

## COGNITIVE IMPAIRMENTS ASSOCIATED WITH SOCCER

Eric Matser, Ph.D., et al.

The findings of three studies indicate that blows to the head incurred in soccer play can result in cognitive impairment: the kind of impairment players sustain may vary according to their field position. The comparison groups in the first two studies differed, and in the last study the comparison was between test scores and the types of injuries common to soccer players, yet the patterns peculiar to each type of injury appeared with a fair degree of consistency in each study. Thus, players who do the most headers display more problems with both visual and verbal memory, and may suffer deficits in visual analysis and planning, and slowing on tasks requiring focussed attention and visual scanning. Concussions tend to compromise abilities for visual analysis and planning, and aspects of attention, but may also involve both verbal and visual memory reflecting the diffuse nature of concussions. We conclude that since specific deficit patterns appear to occur with specific playing roles, serious soccer players who engage in many hours of practice and play each year are likely to sustain cognitive deficits associable to the nature and frequency of the blows their heads give or receive.

### References

- Matser JT, Kessels AGH, Jordan BD, Lezak MD, Troost J. Chronic traumatic brain injury in professional soccer players. Neurology 1998;51:791-96.
- Matser JT, Kessels AG, Lezak MD, Jordan BD, Troost J. Neuropsychological impairment in amateur soccer players. JAMA 1999;282:971-73.
- Matser JT, Kessels AGH, Lezak MD, Troost J. Contribution of headers and soccer related concussions to cognitive impairment in professional soccer players. Under review.

plus

- Witol, A.D. & Webbe, F.M. (2003). Soccer heading frequency predicts neuropsychological deficits. Archives of Clinical Neuropsychology, 18, 397-417.
- Webbe, F.M. & Ochs, S.R. (2003). Recency and frequency of soccer heading interact to decrease neurocognitive performance. Applied Neuropsychology, 10, 31-41.



COGNITIVE IMPAIRMENTS ASSOCIATED WITH SOCCER (outline)

Eric Matser, Ph.D.<sup>1</sup> Principle Investigator

A.G. Kessels, M.D.<sup>2</sup>, J. Troost, M.D.<sup>2</sup>, M.D. Lezak, Ph.D.<sup>3</sup>, B. Jordan, M.D.<sup>4</sup>

STUDY 1: Chronic traumatic brain injury in professional soccer players  
Neurology 1998;51:791-96.

A. Compared 53 professional soccer players with 27 swimmers and track athletes on 27 variables derived from 17 tests of neuropsychological functions.

B. <u>Subjects</u>	Soccer	Swimmers/track
Mean age	25.4 ± 4.1	24.5 ± 4.5
Median education (3-7, 7=university)	6	5
Median alc intake (drinks/month)	12	28
% players reporting nonsoccer concussions	11.3	14.8

C. Soccer players characteristics

Median matches/year = 50 (range, 25-70)  
Median practices/week = 6 (range, 4-9)  
Player positions: forward-24%; midfield-45%;  
defense-30%  
Median years as amateur = 12 (range, 4 to 23)  
Median years as professional = 5 (range, 1-18)  
Median match headers/season = 800 (range, 50-2,100)  
% players reporting soccer concussions = 54  
% players reporting head-to-head collisions = 79  
% players doing heading drills (30 mn ea) = 30

D. Soccer players scored below controls on 11/27 test variables

Test performances varying inversely with # of headers  
Immediate & delayed visual recall

-----  
<sup>1</sup> Erasmus University, Rotterdam, The Netherlands; <sup>2</sup> University of Maastricht, Maastricht, The Netherlands; <sup>3</sup> Oregon Health & Sciences University, Portland, Oregon, USA; <sup>4</sup> New York, USA.



**Test performance varying inversely with # of concussions**  
Visuospatial accuracy and planning

**Test performances varying with field position**  
Forward & defensive players performed below  
midfield players and goalkeepers  
Verbal learning  
Verbal recall  
Immediate and delayed visual recall  
Visuoperceptual accuracy

**Test performances below controls not  
differentiating soccer subgroups**  
Auditory span  
Conceptual reasoning  
Mental flexibility

STUDY 2: Neuropsychological impairments in amateur soccer players.  
Journal of the American Medical Association 1999; 282: 971-973

A. Compared 33 amateur soccer players with 27 swimmers and track athletes on 27 variables derived from 17 tests of neuropsychological functions.

