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Is Migraine Headache Associated with Concussion in Athletes? A Case-Control Study

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Abstract

Objective—The purpose of this study was to investigate the association between migraine headache and concussion in athletes.

Design—Case-control observational study.

Setting—A university-associated combined sports neurology and orthopedic sports medicine clinic.

Participants—A total of 221 male (n=140) and female (n=81) athletes aged 12-24 years, including 115 concussion cases (52%) and 106 orthopedic controls (48%), were included in this study.

Interventions—Participants completed a one-page questionnaire that recorded their age, sex, reason for visit (concussion vs. any other injury), concussion history, and self/immediate family member migraine headache history.

Main Outcome Measures—The odds of having a prior history of migraine headache were compared in the concussion group vs. orthopedic controls.

Results—Controlling for between-group differences in age and sex, there was a significant positive association between concussion group status and history of migraine headache (Adjusted OR = 1.90; 95% CI: 1.03 – 3.50. p = 0.039). However, when including prior concussion history in the statistical model, this relationship failed to reach significance (Adjusted OR = 1.68; 95% CI: 0.89 – 3.16. p = 0.107).

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Conclusions—These results suggest that there is an association between migraine headache and concussion in athletes, but the cause-effect nature of this relationship cannot be determined. Migraine headache should be considered a modifying factor when caring for concussed athletes.

Keywords

Athlete; Concussion; Headache; Migraine

Introduction

As concussion grading scales have fallen out of favor, a more individualized approach to concussion assessment and management has been advocated.[1] Such an approach requires assessment of individual modifying factors that may place an athlete at elevated risk for sustaining concussion, as well as for experiencing a prolonged recovery course, or presenting with a particular constellation of clinical signs and symptoms. Such modifying factors may include age, sex, concussion history, pre-existing learning disabilities, attention deficit hyperactivity disorder, and other comorbidities.[2] Management decisions should take these modifying factors into account as each concussion is unique and can result in a variety of clinical outcomes, ranging from rapid symptom resolution to chronic neurological impairment. Therefore, any potential prognostic information obtained before or after the injury should be utilized when managing sport-related concussion.

Migraine headache has also been suggested as a potential modifying factor for concussion. In support of this, Gordon et al. reported a positive association between migraine headache and concussion in a cross-sectional survey of Canadian respondents aged 12-24 years.[3] In this study, respondents with history of concussion had 2.36 times greater odds of having been diagnosed with migraine headache than those without. Similarly, a prospective cohort study by Kuczynski et al. reported a personal or family history of migraine in 82% of children aged 0-18 years presenting to the emergency department with mild traumatic brain injury.[4] While not specific to migraine, Schneider et al. also reported that male youth ice hockey players with a positive response to the Sport Concussion Assessment Tool headache question at preseason baseline had an incidence rate ratio for being diagnosed with concussion during the season of 1.47 compared to those with a negative response, after adjusting for age and concussion history.[5] The complaint of baseline headaches may also be associated with an increased incidence and severity of other symptoms associated with concussion.[6] In addition, clinical experience suggests that migraineurs may experience a prolonged recovery course following injury,[7] and concussed athletes experiencing migraine-like symptoms in the acute post-injury period have been shown to recover more slowly than those not experiencing migraine-like symptoms.[8, 9]

There are pathophysiological alterations in migraine headache that may underlie a physiological susceptibility to concussion and post-concussion symptoms. This is supported by previous research suggesting a common molecular pathophysiological cause of migraine and mild traumatic brain injury (mTBI).[10-12] For example, extracellular potassium and intracellular sodium, calcium, and chloride are all increased with respect to their usual concentrations in the brain after mTBI as well as in migraine.[13-15] Furthermore, both

mTBI and migraine are associated with an excess release of excitatory amino acids such as glutamate, in addition to beta-endorphins.[10, 14] Mild head trauma may also stimulate trigeminal sensory afferents through cervicogenic mechanisms similar to those seen in migraine.[16] Following forced flexion and extension of the cervical spine, upper cervical sensory nerve roots converge on the trigeminal nucleus caudalis, resulting in the sequential activation of second and third order neurons in the nociceptive pathways of the brain stem, hypothalamus, and thalamus. This in turn can lead to cortical spreading depression.[16] If damage to cervical structures also occurs during the mTBI, nociceptive input from cervical segments arriving to the trigeminal nucleus may also serve as a source of referred pain, ultimately resulting in mechanical hyperalgesia.[16]

To better characterize the relationship between migraine headache and concussion we conducted this case control study in athletes presenting to a combined sport neurology and orthopedic sports medicine clinic. The purpose of this study was to compare the presence of migraine headache between athletes being evaluated for acute concussion and a reference group being evaluated for musculoskeletal injuries.

