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No Neuropsychological Consequence in Male and Female Soccer Players after a Short Heading Training

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Abstract

The impact of heading on neuropsychological performance is a subject of controversy. In this experimental study, a controlled group design was used to investigate the possible effects of a short heading training session on neuropsychological performance. Ninety-one participants matched by age, sex, and intelligence were assigned to one of the following groups: A heading-training group, a placebo control group, and a waiting control group. All participants completed a neuropsychological test battery for attention and working memory (D2 Test, Benton Visual Retention Test, Paced Auditory Serial Addition Task Test). After 1 week, they received heading training, football (e.g., soccer) training without heading, or no training. Immediately after this training, the neuropsychological tests were conducted again. There was no neuropsychological deficit which could only be attributed to the heading training. However, within the heading group, women complained more about headache than men.

Keywords: heading training; acute head impacts; neuropsychological measurements; headache; concussion

Introduction

Soccer is one of the most popular sports, with more than 265 million players around the world (cf. Stephens, Rutherford, Pottler, & Fernie, 2010). One of the main risks besides injuries in the lower extremities (knee and ankle) (Dvorak & Junge, 2000) is head injuries. These risks and their possible acute and cumulative impacts have been discussed among researchers (McCrory, 2011; Rutherford & Stephens, 2007; Rutherford, Stephens, & Potter, 2003). In their review in 2003, Rutherford and Stephens remarked on the methodological flaws of most studies. Some authors argued that impacts to the head while playing soccer, caused by heading, can be massive enough to lead to mild traumatic brain injury characterized by neck ache, vegetative symptoms or a decline in neuropsychological test performance, and brief changes of consciousness (Rutherford & Stephens, 2007). These symptoms of mild traumatic brain injury are reversible and normally disappear after a short time. Nevertheless, repeated blows can lead to cumulative effects and cause permanent problems (Gronwall & Wrightson, 1975).

The cumulative effects of mild traumatic brain injury on neuropsychological test performance, mainly on memory, are discussed often in research literature (Iverson, Gaetz, Lovell, & Collins, 2004). Studies in boxing have shown head injury might lead to significant consequential damage even if the injuries are not severe. The main cause of neurological injuries in boxers is the cumulative effect of punches, which would separately only cause subclinical symptoms of traumatic brain injury (Heilbronner et al., 2009). Talavage and colleagues (2010) investigated neurological performance and health after head collisions in high-school football players. They used measurements of collision events, neurocognitive testing, and MRT. Due to these results, Talavage and colleagues differentiated between patients (a) who were not clinically diagnosed with concussion and showed no changes in neurological behavior, (b) who were clinically diagnosed with concussion and showed changes in neurological behavior, and (c) football players who did not exhibit clinically observed symptoms associated with concussion

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but demonstrated measurable neurocognitive and neurophysiological impairments. The third category was a new category and was associated with more concussion symptoms in the top-front of the head, directly above the dorsolateral prefrontal cortex. Moser, Schatz, and Jordan (2005) investigated the neurocognitive performance in high-school athletes according to when they had sustained a concussion (a) no concussion at all, (b) (i) one or (ii) two or more concussions but not within the last 6 months, or (c) one concussion within 6 months before testing. The results show that youth athletes who had experienced one concussion within 6 months of testing performed significantly worse than those in the other two groups. Athletes who had experienced two or more concussions performed similarly to the groups of athletes who experienced a concussion just before testing. This study was conducted with youth athletes of different sports (ice hockey, football, field hockey, etc.). Those participants, who had two or more concussions within their lifetime, as well as those with one recent concussion, demonstrated neuropsychological impairments. Killiam, Cautin, and Santucci (2005) also showed that athletes who have had recent head injuries (less than 2 years ago) demonstrate decreased neuropsychological test performance when compared with athletes who do not have a recent history of concussion (more than 2 years ago). In addition, Schatz, Moser, Covassion, and Karpf (2011) demonstrated that teen athletes with two or more concussions suffer from intellectual, physical, and sleep but not emotional (e.g., depression) symptoms.

Rutherford and colleagues (2003) hypothesized that in soccer, cumulative effects similar to those described in boxing could occur. Following the etiology of the “punch drunk” syndrome in boxing, Rutherford and colleagues (2003) assumed that playing soccer can result in head impacts involving smaller forces than boxing, but can nonetheless cause mild traumatic brain injury, which may result in neurological damage and neuropsychological impairment. This is in accordance with Gavett, Stern, and McKee (2011) who assumed that any blow to the head might lead to chronic traumatic encephalopathy, a form of neurodegeneration.

