Premorbid Primary Headache and Vestibular and Oculomotor Baseline Assessments in Collegiate Athletes

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Abstract

Objective: The purpose of this study was to determine the effects of premorbid headache status on vestibular and oculomotor baseline tests in collegiate club athletes. **Design:** Retrospective case–control study. **Setting:** Sport Concussion Laboratory. **Patients (or Participants):** Collegiate club athletes with a self-reported premorbid headache history (n = 32, 19.50 ± 1.98 years, and 31% women) and age–sex–sport–matched controls (n = 32, 19.56 ± 1.47 years, and 31% women) without a self-reported headache history were included. **Interventions:** Participants were grouped based on a self-reported headache history at baseline. Controls were randomly matched to self-reported headache participants by age, sex, and sport. **Main Outcome Measures:** Vestibular/ocular motor screen (VOMS) baseline symptoms, symptom provocation, near point of convergence (NPC) distance, and King–Devick (K-D) test time were compared between groups. **Results:** Athletes with a self-reported headache history at baseline are 3.82 times more likely to have abnormal NPC scores ($P = 0.032$) and 4.76 times more likely to have abnormal K-D test times ($P = 0.014$) than those without a headache history. There was no difference in VOMS baseline symptoms or symptom provocation between groups ($P > 0.05$). **Conclusions:** Club collegiate athletes with a headache history were more likely to screen as abnormal during a vestibular/ocular motor function assessment than athletes without a history of headaches. Healthcare professionals should screen for pre-existing headache during baseline concussion assessments before test interpretation. **Clinical Relevance:** A premorbid headache history at preseason baseline assessment may influence vestibular and oculomotor function, and care should be taken when interpreting these individuals' tests.

Key Words: headache, oculomotor, near point of convergence, athlete

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INTRODUCTION

Ninety-six percent of individuals will experience a headache within their lifetime with women suffering at a higher rate.[1] In the young adult population, 14.2% reported at least one severe headache in a 3-month span.[2] Primary headaches have no underlying cause and include diagnoses of migraine, tension-type headache, and cluster headache, whereas secondary headaches are the result of another condition causing inflammation of pain-sensitive structures. The most common causes of secondary headaches are infection, vascular disease, and trauma, including concussion.[1]

Concussions are also a national health concern with estimated 3.8 million sports-related injuries occurring annually.[3] Headaches are one of the most commonly reported symptoms postconcussion,[4] with 93% of concussed individuals reporting posttraumatic secondary headache.[5] In addition, secondary headache has been identified as a predictor for prolonged concussion recovery.[6] Many clinicians use a single questionnaire (eg Postconcussion Symptom Scale) to determine headache status postinjury, which fails to account for headache origin or preinjury headache status.[7]

Clinicians commonly use symptomology as part of the concussion assessment. Headache, dizziness, fogginess, and nausea are used to group individuals into the ocular motor, vestibular, and posttraumatic migraine trajectories for concussion recovery.[8] These same symptoms are used during the vestibular/ocular motor screen (VOMS) to assess a change of function in the vestibular and ocular motor systems. However, the VOMS is also able to identify motor deficiencies that are experienced by up to 65% of concussed patients,[9,10] whereas the King–Devick (K-D) test offers a more objective measure of saccadic eye movement.[10]

Vestibular ocular function was shown to be affected by diagnosed migraines in adolescents, with VOMS and K-D performance at baseline concussion assessment being worse than nonmigraine controls.[11] However, little is known regarding whether premorbid headache status affects vestibular and oculomotor function in collegiate athletes. Therefore, the objective of this study was to determine whether a self-reported history of headache in collegiate club athletes had an effect on baseline VOMS symptom provocation, near point of convergence (NPC) distance, and time on the K-D test.

METHODS

Collegiate club men's and women's rugby and men's ice hockey athletes at an urban university were recruited to have their information collected during their routine preseason

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TABLE 1. Demographic Information for Groups

	Headache	Control	*P*
Weight (kg)	78.00 ± 22.51	82.17 ± 19.44	0.469
Height (cm)	171.40 ± 9.36	173.21 ± 9.47	0.886
Age (yr)	19.50 ± 1.98	19.56 ± 1.47	0.824

Data presented as mean ± SD.

concussion baseline testing. Data were collected from September 2016 to September 2019, with all participants being 18 years or older at time of data collection with no history of concussion in the previous 3 months or vision problem that could not be corrected with lenses. Athletes were included in the case group if they self-reported a history of primary headache on their concussion baseline health history questionnaire. Cases were randomly matched from the data set of eligible athletes on age, sex, and sport.[12]

Health History Questionnaire

A health history questionnaire consisted of questions regarding past and present medical conditions. The questionnaire encompassed 11 demographic questions (eg, age, year in college, sport, and current medications), 13 questions regarding known concussion risk factors including diagnoses of mental and clinical health, such as depression, anxiety, and attention deficit hyperactivity disorder. The participants also answered questions about past and present headache disorders, musculoskeletal injury, vestibular, and ocular conditions (ie, balance issues, motion sickness, and vision impairments).

