 (3%)	0.7	3 (3%)	25 (3%)	0.9	2 (3%)	26 (3%)	0.8	5 (3)	23 (3%)	0.8
CIND[1]	19 (28%)	142 (14%)	0.003	19 (16%)	142 (15%)	0.8	17 (18%)	144 (15%)	0.4	37 (20)	124 (14%)	0.038
Vascular CIND[1]	3 (6%)	33 (4%)	0.5	3 (3%)	33 (4%)	0.6	4 (5%)	32 (4%)	0.6	6 (4)	30 (4%)	0.9
Amnestic CIND[1]	16 (25%)	109 (11%)	0.002	16 (14%)	109 (12%)	0.6	13 (14%)	112 (12%)	0.5	31 (18)	94 (11%)	0.018

1. CIND = Cognitive Impairment Not Dementia

Table 3: Logistic regression of cognitive impairment according to boxing or head injury

Cognitive Impairment	exposure	Model 1: Adjusting for age, BMI, social class, alcohol, smoking, previous vascular disease, diabetes, hypertension, early cognitive decline			Model 2 Further adjustment for premorbid IQ[2]		
		OR	**95% CI**	**p**	**OR**	**95% CI**	**p**
Any impairment	Boxing	**2.21**	**1.22, 4.00**	**0.009**	**2.27**	**1.18, 4.38**	**0.014**
	Any head injury	**1.70**	**1.12, 2.59**	**0.013**	**1.77**	**1.11, 2.81**	**0.017**
Dementia	Boxing	1.73	0.54, 5.56	0.35	1.77	0.44, 7.16	0.43
	Any head injury	1.91	0.91, 4.04	0.088	1.97	0.82, 4.74	0.12
Vascular dementia	Boxing	2.35	0.44, 12.41	0.32	1.16	0.11, 12.92	0.90
	Any head injury	**3.17**	**1.08, 9.27**	**0.035**	**3.10**	**0.83, 11.62**	**0.093**
Amnestic dementia	Boxing	1.28	0.26, 6.37	0.76	1.44	0.22, 9.42	0.70
	Any head injury	1.21	0.42, 3.45	0.72	1.28	0.39, 4.20	0.69
CIND[1]	Boxing	**2.38**	**1.27, 4.46**	**0.007**	**2.31**	**1.17, 4.60**	**0.016**
	Any head injury	**1.60**	**1.00, 2.53**	**0.048**	**1.61**	**1.98, 2.68**	**0.062**
Vascular CIND	Boxing	1.28	0.28, 5.83	0.75	0.62	0.08, 4.12	0.66
	Any head injury	1.09	0.39, 3.05	0.84	0.91	0.29, 2.86	0.87
Amnestic CIND	Boxing	**2.68**	**1.39, 5.21**	**0.003**	**2.78**	**1.37, 5.65**	**0.005**
	Any head injury	**1.70**	**1.04, 2.80**	**0.036**	**1.81**	**1.06, 3.10**	**0.029**

1. Cognitive Impairment not dementia
2. Premorbid Intelligence estimated by the NART[11]