Neuropsychological investigation of amateur boxers

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Amateur boxing is faced with criticism over the potential damage the sport inflicts on those who participate. The most sensitive measure of early neurological dysfunction is neuropsychological investigation. Ten studies employing such assessments on 289 amateur boxers are reviewed. The forms of analysis undertaken include controlled comparison with other sportsmen, of both active and former boxers, detailed pre- and post-bout analysis, analysis of the influence of within-boxing variables, length of career, level of competition and prospective longitudinal investigation. Amateur boxers were found to exhibit no signs of neuropsychological dysfunction in any analysis. However some trends emerged suggesting a long career in amateur boxing might reduce fine motor reactions, although such findings are within the normal range and do not represent central neuropsychological functioning. Thus amateur boxing does not appear to expose individuals to neurological dysfunction.

Keywords: Amateur boxing, neuropsychological assessment

During 1984–1994 boxing has faced repeated and forceful claims for its abolition from many sectors[1,2], the most influential of which have been medical authorities from around the world[3,4]. The argument usually hinges on the issue of whether clinical and scientific evidence suggests that participation in boxing causes progressive neurological impairment[5,6].

Contact with boxers in clinical practice has led some neurologists to make emotive statements about the potential harm and irreparable scarring resulting from boxing[1]. Jordan[7] has been particularly critical of clinical assumption and poorly designed studies which 'support a subjective and popular opinion and which can be propagated through the medical literature as fact'. Only recently have reports begun to appear where examinations have been performed on boxers not preselected because of neurological impairment[8].

For some time, the need for controlled prospective studies, to identify the neuropsychological effects of participation in boxing[9], has been recognized. Recently a steady trickle of scientific studies on the effect of boxing has appeared in the literature. Although some have methodological weaknesses they have contributed enormously to an increased understanding of how boxing influences neurological and psychological functioning of those individuals who choose to participate.

A first requirement is to differentiate between the two forms of boxing. In comparison with professional boxing, amateurs box fewer rounds (either three 3-min rounds, or five 2-min rounds), spar much less, wear headgear, have more medical supervision, take a standing count of eight after receiving a powerful punch, and the bout is scored by five judges using (in international competition) a scoring machine to improve objectivity. In addition amateur contests are stopped after three standing counts in a round and following a knock-out the boxer is prevented from boxing or sparring again for predetermined periods, the shortest being 28 days. A bout finishing with a knock-out is also much rarer in amateur boxing where the emphasis is often on technical superiority not power. At the Barcelona Olympic Games, of 327 contests only six (1.8%) ended with a knock-out[10].

There is increasing evidence that professional boxing can lead to chronic brain damage, ranging from mild subclinical dysfunction to the slowed motor performance, tremors, memory defects and slowness of thought associated with severe neurological impairment[11]. Neurological examination, computed tomographic scans, electroencephalograph recordings and psychoneurological investigations have indicated abnormalities in former professional boxers[12–14].

In professional boxing, there also appears to be a relationship between the incidence of abnormality and length of career[14], number of bouts[14–16] and number of knock-outs[17]. Such links appear to conform with the model of cumulative effect which proposes that blows to the head have an additive deleterious effect[18].

This article seeks to explore current evidence on amateur boxing through reviewing those reports which employed neuropsychological assessments in their investigations.

Review of articles

Neuropsychological assessment has been advocated as the most sensitive instrument for detecting early and subtle neurological abnormality[14,16,19]. Ten studies have published the results of such investigations and these are detailed in *Table 1*.

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Table 1. Studies of amateur boxers employing neuropsychological investigations