The relationship between heading and neurological deficit has been widely researched, and many studies have attempted to investigate the cumulative effects of repeated head trauma caused by heading (Jordan, Grenn, Galanty, Mandelbaum, & Jabour, 1996; Killiam et al., 2005; Stephens et al., 2010; Webbe & Ochs, 2003; Witol & Webbe, 2003). All these studies used a quasi-experimental design and showed different neuropsychological impairments of soccer players compared with control subjects. As the nature of quasi-experimental design implies, the found impairments could not clearly be attributed to heading. Stephens and colleagues (2010) found no neuropsychological decrement in a group of adolescent school team soccer players compared with rugby and non-contact sport players.

In addition, the influence of gender on concussion has been researched (Covassin & Elbin, 2011) showing that women seem to have a higher risk of sustaining a concussion (Covassin, Swanik, & Sacks, 2003) as well as take a longer time to recover. Women also seem to have different impairments due to concussion (see literature review of Dick, 2009). Colvin and colleagues (2009) investigated the differences in concussion recovery between men ($N = 93$) and women ($N = 141$). They showed that female soccer players, compared with male soccer players, had a lower performance on computer-based neuropsychological testing using reaction time, memory, and visual motor-speed composite scores of the ImPACT test battery. Women also reported more concussion symptoms. The impaired performance of concussed women in visual memory tasks compared with concussed men was already shown by Covasin, Schatz, and Swanik (2007). Broshek and colleagues (2005) showed a greater decline in both simple and complex reaction time measurements for concussed women than for concussed men. Ellemberg, Leclerc, Couture, and Daigle (2007) compared concussed female athletes with a group of aged-matched teammates who had never a concussion. They were able to show that the concussed women were slower on decision-making tasks. Until now, these gender effects have not been investigated in a prospective study.

At this point, we only know about one experimental study investigating the effects of heading training on cognitive function (Putukian, Echemendia, & Mackin, 2000). During this study, every participant was tested before and after two separate practice sessions. Each participant was randomly paired to another player. During the first training session, one member of the paired group was considered an “active header”, and the other an “exertional control”. Two days after the first training session, a second session took place during which the roles of each of the participants were reversed. Those who were initially active headers became exertional controls and vice versa. This allowed each athlete to serve as his or her own control. The authors did not find any change in cognitive functions due to the heading training. However, it is possible that in this study practice, effects counteract acute changes in cognitive function caused by heading, because every participant underwent the same testing three times and there was no additional group for controlling possible effects of learning. From a clinical perspective, the absence of improvement on repetitive testing may signal cognitive deficits in some measures (Putukian et al., 2000). According to this, on the basis of previous findings, it is not possible to make a clear statement concerning acute and cumulative effects of heading on neuropsychological functions.

The present study examines the acute effects of heading on cognitive performance after a short heading training, as it is common in a normal soccer training session. Impairments of attention, memory, and information processing are effective in detecting mild head injuries (Collins, Grindel, Lovell, et al., 1999). A neuropsychological battery commonly used to detect neurocognitive impairment was chosen (Freytag, Walter, Weber, & Wulffen, 1979; Gronwall & Wrightson, 1974). This battery of tests was already applied in a pilot study to measure cognitive abilities and indicated that neurological changes do occur after heading (Rieder, Vetter, Buchner, & Jansen, 2010). Parallel groups were used for assessing the impact of learning. In addition to possible neuropsychological deficits, further symptoms of mild traumatic brain injury were examined using the neuropsychological questionnaire described below. Due to the recent literature on gender differences in concussion, it was also investigated whether the hypothesized effects of heading differ between female and male soccer players. The main goal of this prospective study with three experimental groups was to investigate if a "normal" heading training may lead to acute neuropsychological effects.