Methods

Participants

A total of 263 respondents (40.4% female) completed the study questionnaire. Study eligibility criteria included age 12-24 years and participation in an organized sport or athletic activity for at least 30 minutes two or more times per week. Potential participants were given a brief written description of the study and the 1-page study questionnaire upon checking-in to a busy University-associated outpatient sports medicine clinic. Those athletes being seen by a sport neurology provider for concussion were classified as cases, while those athletes being seen by an orthopedic sports medicine provider for any reason other than concussion were classified as controls. The instructions to participants explained that the questionnaire was anonymous and that participation in the study was voluntary. Informed consent was implied by completion and return of the anonymous questionnaire. Participants under the age of 18 were instructed to obtain parent/guardian approval before completing the questionnaire. Participants were instructed to complete the questionnaire only once. The ethics of this study were approved by the institutional research ethics board at the lead author's institution.

Procedures

Participants completed the 1-page study questionnaire before or after their medical appointment and returned it to clinic staff at the time of check-out. The questionnaire inquired about the participant's age, sex, reason for visit (concussion vs. any other injury), self and immediate family history of diagnosed migraine headache, concussion history, and their sport/athletic activity participation. A modified version of the ID Migraine Questionnaire was also included in the questionnaire. The ID Migraine Questionnaire is a valid and reliable 3-item screening instrument that has been shown to be 81% sensitive and 75% specific for migraine headache.[17] The modification to the original ID Migraine Questionnaire instructed respondents not to consider any new headaches related to a recent

concussion when answering the ID Migraine questions to reduce the possibility of a positive ID Migraine response being due solely to post-concussion symptoms. Participants were considered to have a history of migraine headache either if they reported a prior diagnosis by a health care provider or had a positive response to the modified ID Migraine Questionnaire.

A copy of the questionnaire printed on blue paper was provided to athletes whose appointment was with a sport neurology provider and a copy of the questionnaire printed on white paper was provided to athletes seeing an orthopedic provider. The color of the questionnaire was cross-checked with the participant-reported reason for visit to ensure correct assignment to the case and control groups. A total of 3 respondents seen by a sport neurology provider for any reason other than concussion or seen by an orthopedic provider who reported a visit reason of concussion were excluded from the analysis. In addition, 3 respondents were excluded because their age fell outside of the eligible age range, and 36 were excluded because they did not meet the study's minimum sport or athletic activity participation criteria.

Statistical Analysis

Descriptive statistics and frequencies were calculated for continuous and discrete variables, respectively. T-tests were used to compare continuous outcomes between groups. Chi-square tests were used to compare discrete outcomes between groups, with calculation of associated odds ratios. Comparisons between the concussion and control groups were considered the primary analyses of the study. Additional secondary analyses were performed to compare those participants with a prior history of migraine headaches to those without. Variables found to be significantly related to either concussion/control group status or prior history of migraine headache were then included in multiple logistic regression models, with calculation of adjusted odds ratios.

Results

A total of 221 participants were deemed eligible for study inclusion [115 concussion cases (52%), 106 orthopedic controls (48%)]. The concussion group was younger (16.2 ± 2.4 vs. 17.1 ± 3.0 years; $p < 0.001$) and contained 8% fewer females (33% vs. 41%; $X^2 = 1.3$, $p = 0.25$) than the control group. Additional primary comparisons between the concussion and control groups are presented in Table 1. The concussed group had 1.80 times greater odds of being previously diagnosed with migraine headache by a medical provider (95% CI: 0.79 – 4.10) and 1.64 times greater odds of a positive response to the modified ID Migraine Questionnaire (95% CI: 0.90 – 3.02) compared to the control group. Twenty-three participants in the concussion group (23.7%) and 16 participants in the control group (16.7%) who had not previously been diagnosed with migraine headache by a medical provider had a positive response to the modified ID Migraine Questionnaire. Based on the study definition of either a prior clinician diagnosis or a positive modified ID Migraine response to indicate a history of migraine headache, those in the concussed group had 1.70 times greater odds of having a history of migraine headache (95% CI: 0.95 – 3.06) compared to controls. A post-hoc power analysis demonstrates that our study sample was underpowered (Power = 0.42) to detect a significant primary relationship of the observed

magnitude between migraine headache history and group status, using a two-tailed alpha of 0.05. The odds of having a first degree relative diagnosed with migraine headache in the concussed group were 0.98 times (95% CI: 0.57 – 1.67) those of the control group. Those in the concussion group were significantly more likely to have sustained a previous concussion than controls (OR = 3.21; 95% CI: 1.83 – 5.62).