Vestibular/Ocular Motor Screen

The VOMS is a clinical screening tool that assesses vestibular and ocular motor function and patient-reported symptoms. It is a validated assessment tool (intraclass correlation coefficient [ICC] = 0.89) for the screening of vestibular/ocular deficiencies after concussion.[10] The VOMS assessment is composed of subtests including (1) smooth pursuits, (2) horizontal saccades, (3) vertical saccades, (4) NPC, (5) horizontal vestibular ocular reflex (VOR), (6) vertical VOR, and (7) visual motion sensitivity.[10] Athletes rate their symptoms for headache, dizziness, nausea, and fogginess from 0 (none) to 10 (severe) at baseline and after each subtest. NPC distance was assessed using an accommodative convergence ruler across 3 trials, with the average recorded (in centimeters from the upper lip) at the point the athlete self-reported double vision or lateral deviation of an eye was observed. For this study, baseline scores (ie, sum of total symptoms at preassessment), symptom change scores for each subtest (ie, post-subtest score subtracted from preassessment score), and average NPC distance were recorded and classified as normal or abnormal. Symptoms were normal if < 2 were reported during the assessment and abnormal if ≥ 2. NPC was normal if the average was < 5 cm and abnormal if ≥ 5 cm.[10]

King–Devick

The K-D test is an assessment of eye movement, attention, and language. It is performed by the participant speed reading aloud single-digit numbers from left to right from 1 demonstration card to 3 test cards that become progressively more difficult.[13] The test was performed using spiral-bound paper test cards. The K-D test has shown high levels of reliability with an ICC of 0.97.[14] Owing to a high learning effect, the average total time of the 3 test cards (in seconds) of 2 trials with no errors was taken.[13,15,16] Higher scores represent worse performance on the test. K-D was classified as normal and abnormal, with the average test time of all participants taken, and those scoring ≥ 5 seconds above average classified as abnormal.[17,18]

Data Collection

Athletes provided self-reported demographic and medical history information during their preseason baseline concussion assessment. Pertinent demographic data included sex, age, and sport. The relevant medical history included history of headaches (ie, "Do you have a problem with headaches?"), previous concussion history, personal/familial migraine history, motion sickness, and history of vision disorders. Participants were then administered the VOMS and K-D tests by a trained research staff member, with all items being given in a standardized order (ie, items given in the same order and metronome speeds).

Primary outcomes of the study included the VOMS baseline score, VOMS subtest change scores, NPC distance, and K-D reading times between groups. The university's institutional review board approved all procedures, and athletes consented to be included in the study before baseline testing.

Statistical Analysis

Descriptive statistics, including mean values and standard deviations (SD), for continuous variables and frequencies for categorical variables were determined for each group and assessment outcome. Fisher exact tests with odds ratios (ORs) were used to identify significant differences between groups

TABLE 2. Near Point of Convergence (NPC) by Headache Group

	Abnormal	Normal	Total
Headache	15	17	32
Control	8	24	32
Total	23	41	64

TABLE 3. K-D by Headache Group

	Abnormal	Normal	Total
Headache	15	17	32
Control	5	27	32
Total	20	44	64

and assessment outcomes. $P < 0.05$ was set as the level of significance a priori, and SPSS software (version 27.0; IBM, Armonk, NY) was used for all analyses.

RESULTS

A total of 64 athletes were included from eligible baselines, 32 athletes that self-reported a history of headaches and 32 matched controls. Athletes were aged 18 to 27 years with no significant differences ($P > 0.05$) between groups. Women comprised 31% of each group. Demographics for each group are listed in Table 1.