Methods

Participants

Altogether 123 healthy students of sport science at the University of Regensburg (66 women and 57 men) participated in this study. Thirty-two students had to be excluded because they had head injuries within the last three years (2 women and 4 men; *see* Killiam et al., 2005), neurological or psychiatric diseases (1 woman and 0 man), headed a ball within 3 days before the test (1 woman and 10 men), drank alcohol in the 12 h before testing (0 woman and 12 men), or had missing data (1 woman). Due to the exclusions, the data of 91 participants (61 women and 30 men) between 19 and 29 years ($M = 21.97$, $SD = 1.95$) were included in analysis. Controlling for sex, age, and IQ, participants were assigned after the pretest to one of the three groups; the heading-training group (TG), the placebo control group (PCG), or the waiting control group (WCG). Twenty-four students played soccer in a German soccer club, 67 did not. From these 67 students, 31 played soccer regularly without being in a soccer club. The three groups did not differ regarding the number of training sessions per month or the number of headings during the trainings (Kruskal–Wallis test for independent samples). All students gave their voluntary informed consent and were informed of the general nature of this study. Data were collected anonymously.

Materials

Participants completed a questionnaire, a cognitive speed measurement (ZVT [Zahlen-Verbindungs test]; Oswald & Roth, 1987), a neuropsychological test battery (measuring attention, working memory, visual memory, and speed of information processing), and a neuropsychological questionnaire. The neuropsychological test battery included three standard neuropsychological instruments with demonstrated reliability and validity, including the D2 Test (Brickenkamp, 2002), the Paced Auditory Serial Addition Task (PASAT) Test (Gronwall, 1977), and the Benton Visual Retention Test (Benton, 1996).

Questionnaire. The questionnaire asked for information pertaining to previous head injuries, neurological diseases, sport participation history, alcohol consumption the day before, and personal data.

Cognitive speed (ZVT; Oswald & Roth, 1987). Cognitive speed was measured with the Number Connection Test (ZVT; Oswald & Roth, 1987). This test consists of four sheets of paper. On each sheet, the numbers 1–90 are presented in a scrambled order in a matrix of 9 rows and 10 columns. The participants had to use a pen to connect the numbers as fast as possible in ascending order. The number of correct connected numbers was analyzed for each participant.

ZVT scores can be converted into IQ estimations. The correlation between the ZVT and the standard IQ tests is about $r =$ .60–.80 (Vernon, 1993). The internal consistency as well as 6-month test–retest reliability of the ZVT is about 0.90–0.95. The ZVT is the equivalent to the Trail Making Test A (Reitan, 1956). The test administration, including instructions and practice matrices, takes about 20 min.

D2 Test (Brickenkamp, 2002). The D2 Test (Brickenkamp, 2002) is a letter cancellation test that taps selective attention and concentration. In this task, the subject was given a sheet of paper with 14 rows of the letters p or d with none, one, or two lines above or below it. Participants are instructed to cross out the letter d whenever it is accompanied by two small lines. d's with more or less than two lines or any stimuli containing the character p serve as distracters. Subsequent to a practice trial, 14 rows with target and distracter stimuli are presented. The subject is given 20 s to complete each row. The test is scored for errors and the number of crossed out stimuli within the allowed time. From this basis, the "Concentration-Performance Score (CL)" is assessed. This score correlates with a value of .78 on the mosaic test of the HAWIE (Wechsler, 1964). The test–retest reliability for 4–18 days is 0.93.

PASAT Test (Gronwall, 1977). The PASAT (Gronwall, 1977) is used to assess speed of information processing, sustained attention, and working memory. It was developed to differentiate between persons who had sustained a concussion and uninjured persons. It is delivered as a series of numbers from 1 to 9, one number every 2 sec. The participant is instructed to add the numbers in pairs, so that each number is added to the one that immediately precedes it. Correct answers are recorded. Test–retest coefficients across testing intervals spanning 0, 5, 6, 12, and 18 months range from 0.9 to 0.96 (McCaffrey, Westervelt, & Haase, 2001).

Benton Visual Retention Test (Benton, 1996). The Benton Visual Retention Test (Benton, 1996) assesses visual perception and visual memory and is used in clinical diagnosis of brain damage and dysfunction in children and adults. The multiple-choice form, which was administered to the participants, consists of 15 stimulus cards and 15 multiple choice cards. After the presentation of a stimulus card for 10 s, the subjects are asked to choose the initial figure among four options. Correct answers are recorded, possible total scores range from 0 to 15. Test–retest coefficients range from 0.78 to 0.93. The "split-half" reliability of the multiple choice form was found to 0.76 (Benton, 1950).