B. <u>Subjects</u>	Soccer	Swimmers/track
Mean age	24.9 ± 4.2	24.5 ± 4.5
Median education	5	5
Median alc intake (drinks/month)	50	28
% players reporting 1 nonsoccer concussion	27.3	14.8

C. Soccer player characteristics

Median matches/year = 36 (range, 20-70)  
Mean practice time/week = 3.6 hrs  
Mean years as amateur = 17  
(67% played > 16 years)  
Median headers/match = 8.5 (range, 0-20)  
% players reporting soccer concussions = 48  
(9 reported 1, 7 reported 2-5)

D. Soccer players scored below controls on 9/27 test variables

**Test performances below controls (subgroups not differentiated)**  
Auditory span forward & reversed  
Verbal learning and recall  
Visual immediate recall



**Test performances varying inversely with # of concussions**

Auditory span forward  
 Visuoperceptual accuracy  
 Verbal recall  
 Visual recall, immediate & delayed  
 Visual tracking with learning component

E. Comparisons between soccer players and controls on cognitive function areas (cluster analysis)**Cognitive functions on which soccer players displayed more impairment than controls**

Planning impairments: 27% of soccer players, 7% of controls  
 Learning & memory: 39% of soccer players, 13% of controls

**Cognitive functions on which controls displayed more impairment than soccer players**

NONE

STUDY 3: Contributions of headers and soccer-related concussions to cognitive impairment in professional soccer players Journal of Clinical and Experimental Neuropsychology, 2001; 23, in press.

A. Compared the patterns of cognitive impairment associated with headers and with soccer-related concussions in 84 professional players.

B. Subjects

	Median	10 <sup>th</sup> %ile	90 <sup>th</sup> %ile
Age	24	19	32
Alc intake (drinks/month)	5	0	40
Length of professional career (years)	4	1	12
Training hours/week	10	9	14
Matches last season	50	40	65
Headers last season	500	70	1,260
Soccer concussions in professional career	1	0	12



C. Cognitive test score disassociation between number of headers and soccer-related concussions

**Impairment per 1000 headers (one-tailed  $p$  value)**

Rote verbal learning (0.03)  
Visual recall, immediate (0.02), delayed (0.01)  
Visuographic response speed & scanning (0.48)

**Impairment per #/soccer-related concussions**

Visuospatial planning & accuracy (0.01)  
Face recognition (0.04)  
Visuoperceptual speed and accuracy (0.04)

STUDY SYNTHESIS

A. **Players who do many headers show deficits in**

Verbal & visual memory  
(both learning and recall)  
Slowing with focussed attention  
& visual scanning

B. **Players concussed in play show deficits in**

Visual analysis and planning  
Visuoperceptual accuracy

C. **Regardless of position, some soccer players show deficits in**

Auditory span &/or  
Conceptual reasoning &/or  
Mental flexibility



## COGNITIVE IMPAIRMENTS ASSOCIATED WITH SOCCERS

### SLIDE 1: TITLE & AUTHORS

This is a summary of a series of studies asking whether blows to the head in soccer can affect the players' cognitive abilities. The principal investigator in each of these studies is a Dutch neuropsychologist, Eric Matser. While the others listed have assisted with advice on organizing the studies, test interpretation, statistical analysis, data presentation, etc., the planning, work, and writing have been essentially done by Matser.

### SLIDE 2: STUDY 1--CHRONIC TBI IN PROFESSIONAL SOCCER PLAYERS

The first study, published in Neurology in 1998, compared 53 active professional soccer players to 27 members of elite swimming or track teams on 27 variables drawn from 17 different tests of cognitive functions. The groups were similar in age and health history, but soccer players had a higher education level and consumed less alcohol than their controls.

### SLIDE 3: STUDY 1--FINDINGS

Performance differences between these two groups reached significance on 11 of the 27 variables. Without exception, tests in which response speed makes an important contribution to the score did not differentiate these two groups: mean scores on timed tests for both groups were at average or better levels. However, on tests of both visual and verbal memory, conceptual reasoning, visual analysis and planning, and mental flexibility, the soccer players' performances fell below those of the other athletes at levels well beyond chance. What is perhaps most telling about these data comes from an analysis of how performance levels related to specific



aspects of the soccer game with the primary focus on the contribution of headers to cognitive performances.

The first of these subanalyses compared soccer players whose field position involved more headers (forward and defensive players) or fewer headers (midfield players and goal keepers). Tests of both visual and verbal memory and of visual analysis and planning differentiated these two groups, with players in positions in which headers are more frequent doing less well than their more protected teammates. Two other analyses found inverse relationships between the number of lifetime concussions players reported and visual analysis and planning, and between the number of headers a player makes in one season (excluding headers in training practise) and visual memory.

