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Case Report

Olfactory Dysfunction in Sports Players following Moderate and Severe Head Injury: A Possible Cut-off from Normality to Pathology

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ABSTRACT

Concussion occurs with some frequency in a variety of sports. Any trauma to the brain can also result in temporary or chronic olfactory dysfunction. The relationship between sports concussion and olfactory dysfunction is not well studied, nor do we know whether only more severe injuries result in smell impairments. Three sports players who had previously experienced either a moderate or severe concussion were compared to matched controls. Only the player with a previous severe concussion had a current olfactory impairment. We tentatively suggest that the distinction between moderate and severe concussion may represent a possible cut-off between the presence and absence of olfactory impairment in sports players.

INTRODUCTION

Traumatic brain injury (TBI) is one of the most common causes (approximately 20%) of olfactory impairment [1-6]. Suggested underlying mechanism accounting for complete or partial deprivation of olfactory function include olfactory nerve fiber fragmentation, nasal bones and/or skull-base fractures and hemorrhage-related damage in olfactory brain areas. The type and degree of the disorder depends upon several factors, however a severe brain injury, especially at the level of the occipital lobes (coup-contra-coup condition), together with a loss of consciousness during concussion is likely to cause posttraumatic anosmia [7,8]. Restoration of olfactory function is severity dependent and according to the literature may only occur in about 25-35% of the patients who suffered a moderate or severe injury [9,10]. Typically, recovery follows surgical intervention, or contusion resolution, but it can also occur physiologically over a few months - due to the capacity of the olfactory nerve fibers to regenerate. Rare cases of recovery post olfactory loss have been observed even nine years from head trauma [5]. As a group, sports players are at an increased risk of head injuries, which may occur from falls and collisions. Presumably, they are also at increased risk of olfactory dysfunction although this has not been well explored [1]. Olfactory dysfunction may adversely affect many aspects of life and as noted above is generally a chronic impairment.

Here we report on olfactory function (identification and detection threshold) in 9 sports players (3 case studies and 6 matched controls) two of whom suffered moderate and one a severe concussion (a clinical syndrome of biomechanically induced alteration of brain function) during rugby and football practice, and motocross, respectively. We investigated the relationship between severity of head trauma and olfactory loss and

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whether the stage in between moderate and severe head trauma may represent a cut-off at which point olfactory dysfunction is more likely to be observed.

METHODS

Participants

Of the three players who suffered a concussion, two were of moderate grade and one of severe grade, occurring in rugby and football practice, and motocross, respectively. These injuries occurred in the last three years (rugby: 1 year 8 months; football 2 years 1 month; motocross 2 year 4 months). As to the athlete who suffered the most severe TBI, Magnetic Resonance Imaging (MRI) did not reveal any clinically significant structural injury or intracranial hemorrhage although he had a one-day loss of consciousness. All the 3 sport players received after the concussion a complete neuropsychological examination which measured intelligence, short and long term verbal and visual memory, attention, language, visual perception and motor skills. No cognitive abnormalities emerged in any of them. In terms of other injuries, BR reported blurry vision in his right eye due to bruising, which rapidly resolved.

The control athletes did not report experiencing any life-time concussive incident. Severity of concussion was assessed by means of the *Glasgow Coma Scale* [11] with scores ranging from 3 to 15 and by the *Sports Concussion Grading System* [7,12,13] with scores ranging ranges from grade 1 to grade 3. The *Sports Concussion Grading System* is an evidence-based guideline for evaluating and managing athletes with concussion developed by the American Academy of Neurology (AAN). Its last version [13] provides information on risk factors, diagnostic tools, standardized assessment of concussion and interventions to enhance recovery (the two assessment tools are presented in tables 1 and 2). All participants were in good health (or reported being fully recovered) at testing, and none of them had a history that would suggest any preexisting olfactory pathology. Exclusion criteria were: conditions causing temporary or permanent impairment to the sense of smell, drug or alcohol abuse, smoking, previous history of neurological and/or psychiatric disease, previous traumatic brain injuries not related to sport. The study was performed according to the Declaration of Helsinki for experimentation with human subjects. All participants provided written informed consent to take part in the study.

Table 1: Sport Concussion grading System [12].

GRADE	SYMPTOMS
1	Transient confusion, no loss of consciousness, concussion symptoms last < 15 min.
2	Transient confusion, no loss of consciousness, concussion symptoms last > 15 min.
3	Any loss of consciousness, brief(s) or prolonged (min)

Table 2: Glasgow Coma scale [11].