Neuropsychological questionnaire. To analyze the state of the participant's health after the training, the following questions were administered: (a) Do you have a headache now? (b) Did you have a headache during the training? (c) Do you have neck-pain now? (d) Do you have neck-pain if you move your head toward your chest? (e) Do you feel nauseated? (f) Are you dizzy now? (g) Are you sweating a lot? (e) Are your hands trembling? (g) Are you especially sensitive to light now? (h) Did your sense of taste and smell change since you trained? All questions had to be answered with "yes" or "no".

Procedure

On the pretest, participants had to complete all tests mentioned in the methods section. Participants were matched by their performance in the ZVT, age, and sex and assigned to one of the three experimental groups. The post-test took place 1 week after the pretest at the same time during the day as the pretest. Immediately prior to the post-test, the participants of the TG underwent a typical 30-min training session with 15 min dedicated to heading exercise. Fifteen minutes is considered to be normal heading time during actual soccer training. The PCG received a 30-min training session with non-heading exercises. Fig. 1 shows the course of these training sessions. Participants of WCG were instructed not to exert themselves physically 30 min prior to the post-test. Participants needed approximately 30 min to complete the questionnaires and the neuropsychological tests.

Statistical methods

To analyze the neuropsychological tests, a 2 × 2 × 3 analysis of variance with test time (pre- and post-tests) as a within-subject factor and the factors group (TG, PCG, WCG) and sex (men and women) as between subject factors for each of the dependent variables (D2 Test, PASAT Test, Benton Test) was conducted. One participant did not complete the post-test of the PASAT Test, and four participants did not complete the post-test of the D2 Test.

The Kruskal–Wallis Test was applied to examine differences between the groups regarding the frequency of headache, dizziness, neck pain, and nausea after the training (see neuropsychological questionnaire). The significance level of the test was corrected for multiple testing resulting in a significance level of $\alpha = 0.05$.

Results

Because participants were matched by age, sex, and intelligence, the three groups did not differ in age, $F(2, 88) = 2.2$, $p = .12$; sex, $F(2, 88) = 0.32$, $p = .72$; or intelligence, $F(2, 88) = 1.04$, $p = .36$. Furthermore, the pretest data for the three neuropsychological tests, PASAT Test, $F(2, 88) = 0.88$, $p = .42$, Benton Test, $F(2, 88) = 0.27$, $p = .76$, and D2 Test, $F(2, 88) = 2.94$, $p = .06$, did not differ between groups.

The analysis of variance of the performance on the D2 Test showed a main effect of test time, $F(1, 81) = 172.49$, $p < .001$, $\eta^2 = 0.68$, and sex, $F(1, 81) = 4.76$, $p < .05$, $\eta^2 = 0.06$, but not for group, $F(2, 81) = 2.52$, $p = .09$. The concentration performance score was higher on the post-test than the pretest. Besides this, the CL was higher for women than men. There was no significant interaction between test time and sex, $F(2, 81) = 0.25$, $p = .88$; test time and group, $F(2, 81) = 0.82$, $p = .45$; sex and group, $F(2, 81) = 0.06$, $p = .94$; or test time, group, and sex, $F(2, 81) = 1.05$, $p = .36$.

The analysis of variance of the performance on the PASAT Test showed a main effect of test time, $F(1, 84) = 55.84$, $p < .001$, $\eta^2 = 0.40$, and of sex, $F(1, 84) = 5.87$, $p < .05$, $\eta^2 = 0.07$, but not of group, $F(2, 84) = 1.0$, $p = .37$. There was also a significant interaction between test time and group, $F(2, 84) = 3.14$, $p < .05$, $\eta^2 = 0.07$ (Fig. 2). This interaction is due to the fact that the performance on the PASAT Test was higher for the WCG than for the PCG—$F(1, 53) = 4.13$, $p < .05$, $\eta^2 = 0.07$—only in the post-test.