In secondary analyses, females were significantly more likely to have a history of migraine headache than males (39.5% vs. 25.0%; $p = 0.024$). There was no significant relationship between history of migraine headache and age (16.61 ± 2.20 vs. 16.66 ± 2.93 years in migraineurs vs. those without migraine headache; $p = 0.890$), family history of migraine headache (47.8% of migraineurs vs. 37.0% of those without migraine headache; $p = 0.134$), or prior history of concussion (52.2% of migraineurs vs. 39.9% of those without migraine headache; $p = 0.089$). A total of 14 participants who had previously been diagnosed by a medical provider with migraine headache also had a prior history of concussion. In this subset of participants, 11 (78.6%) sustained their first concussion prior to being diagnosed with migraine headache.

A multiple logistic regression that controlled for between-group differences in age and sex, demonstrated a significant positive association between concussion group status and history of migraine headache (Adjusted OR = 1.90; 95% CI: 1.03 – 3.50. $p = 0.039$). However, when concussion history was also accounted for in the multiple logistic regression model, the relationship between concussion group status and history of migraine headache failed to reach statistical significance (History of migraine: Adjusted OR = 1.68; 95% CI: 0.89 – 3.16. $p = 0.107$; History of prior concussion: Adjusted OR = 3.15; 95% CI: 1.76 – 5.65. $p < .001$). A secondary multiple logistic regression analysis controlling for the effects of age and sex identified a significant positive association between history of migraine headache and prior history of concussion (Adjusted OR = 1.86; 95% CI: 1.02 - 3.37. $p = 0.042$).

Discussion

These results suggest that migraine headache may be a risk factor for concussion in athletes. However, a true cause-effect relationship cannot be inferred from these data. In this study, prior concussion was a stronger risk factor for being a member of the concussion group than migraine headache in both the bivariate and multivariate models. There was also a significant positive association between prior concussion history and prior history of migraine headache in the secondary multivariate analysis. This raises a “chicken-and-egg” question as to whether presence of migraine headache predisposes athletes to concussion, or concussion predisposes athletes to develop migraine headache. While not a definitive finding, almost 80% of those participants reporting both a history of clinician-diagnosed migraine headache and prior concussion sustained their concussion prior to receiving their migraine headache diagnosis.

The association between sport-related concussion and subsequent migraine headache is consistent with prior research. In a 2015 study of collegiate athletes, 35.9% with a prior history of concussion, and 40.4% of those with a history of more than one concussion, also self-reported a history of migraine.[18] In a similar study of high school football players,

40.7% of those indicating a history of concussion also reported a personal history of migraine.[19] However, as these studies were retrospective in nature, it is unclear whether a predisposition to headaches existed prior to the documented concussions. Additionally, a 2015 study of retired NFL players with prior history of concussion found a significantly higher incidence and frequency of headache, migraine, and chronic migraine when compared to the general population.[20] Furthermore, a report in non-athletes that almost one third of patients experiencing chronic migraine headache precipitated by minor head trauma have a family history of migraine, suggests that there may be an inherent predisposition to refractory post-traumatic migraine headache symptoms in this subset of the population.[21]

The reason for a possible elevated risk of migraine following concussion is uncertain. Endogenous opioids, i.e. those that are naturally occurring within the brain such as beta-endorphins, may play a role. Endogenous opioids are known to increase following mTBI.[22] In both episodic and chronic migraine, basal plasma beta-endorphin levels are decreased.[22, 23] Of note, a similar finding has also been observed in medication overuse headache.[24] These observations suggest that unique differences in endogenous pain modulation involving the opioid system in migraineurs could conceivably contribute to the pathophysiology of other pain hypersensitivities. Specifically, it is possible that such biochemical baseline abnormalities decrease the symptom threshold in migraineurs following head trauma, subsequently predisposing to more pronounced and/or more refractory symptoms post-injury.

Individuals with post-traumatic headache have also exhibited nociceptive dysfunction consistent with a generalized impairment of the spinothalamic system.[25] Chronic post-traumatic headache seems to result from a combination of injury to both central and peripheral structures, possibly leading to central pain, and chronic sensitization of intra- and extracranial nociceptors.[26, 27] This apparently traumatically-induced sensory profile is compatible with the central sensitization seen in migraine sufferers and may further explain an elevated risk of migraine headache following concussion.

There may also be other pathophysiological underpinnings for development of persistent post-traumatic migraine headache, i.e., migraine headache following head trauma, after concussion. An association between chronic pain and dysfunctional pain modulation has been reported for migraine, as well as other types of primary headache disorders.[28] Pain “remapping” has been observed in migraineurs following injury to the trigeminal system.[29] This response appears to be specific to migraine, suggesting the pathophysiology of migraine is impressionable and responds uniquely to external insults such as concussion. This would suggest that the refractory clinical course noted in some athletes with chronic post-traumatic headache may be more attributable to an inherent susceptibility for dysfunctional pain modulation than a direct result of the injury itself.