Reference	n	Former/ active	Age range	No. contests	Length of career (years)	Controls	Design/comments
Thomassen *et al.*[22] 1979 (Denmark)	53	Former	—	19–209	3–16	53 soccer	3–19 Years since last bout
Kaste *et al.*[13]* 1982 (Finland)	8	7 Former	19–36	mean 129	>11 (former)	—	All national championships
Ross *et al.*[12]* 1983 (USA)	13	?	14–65	13–150	—	—	
Casson *et al.*[14]* 1984 (USA)	5	2 Former 3 Active	18–55	0–80	0.25–5	—	
McLatchie *et al.*[19] 1987 (UK)	20	Active	18–49	4–200	—	—	Comparison with orthopaedic patients made
Brooks *et al.*[21] 1987 (UK)	29	Active	15–27	2–96	1–13	19 non-sparring amateur boxers	
Levin *et al.*[20] 1987 (USA)	2	Active	—	69–100	6–9	13 sportsmen	Matched controls 6-month follow-up
Heilbronner *et al.*[23] 1991 (USA)	23	Active	16–30	0–>50	—	—	Effect of single bout
Murelius and Haglund[24†] 1991 (Sweden)	50	Former	—	0–230	1–17	25 soccer	Compared low match boxers (0–15 bouts) with high match boxers (25–230 bouts)
						25 track and field	
Butler *et al.*[25] 1993 (UK)	86	Active	12–26	0–75	0–9.5	47 rugby	Analysis post-bout and 6-month–2-year follow-up
						31 water polo	Bout videotaped to count head blows

*Studies which also investigated professional boxers; †Study also reported by Haglund and Eriksson[28] 1993 (Sweden)

Some studies included both amateur and professional boxers[12–14, 20] which made detailed analysis sometimes difficult and where the distinction was unclear, rather than prejudice remaining data, they were excluded from the analysis.

In total, 289 amateur boxers have undergone neuropsychological assessment, 164 while still active in the sport, 112 former boxers and 13 unknown. The assumption underlying selection of neuropsychological tests has been that dysfunction if present would be of the sort found in minor closed head injury[14, 16, 21].

There have been 44 different neuropsychological tests employed covering seven functions: (1) learning (four tests, used in six studies – some studies used a number of tests to examine one function) usually of an associative type; (2) memory (16 tests, 26 studies) including auditory and visual modalities, immediate and delayed recall, and recognition; (3) speed of information processing (five tests, 12 studies) from reaction time to rate of encoding and responding to more complex information; (4) visuospatial problem solving (six tests, eight studies); (5) attentiveness and vigilance (five tests, 11 studies); (6) verbal functioning (six tests, six studies) including conceptual understanding, fluency and vocabulary; and (7) motor speed (two tests, three studies) assessed through finger tapping. Thus a wide breadth of neuropsychological functioning has been investigated.

Studies without a control group[12–14, 19] have sought to compare results with normal population standards. Despite the methodological weakness of such a design the results suggest similar tendencies and themes. Three studies found 'some evidence' of poor functioning on one of the tests – trail making[13], verbal memory[14], word learning[19] – yet scores on the whole fell overwhelmingly in the average range. McLatchie[19] stated that variance of scores appeared to prevail in that whereas most boxers 'performed normally on a given test, a small subgroup (not always the same subgroup) performed extremely badly on each test'. With so many tests employed – 25 in the four studies – it would be unusual not to find some outlier scores among a sample population. Indeed McLatchie[19] claimed it was impossible to conclude that any abnormal score was as a result of boxing.

Five studies employed sportsmen as control groups matched for age. Soccer players were selected because of impact of the ball on the head[22, 24] and rugby players as representative of body contact sport[25]. Other controls were selected to minimize the possibility of head injury and have included water polo players[25], track and field athletes[24], amateur boxers in training but not sparring[21] and a group of sportsmen from a variety of sporting backgrounds[20].

Comparison of 132 former boxers with controls[21, 22, 24] found essentially no difference in neuropsychological functioning. However, both Murelius and Haglund[24] and Thomassen *et al.*[23] found a slightly slower finger motor function of the non-dominant hand particularly with boxers having a high number of bouts. Interestingly Drew *et al.*[15] found a similar result with professional boxers. Murelius and Haglund[24] however make it clear that despite the slight difference, the boxers' performance on this task was 'well within normal range'. The reason for the slight difference could be that most boxers (other than 'southpaws', who lead with the right hand) lead with the non-dominant left hand and

throw more punches with this hand (with the jab), thus making the left hand more vulnerable to injury. The likelihood is that reduced fine motor performance is a peripheral effect rather than a sign of central cognitive functioning[24] and thus where sportsmen show poor finger tapping skills this provides no evidence of central neuropsychological disturbance.