Athletes with self-reported headaches were 3.82 times more likely to have abnormal NPC scores ($\geq$ 5 cm) at baseline than peers without a self-reported history of headache (95% CI = 1.239, 11.801; $P = 0.032$; Table 2). Athletes with premorbid headache were 4.765 times more likely to have abnormal K-D reading times than those without (95% CI 1.464, 15.508; $P = 0.014$; Table 3). Notably, 25% and 16% of controls scored abnormal during NPC and K-D, respectively. The baseline VOMS score and change in VOMS symptoms were not statistically significant between headache groups (OR = 1.552, 95% CI = 0.241, 9.974; $P = 1.000$ and OR = 1.000, 95% CI = 0.131, 7.605, $P = 1.000$, respectively; Tables 4 and 5).

DISCUSSION

This study found that collegiate student athletes reporting a history of headache at baseline testing were at greater risk for abnormal vestibular ocular findings, specifically during NPC and K-D. VOMS baseline symptoms and symptom provocation were not similarly affected. A considerable portion of the control athletes also had abnormal findings on both the NPC and K-D tests. Abnormal NPC scores may be attributed to asymptomatic convergence insufficiency that occurs in up to 27.5% of the general population.[17,18] The false-positive rate for the NPC test in healthy collegiate student-athletes has been previously recorded as high as 16%.[19,20] Reading skill level, learning disorders, and a primary home language other than English are factors that affect performance on the K-D and may falsely flag an individual as abnormal.[21] Clinicians should be aware of individuals testing outside the normal range at baseline, particularly during any postinjury test interpretation because they fall outside the expected outcomes.[10,22–24]

Abnormal K-D findings may be due to the effect of migraine or headache on rapid eye movements, attention, and information processing necessary to complete the test efficiently.[25] K-D has been found to be highly sensitive to altered cerebral function, seen with both concussion and headache, making it difficult to distinguish abnormal results between conditions.[25] Abnormal NPC findings may be indicative of convergence insufficiency, this occurs when the eyes fail to move inward to focus on a close object.[26] When an individual has convergence insufficiency, doing tasks up close, such as reading, are more difficult. Symptoms of convergence insufficiency include other vision problems, which were controlled for in this study, and headache.[26] Duprey et al[27] found athletes with abnormal NPC at baseline to have a 12.3-fold increased risk of prolonged recovery after concussion ($\geq$ 28 days from injury) than those with normal convergence. Identifying these individuals at baseline may have implications for management and treatment postinjury.

Although headache status in the current study was not associated with an increased risk of abnormal VOMS scores, Moran et al[11] identified preinjury migraine status effected VOMS and K-D outcomes at baseline. Adolescent athletes with premorbid migraine reported greater symptom provocation during smooth pursuits, convergence, vestibular ocular reflex, and visual motion sensitivity, and they had slower K-D reading times. More severe headache cases that have required physician assessment may be at higher risk for greater vestibulo-ocular deficits. Posttraumatic headache (ie, headache occurring after concussion) has also been established as a predictor for abnormal convergence and VOMS scores after concussion. However, this did not take into account preinjury headache status.[28]

Limitations

The primary limitation with this study was that sport participation was limited to 2 sports limiting the generalizability to other age groups and levels of sport participation. However, this study may propel findings in future research within other populations and if they are similar and remain stable. Further classifying headache type may help the clinician understand the full effect of the headache. Using a larger symptom checklist or patient reported outcome to understand the patient's headache experiences may be beneficial in achieving this in the future. In addition, the K-D test only determines differences in clinical outcome

TABLE 4. VOMS Baseline Symptoms by Headache Group

	Abnormal	Normal	Total
Headache	3	29	32
Control	2	30	32
Total	5	59	64

TABLE 5. VOMS Symptom Provocation by Headache Group

	Abnormal	Normal	Total
Headache	3	29	32
Control	3	29	32
Total	6	58	64

measures, assessing patient reported outcomes, including changes in symptoms, similar to the VOMS assessment may give more insight into patient experiences.

Future Directions

Based on the results of this study, future research should evaluate how differences in primary and secondary headaches affect outcomes on vestibular and ocular function and if these differences are still present and how they change postconcussion. Determining differences in patients currently experiencing a headache or migraine attack and those in an interictal state (ie, between attacks) on commonly performed concussion assessments may also give clinicians better understanding for test interpretation.[25]

CONCLUSIONS

Collegiate athletes with a headache history had increased risk of abnormal K-D test times and abnormal NPC scores. Identifying a patient's history of headache is critical for appropriate test interpretation and patient care of vestibular ocular function. Clinicians should be aware that the impact of prior headache history may have on vestibular and ocular function and how this may influence the individuals' normal function before flagging them as abnormal or, if function is impaired, refer them for additional care before sport participation.

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