#### **SLIDE 4: STUDY 2--NEUROPSYCHOLOGICAL IMPAIRMENT IN AMATEUR SPs**

The next study, published in JAMA in 1999, looked at amateur soccer players, comparing 33 soccer league members to a group of 27 swimming and track athletes, also amateurs. In this study the two groups were well matched for both age and education but the soccer players tended to drink almost twice as much as their controls (which amounted a median monthly intake of almost two drinks per day).

#### **SLIDE 5: STUDY 2--FINDINGS**

With few exceptions these amateur players produced a comparison pattern similar to that of the professionals. Again no differences between the groups showed up on speed-dependent tests. However, the soccer players had lower scores on tests of visual and verbal memory and of auditory span, and tests involving visual analysis and planning, concept formation and mental flexibility. These amateur players--who spend less time in practice



or in competition, and who on average do about half as many headers as the professionals, performed as well as the other athletes on a test of abstract reasoning on which the professionals had scored below their controls. It is interesting to note that on a test of fine motor behavior--which is also speed-dependent--the soccer players out-performed the other athletes (we suspect this may be attributable to the visual aiming speed which soccer players develop, unlike swimmers and runners). A separate analysis of the 16 soccer players who had sustained concussions while playing soccer showed that these players scored below their nonconcussed teammates on two tests involving attention--one speed-dependent, and on tests of visual and verbal memory.

**SLIDE 6: STUDY 3--CONTRIBUTIONS OF HEADERS & CONCUSSIONS**

*is in press, J Exp Clin Psychol*

The third study<sup>1</sup> asked whether headers and concussions received in soccer play affected cognitive abilities differently. Of course, concussions go with the territory in all contact sports; but headers are soccer's unique contribution to the list of sports injuries.

The 84 subjects of this study were all premier league professional soccer players who reported both the number of life-time concussions (sports- and nonsports-related) they had received and the number of headers made in a single match. The sum of headers for the season was calculated by multiplying the single match number by the number of matches played in the last season. Nonsports concussions were included with demographic and health data as covariants to provide statistical control of the data. It is interesting to note that there was no relationship between the number of headers players made and the number of concussion they received in soccer play ( $r = .18$ ,  $r^2 = .03$ ).



Statistical analyses separated correlations of neuropsychological test scores with the number of headers from correlations of the test scores with the number of concussions. Findings indicated that each type of blow to the head is associated with a different pattern of cognitive impairment: Concussions were associated with impairment on tests involving short-term visual recall and visual analysis and planning. Slowing on responses requiring visuoperceptual accuracy contributed to the concussion findings. This impairment pattern is consistent with the kind of diffuse injury known to occur with concussions. In contrast, using the criterion of 1000 headers, impairment due to headers involved visual and verbal memory and slowing when focussed attention and visual scanning were required. This pattern suggests compromise of fronto-temporal structures as would be expected from the linear movements and striking force involved in heading the ball.

#### SLIDE 7: STUDY SYNTHESIS

The findings of these three studies indicate that blows to the head incurred in soccer play may result in cognitive impairment, and that the kind of impairment players sustain can vary according to their position on the field. Although the comparison groups in the first two studies differed, and in the last study the comparison was only between test scores and the types of injuries common to soccer players, the patterns peculiar to each type of injury appeared with a fair degree of consistency in each study. Thus, players who do the most headers display more problems with both visual and verbal memory, and may suffer deficits in visual analysis and planning, and slowing on tasks requiring focussed attention and visual scanning. Concussions tend to compromise abilities for visual analysis and



planning, and aspects of attention, but may also involve both verbal and visual memory reflecting the diffuse nature of concussions. Although these patterns tend to characterize specific playing roles, the overall findings indicate that serious soccer players who engage in many hours of practice and play each year are likely to sustain cognitive deficits associable to the nature and frequency of the blows ~~to~~ their heads receive.

① Q what is happening when a youngster has HA after headg-

② Ball Δs - when wear a cold

③ Functional Δs - why may be below awareness -

- Δs occur slowly
- v high level cognitive activity
- not required in relg few jobs

a salesman

- car mechanic

- shop clerk

- accountant = computer data

④ Re Dr Johnston: absence of evidence ≠ evidence of absence

~~④ Cooling effects?~~  
Practice "

⑤ Dr Jochims' study pts not need to look @ individual cases