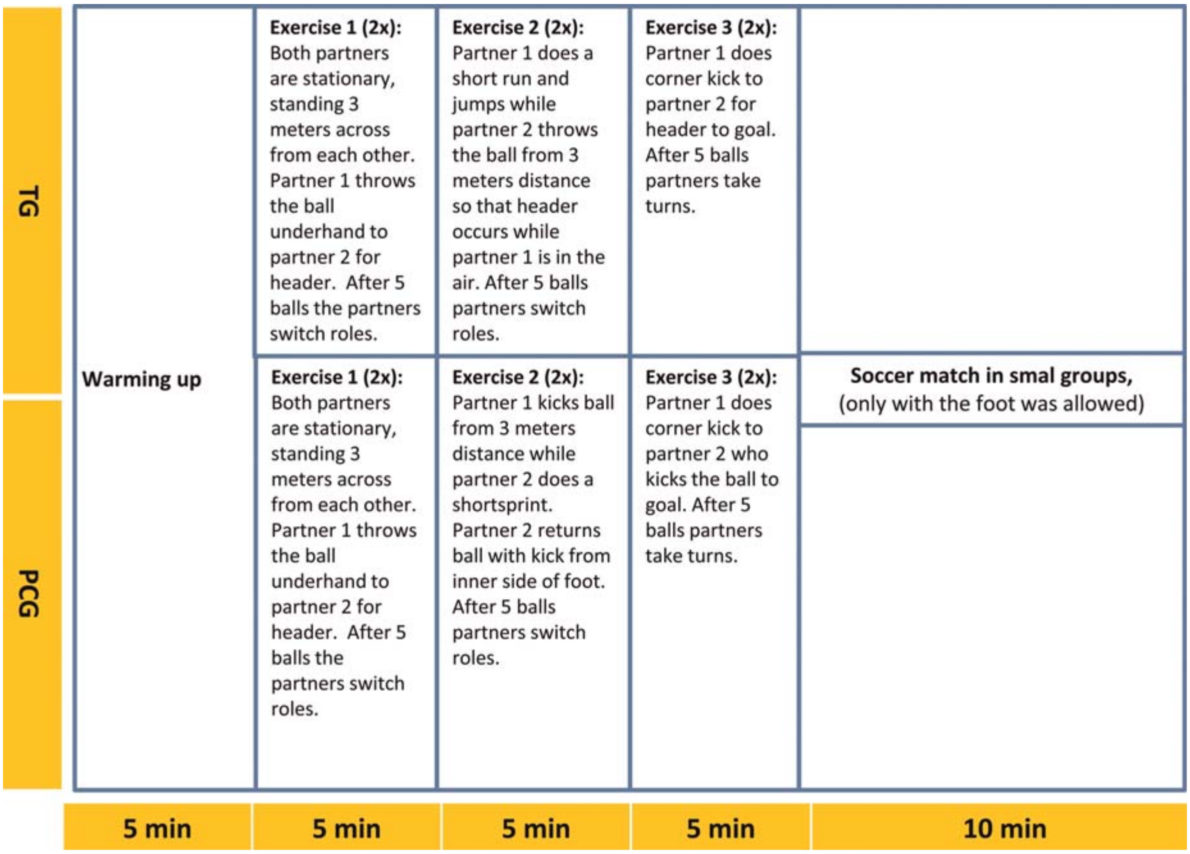

Fig. 1. Course of training sessions for TG and PCG.

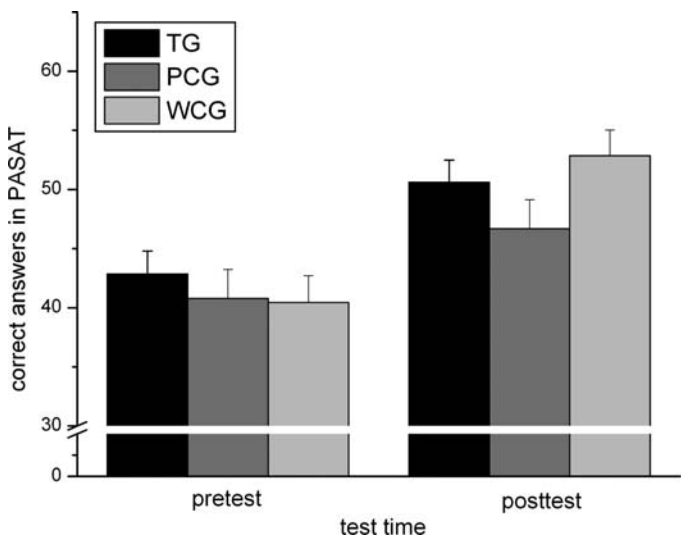

Fig. 2. Mean and standard error of correct answers in the PASAT dependent on test time and group.

There was no significant interaction between test time and sex, $F(1, 84) = 1.41$, $p = .29$; sex and group, $F(2, 84) = 0.13$, $p = .88$; or test time, group, and sex, $F(2, 84) = 0.48$, $p = .62$.