The relationship between migraine headache and concussion is further complicated by the fact that head trauma is a known trigger for migraine headaches. Indeed, the diagnosis of “footballer's migraine” has been described in the medical literature for over 40 years.[30] Given the significant overlap between symptoms of concussion and those of migraine

headache, it is possible that in some cases an athlete experiencing a migraine headache could be mis-diagnosed with concussion. It is possible that the mis-classification of post-traumatic headaches as concussion may spuriously inflate the strength of their association.

There is also a growing body of literature suggesting a potential association between sport-associated head trauma exposure and neuroanatomical,[31-35] neurophysiological,[36, 37] and neurocognitive[33, 35-38] changes in athletes not manifesting clinically-evident signs or symptoms of concussion. It is possible that migraineurs may have a lower tolerance than non-migraineurs for such disruptions and that their physiological threshold for developing headaches and related neurological symptoms in response to such changes may therefore be lower. If this is the case, then migraineurs may be predisposed to developing signs and symptoms of concussion in response to lesser degrees of neurological dysfunction that would remain sub-clinical in non-migraineurs. The presence of such a differential threshold for symptom manifestation could also increase the likelihood of migraineurs receiving a concussion diagnosis.

It is important to consider that headache, like most post-concussion symptoms, is not specific to concussion and can also be caused by various other exposures that are relevant to athletes. For example, migraine headache can be triggered by sleep deprivation, physical exertion, changes in environmental conditions, emotional stress, and dehydration. It has been also been demonstrated that dehydration in athletes can mimic other symptoms of a concussion as well.[39] Prescription medication use/abuse should also be considered when an athlete presents with concussion-like symptoms in the absence of reported injury. Similarly, excessive use of analgesics following concussion may contribute to persistent post-traumatic headaches in some individuals. A 2014 retrospective chart review of adolescent concussion patients diagnosed with chronic post-traumatic headache found that 70.1% met criteria for probable medication overuse headache.[40] Of these, 68.5% had resolution of headaches (or return to pre-concussion headache patterns) after discontinuing analgesics. In attempt to limit the progression to a more prolonged/refractory recovery course, athletes presenting with headache should routinely be screened for the potential of medication overuse headache.

This case-control study has several limitations that merit further discussion. The biggest limitation is the inability of this study design to establish a cause-effect relationship between migraine headache and concussion, as is discussed above. Secondly, participants were surveyed at only one post-concussion time point, the timing of which was not standardized relative to the time of injury. As such, they were not asked to complete a formal post-concussion symptom inventory. Therefore, it is not possible to comment on the potential influence of migraine headache on the severity or duration of post-concussion symptoms based on the results of this study. Thirdly, the anonymous nature of the survey did not permit confirmation that participants being seen in the sport neurology clinic were in fact diagnosed with a concussion, so in some cases an alternative diagnosis may have been assigned. Fourthly, since the relative timing of questionnaire completion and the clinic visit was not strictly controlled for, it is possible that participants who completed the questionnaire after a neurological history was taken during a sport neurology clinic visit may have been more likely to report a history of migraine headache or concussion than those who completed the

questionnaire before their visit, or than those who were seen by an orthopedic provider. Finally, this case-control study design does not address the incidence of concussion or migraine headache in the general athlete population.

In conclusion, this study supports the presence of an association between migraine headache and concussion in athletes, but the cause-effect nature of this relationship cannot be determined. Additional prospective research is necessary to further define this relationship, as well as to further assess the potential effects of a migraine headache diagnosis on concussion severity. Until such results are available, clinicians should continue to consider the potential effect of an athlete's migraine headache history on their recovery and risk for re-injury when making return-to-play decisions following concussion.

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Table 1

Characteristic	Concussion Group	Orthopedic Control Group	Significance
Prior Clinician Diagnosis of Migraine Headache	18 (16%)	10 (9%)	$X^2 = 2.0$ $p = 0.16$
Positive Response to Modified ID Migraine Questionnaire	36 (31%)	23 (22%)	$X^2 = 2.60$ $p = 0.11$
History of Migraine Headache *	41 (36%)	26 (25%)	$X^2 = 3.2$ $p = 0.07$
Family History of Migraine Headache	46 (40%)	43 (41%)	$X^2 = 0.01$ $p = 0.93$
Prior History of Concussion	65 (57%)	31 (29%)	$X^2 = 17.23$ $p < 0.001$

* History of migraine headache was defined as either prior clinician diagnosis or positive response to the modified ID Migraine Questionnaire.