Two studies assessed boxers active in the sport with controls. Levin *et al.*[20] had only two amateurs in their group of 13 boxers and failed to differentiate between them. They however found no difference between controls and boxers except that boxers tended (although not significantly) to perform worse on reading and verbal learning. Butler *et al.*[25] compared 86 boxers with controls from water polo and rugby union. They also found evidence of lower functioning at the initial testing for boxers compared with controls. However, further analysis showed that the initial scores were unrelated to number of previous bouts or recovery from a previous contest, and thus the lower scores for boxers were not because of a boxing history. A possible explanation offered by both Levin *et al.*[20] and Butler *et al.*[25] is that there is an association between self selection of boxing and subtle learning difficulties. Certainly the boxers assessed by Butler *et al.*[25] tended to be early school leavers compared with controls who were committed to further education.

The effect of one bout of boxing has been studied in some detail. Heilbronner *et al.* examined 23 amateurs pre- and post-bout (within 30–40 min of boxing)[23]. On most neuropsychological measures there were no differences in scores. However, some deficits occurred in verbal and incidental memory and improvements in finger tapping (fine motor performance) and cognitive flexibility. They argue that those changes resulted from heightened autonomic nervous activity because the boxers were tested so soon after competing. There is evidence suggesting changes in autonomic arousal may interfere with memory performance[26] and improve motor performance[27]. Thus Heilbronner *et al.*[23] conclude that it is 'unlikely that a single *amateur* boxing match leads to irreversible and permanent cognitive deficits' (author's italics).

After a pre-bout assessment Butler *et al.*[25] videotaped the contest and completed a post-bout assessment within 6 days of the contest – 67% of the boxers being assessed within 24 h of the bout. Number of head blows taken by the boxers ranged from 0–54 and a correlated analysis showed no relationship between number of blows received and impairment on neuropsychological functioning. Thus no detrimental effects appear to result from one bout of boxing.

Of perhaps more relevance, however, is the effect of a continued career in amateur boxing. From the published reports, this can be addressed in four ways:

1. *Within boxing effects*

Brooks *et al.*[21] examined the relationship between number of knock-outs, numbers of wins and losses, number of bouts where the referee stopped the contest, and the weight at which the boxer competes, with neuropsychological functioning and no significant effects were found.

2. *Length of career*

The number of contests ranged between 0[14, 24, 25] to over 200[19, 22, 24]. Murelius and Haglund[24] contrasted boxers with few contests (0–15 bouts) with those having a high number of contests (25–230 bouts). The only difference was in fine motor coordination (although scores were within the normal range). Interestingly Heilbronner *et al.* found the boxers with the most extensive career demonstrated comparatively slower finger tapping after a bout[23]. As previously discussed, fine motor reactions do not reflect central cognitive processes and thus neuropsychological functioning appears unaffected by length of boxing career.

3. *Level of competition*

Most reports have investigated boxers competing at local or regional levels where it could be argued that the blows received might not be of comparable strength and power to those in contests at a national or international level. However, Kaste *et al.*[13] studied national and European champions and found no evidence of neuropsychological abnormality in their sample.

4. *Prospective analysis*

Levin *et al.* reassessed two amateur boxers after 6 months[20] and Butler *et al.* re-examined their initial sample of 86 boxers between 6 months and 2 years after assessment[25]. The number of bouts between the two assessments in Butler *et al.*'s sample ranged from one to 18 and a correlated analysis between number of bouts and change in test score revealed no significant findings.

Both Levin *et al.*[20] and Butler *et al.*[25] found boxers and controls tended to improve scores on the neuropsychological assessments between tests but few differences between boxers and controls were found. As Levin *et al.*[20] suggest, given the continued sparring and bouts contested by the boxers between the two assessments, differential change between boxers and controls would be anticipated if boxing was causing neuropsychological impairment. Given no such findings in either study, the likelihood is that amateur boxing is not causing neuropsychological damage.

In conclusion neuropsychological assessment has been advocated as the most sensitive measure for detecting early neurological dysfunction. A wide range of such measures has been undertaken with the aim of exploring what influence amateur boxing might have on the participant. However, the analysis indicates minimal impact of amateur boxing on neuropsychological function. There is a suggestion that a long career in boxing might reduce fine motor reactions, particularly in the non-dominant hand, but even on this measure boxers perform within the normal range.

Amateur boxing has been examined through controlled studies of active and former participants, detailed pre- and post-bout analysis, within boxing effects, influence on length of career, level of competition and prospective studies; and the influence on central cognitive functioning has proved

negative. Thus the results of extensive investigations into boxing, at an amateur level, suggest that participation does not expose the individual to harmful neuropsychological damage.

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