The analysis of variance of the performance on the Benton Test showed a main effect of test time, $F(1, 85) = 33.70$, $p < .001$, $\eta^2 = 0.28$. The performance was better in the post-test than in the pretest. There was neither a main effect for sex, F(1,

Table 1. Mean and standard deviations for all three neuropsychological tests, dependent on group, sex, and test time

		Men			Women		
		TG	PCG	WG	TG	PCG	WG
D2 Test	Pretest	194.31 (43.69)	184.86 (49.78)	216.66 (31.53)	218.95 (45.87)	201.73 (30.68)	226.94 (33.51)
	Post-test	239.38 (45.04)	226.71 (53.04)	248.77 (30.07)	253.23 (32.65)	250.78 (34.77)	265.56 (24.92)
PASAT Test	Pretest	39.16 (12.48)	37.28 (11.51)	34.11 (5.18)	45.04 (12.52)	41.05 (11.45)	43.61 (10.12)
	Post-test	49.00 (11.50)	42.57 (18.61)	50.00 (5.19)	51.54 (8.90)	48.04 (10.93)	54.28 (10.17)
Benton Test	Pretest	13.07 (1.44)	13.62 (0.92)	12.22 (2.81)	12.01 (1.94)	12.95 (1.16)	13.05 (1.25)
	Post-test	14.30 (0.75)	13.37 (2.55)	13.77 (0.66)	14.09 (1.15)	14.43 (0.81)	14.22 (0.65)

Table 2. Frequency of neuropsychological symptoms after training

	Headache now	Headache during the training	Neck pain	Neck pain moving the head	Nausea	Dizziness	Sweating	Tremor	Sensitive to light	Change of smell and taste
TG (m, $N = 13$)	1		1	1			7	3		
TG (w, $N = 22$)	8	12	4	2		3	9	1	3	1
PG (m, $N = 8$)							6			
PG (w, $N = 21$)	3	1	1	5	1	2	15			1
WCG (m, $N = 9$)	1	1		1	1		1		1	
WCG (w, $N = 18$)						1	1			

85) = 0.67, $p = .41$, nor for group, $F(2, 85) = 0.49$, $p = .61$. Furthermore, there was no significant interaction between test time and sex, $F(2, 85) = 1.38$, $p = .24$, test time and group, $F(2, 85) = 1.44$, $p = .24$, sex and group, $F(2, 85) = 0.92$, $p = .40$, or test time, group, and sex, $F(2, 84) = 2.99$, $p = .06$. Means and standard deviations of all analyses are given in Table 1.

Table 2 reflects the number of symptoms after the training (or waiting) for the different symptoms and groups. The appearance of headache differs between the groups (Kruskals–Wallis, $p = .001$). Nine participants (one man and eight women) of the TG reported headache after the training session, and 12 participants (all women) of the TG reported short-term headache during the training session. Nine participants (one man and eight women) of the TG reported headache after the training session (Kruskals–Wallis, $p = .039$); this had no significance after Bonferroni corrections. Overall, there were a significantly larger number of headaches in TG than in PCG (three and one) and WCG (one and one) during the training (Kruskals–Wallis, $p = .001$). In addition, participants in both sports groups sweat significantly more than the participants of the WCG (Kruskals–Wallis, $p < .001$). All data are given in Table 2.

Discussion

The most meaningful result of the study is that more participants of the TG, almost all women, reported headache during and after the training session than in the PCG or WCG. According to Poeck and Hacke (2006), the slightest form of head trauma is cranial contusion, which typically includes acute local or diffuse headache for minutes to hours. Different from head trauma, a decline in neuropsychological performance normally cannot be observed after cranial contusion. Therefore, the results of the present study can be interpreted that technically correct heading under normal training circumstances does not cause mild traumatic brain injury as proposed so far, but in worst case can cause cranial contusion and women seem to be particularly susceptible. At the first glance, this seems to be in contrast to a study of Frommer and colleagues (2011) demonstrating no gender differences in high-school athletes in the number of headaches reported after sports during the high-school year. But they did not investigate the acute effects and furthermore did not restrict their study to soccer players. At this point, it would be interesting to know if the findings of the study presented here are a result of the women's lack of heading experience, resulting in a less optimal heading technique, or indeed of gender-specific muscular differences. In our study, the heading experience between men and women in the training group differed significantly. The heading frequency of men in the heading group was around six times per training, whereas women only headed 0–1 time per training. The women's lack of experience might contribute to the gender differences in headache symptoms. Further prospective studies are warranted, investigating gender differences and incorporating matched groups on heading experience and history. Similarly, participants should be matched for neck strength, as well as reporting bias which suggests that women are more honest in reporting injuries (Dick, 2009).