BEHAVIOR	RESPONSE	SCORE
Eye opening response	Spontaneously To speech To pain No response	4 3 2 1
Best verbal response	Oriented to time, place, and person Confused Inappropriate sounds Incomprehensible sounds No response	5 4 3 2 1
Best motor response	Obeys commands Movies to localized pain Flexion withdrawal from pain Abnormal flexion (decerebrate) Abnormal extension (decerebrate) No response	6 5 4 3 2 1

MATERIALS AND PROCEDURES

Olfactory detection and identification were assessed by means of the "Sniffin' Sticks" test battery (Burghart, Wedel, Germany), which is a reliable and valid method of assessing olfactory function [14,15]. On the detection task participants were presented with three pens, one containing the odorant at one of 16 possible dilutions and with the other two containing solvent only. The subject's task was to determine which of the three pens smelled. On the identification task participants were administered 16 odorants. Identification was performed by selecting the appropriate label from a set of 4 labels provided for each smell. These labels were repeated out loud by the experimenter during sniffing [16]. For both the detection task and the identification task, participants were instructed to keep their eyes closed for the entirety of each test.

Stimuli administration rates and other methodological aspects followed the standard procedures used in odour detection and identification experiments.

RESULTS

The individual number of correct detection and identification scores for TBI and control participants are depicted in Table 3.

Data were analyzed by the statistical program Singlim [17] for case-control designs in neuropsychology, comparing the scores of each sports player who had experienced a concussion against the mean scores of the controls on both tasks.

Testing revealed that participant BR, the sports player who received a severe concussion during motocross practice was significantly impaired on both Detection: $t = 3.9$, $p < 0.006$ and Identification: $t = 8.27$ $p < 0.0001$. The two sports players who had experienced a moderate concussion were not significantly different from controls, and examination of their raw scores, which fell within the normative limits for the "Sniffin Sticks" test [14] suggests no evidence of olfactory abnormality.

DISCUSSION

It has been suggested before that sports players may be at an increased risk of olfactory impairment especially in contact sports following concussions [1,18]. Here we report that only the participant with a previous severe concussion performed significantly worse than controls. Probably loss of consciousness at concussion may reflect a potentially worrisome injury [7], of which impaired olfactory function is probably just one part (noting that this participant regarded himself as fully recovered). Indeed, some degree of olfactory impairment may pass unnoticed, and thus could serve as a retrospective marker of injury severity. While we do not as yet know whether some degree of olfactory impairment is a consistent correlate of severe concussion (or with the time interval since injury) or whether it may serve as a marker for longer-term neurological dysfunction, the data reported here suggest

Table 3: Detection and Identification scores for TBI and Control participants and concussion grade for TBI participants on Glasgow coma scale and the Concussion grading system.

Groups	Identification Scores	Detection Scores	Sport	Glasgow c.s.	Concussion g.d.
Controls				-	-
TO	13	13.5	Motocross	-	-
MG	12	10.25	Rugby	-	-
CM	14	15.5	Football	-	-
MA	13	12.7	Motocross	-	-
RS	14	13.25	Rugby	-	-
BM	13	13	Football		
Injured					
BR	7	6	Motocross	Severe (≤ 8)	3
GA	12	14.5	Rugby	Moderate (9-13)	2
GE	12	15.5	Football	Moderate (9-13)	2

that this should be investigated, especially as few predictive markers of longer term impairment are known [13].

In addition to suggesting the importance of studying olfaction as a potential injury marker, and prognostic tool, a further observation here was that the most severe case (motocross) was unaware that they had sustained an olfactory impairment [19]. Contrast this with the other sensory modalities, where deficits are usually readily evident, which makes this all the more remarkable. This may be one reason why olfactory impairment has not been extensively studied in the context of sports injury concussion.

These preliminary data suggest that the stage in between moderate and severe concussion may represent a cut-off from olfactory normality to a pathological decrease of olfactory efficiency (indeed, according to the 10th percentile of the distribution of the scores for the "Sniffin Sticks" test battery, a cut-off between normal and subnormal performance for the young subjects is set at 6.5 and 11 respectively for the detection and identification task). An olfactory assessment, along with a general neuropsychological evaluation, should then be recommended in case of sport injuries as a possible marker of injury severity.

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