Concerning neuropsychological performance, the results of the current prospective study show that 15 min of heading exercises, as it is practiced in a normal training session (1.5 h) in soccer clubs, results in no acute impairment of neuropsychological performance of attention, working memory, visual memory, or speed of information processing. Even if participants of the WCG showed a significant increase in performance in the PASAT than those in the PCG, a similar difference could not be observed between the TG and the PCG or WCG, respectively. One reason might be that the training in the PCG was more exhausting and cognitively demanding than that of the training group and this led to the poor performance on the PASAT Test. This result is in contrast to the findings of Lambourne, Audiffren, and Tomporowski (2010) who showed no impairment in the PASAT Test after 40 min of ergometric cycling. Reasons for the contradicting findings might be the different types of physical activity (soccer vs. endurance training) or the different experimental designs (in the study of Lambourne and colleagues [2010], the participants served as their own controls). The contrasting results suggest that the influence of the design of the studies, the kind of physical activity that is investigated and the methods used for the measurement of cognitive functioning all have to be carefully considered (*see* also Etnier & Chang, 2009).

Lovell and Collins (1998) argue that neuropsychological testing is a very sensitive method to detect minimal brain damage, but Beglinger and colleagues (2005) stated that these tests are prone to learning effects. In our study, we found significant improvement of test performance from pre- to post-test for all three neuropsychological tests. It is not possible to conclude on the basis of the collected data that heading under typical training circumstances will have an acute effect on neuropsychological performance. These findings confirm the data of Putukian and colleagues (2000) even in an experimental design with matched control groups.

Besides cognitive damage, there are concerns about the neurometabolic effects of concussion as described by Giza and Hovda (2001). After concussion, ionic shifts occur that result in subacute changes in cellular physiology. A "hypermetabolism" occurs during a reduced cerebral blood flow. Because there is a disparity between the supply and the demand of glucose, a cellular energy crisis is triggered. This phase is followed by a period of depressed metabolism. Even though we did not find any cognitive impairment on the behavioral level, we could not rule out changes on cellular physiology.

Although this study offers a glimpse into possible effects of heading, it also has its limitations. It is an exploratory study with a limited number of cognitive measurements, but it is the first study we know of to attempt to control for interfering variables using control groups that are matched by IQ and a pre–post-test design. In following studies, the number of neurocognitive measurements has to be augmented by using parallel versions in the pre- and post-test.

Because the effect of trauma that is caused by impact forces smaller than those needed for traumatic brain injury is most likely to be cumulative (Rutherford et al., 2003), this damage is expected to cause chronic rather than acute symptoms. For that reason, the long-term effects of repeated heading should be examined in further prospective research, even though a lot of quasi-experimental designs already exist. For future research, it might be possible to assess a neuropsychological baseline, count the number of heading trainings and headings in games for a certain duration (e.g., 1 week), and test the neuropsychological functions immediately after one training session at the end of the week by controlling for gender, age, training status, heading experience, and IQ. This would combine the prospective study presented here with those of cumulative effects of heading.

Furthermore, the heading experience of female and male soccer players and the prior concussion history of all participants have to be controlled in more detail. Since there are known gender differences in neck strength and hormonal expression, further research should also control for these factors in relation to the onset of headache. Because of the gender differences found, not only the strength of the neck muscles, but also the hormonal status of the women and the relation to the appearance of headache have to be controlled. Hormonal status might play an important role, because headaches in women have been related to changes in the levels of the female hormone, estrogen, during the menstrual cycle. To provide more thorough conclusions on hormones and heading, there also should be a baseline measurement of concussion symptoms (especially headache).

Conclusion

This prospective preliminary study with matched control groups and a pre–post-test design did not show any neuropsychological impairment immediately after a heading training. In the training group, 50% of women complained of headache during the training and 36% complained of headache after the training session. This result deserves further investigation, where the heading experience, muscle strength, and hormonal status of women must be controlled.

Conflict of Interest

None declared.

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