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High School Start Time and Migraine Frequency in High School Students

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Abstract

Objective: To investigate whether later high school start time is associated with lower migraine frequency in high school students with migraine.

Background: Adequate sleep is thought to be important in managing adolescent migraine. The American Academy of Sleep Medicine recommends teenagers sleep 8 hours/night. Adolescents have a physiologically delayed sleep phase, going to bed and waking later than children and adults. The American Academy of Pediatrics (AAP) accordingly recommends high schools start no earlier than 8:30 AM.

Methods: Cross-sectional observational study of U.S. high schoolers with migraine. Participants were recruited nationally using social media. Respondents attending high schools starting at 8:30 AM or later were compared to those attending earlier start-time schools. The primary outcome was headache days/month.

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SP: None

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Results: 256 subjects constituted the analysis set: 115 later group vs. 141 earlier group. Age and sex did not differ. Mean(SD) self-reported headache days/month were 7(5) vs. 8(7), respectively ($p=0.985$); mean difference (95% CI for the difference) was -0.8 (-2.3 to 0.7) days. Median(IQR) self-reported total hours of sleep/school night were: 5.6 (5.0-6.6) vs. 5.6 (4.5-6.4), $p=0.058$. Students attending later start-time schools woke later (median(IQR) 6:38 AM (55 min) vs. 6:09 AM (59 min), $p<0.0001$) and left home later (median(IQR) 7:28 AM (28 min) vs. 7:02 AM (60 min), $p<0.0001$). Average commute time was also longer: 41(21) min vs. 28(16), $p<0.0001$. The vast majority in both groups reported missing breakfast at least once/week: 103/114 (90.4%) vs. 128/141 (90.8%), $p=0.907$. Hours of sleep did not correlate with headache days per month.

Conclusion: High-school start time does not have a large effect on headache frequency in high-schoolers with migraine. Given the high variance in headache days/month observed in this study, a larger study would be needed to determine whether there might still be a small effect of starting high school at/after 8:30 AM. More research is needed to establish evidence-based recommendations about lifestyle factors in adolescent migraine management.

Keywords

migraine; adolescent; sleep

Introduction:

Migraine is common in adolescents and can cause missed school and disability(1-3). When migraine frequency is high, daily medication is often offered to decrease headache frequency. However, trials of pharmacologic strategies for decreasing migraine frequency in this age group have not generated consistent evidence of efficacy. While one adolescent trial found topiramate effective at decreasing migraine frequency(4), in the NIH-funded Childhood & Adolescent Migraine Prevention (CHAMP) study, 8-17 year-olds with migraine were equally likely to have headache frequency improve if they were treated with placebo, amitriptyline, or topiramate, yet more likely to have side effects on the medications(5). It has been suggested that active co-interventions may have contributed to the high placebo response rate seen in CHAMP, as participants were seen frequently and counseled about “healthy habits” at each visit—including the importance of maintaining regular sleep(6).

Evidence suggests there is an important relationship between sleep and migraine across the age spectrum(7-10). However, one of the societal challenges that adolescents face in their effort to get regular, adequate sleep is that their brains physiologically shift to a naturally later bedtime and later wake-up time(11), yet their schools often start early in the morning. To address this, the American Academy of Pediatrics (AAP) recommends that high schools and middle schools start no earlier than 8:30 AM in order to accommodate the physiologic needs of adolescents and help them to get the minimum of 8 hours of sleep per night they need to function optimally(12, 13). However, according to the Centers for Disease Control and Prevention (CDC), only about 18% of U.S. high schools comply with this AAP recommendation(14).

In this study, we hypothesized that high school students with migraine who attend high schools that comply with the AAP recommendation would have lower migraine frequency compared to those whose schools start earlier. If so, and if the effect size was similar to that seen when taking a daily prescription migraine preventive, this would advocate for changes in high school policy to optimize the health of adolescents with migraine.

Methods:

This study was approved by the UCSF Institutional Review Board and registered on clinicaltrials.gov (NCT03766412) as an observational study. Participants provided assent to participate in the study. Written parental consent was waived given the low-risk nature of the study.

Study design and recruitment:

This was a cross-sectional observational study of high-school students in the U.S. who have migraine and who attend school outside of the home (i.e. are not home-schooled or attending school online). Adolescent participants were recruited using social media advertisements that directed them to a screening website. The recruitment advertisements ran nationally and targeted high schoolers with migraine, with example language such as: “Our goal is to study how high school schedules may influence migraine frequency.” If, after screening, a prospective participant met inclusion criteria, he or she was given access to the survey. To avoid influences of changes in sleep schedule over the course of the school year, we aimed to recruit the entire study sample during the month of October as students would already have been back from summer break for a month, but not yet be in the holiday season. The recruitment period ran from October 1st to October 14th, 2018. Study participants were sent a \$10 electronic gift card to compensate them for their time.

Inclusion and exclusion criteria:

To be included, participants had to live in the U.S., be able to read English, and be in 9th to 12th grade in a high school outside the home that had a consistent start time throughout the week. To determine migraine status we utilized the questions below to approximate ICHD-3 criteria for migraine in adolescents(15). The diagnostic criterion that the question refers to is shown in parentheses after each question. A “Yes” response was required for all questions in order to be eligible.

1. Have you had at least 5 headaches in your life that were at least moderate or severe in intensity and that lasted for at least 2 hours? (Criterion A, B, and part of C)
2. With your headaches, is the pain ever throbbing and/or is it ever worse with movement (i.e. do you ever lay down with a bad headache or avoid moving?) (Criterion C)
3. With your headaches, do lights and sounds ever bother you (even just a little bit) and/or do you ever have nausea (upset stomach)? (Criterion D)

4. Have you been having headaches for at least 3 months? (To get at Criterion E, i.e. that headaches are not from a secondary cause)

Power calculation:

Topiramate, an FDA-labeled medication for migraine prevention in 12-17 year-olds, was shown in one study to lower migraine frequency on average 1.5 days/month compared to placebo (SD=3) in those experiencing 14 headache days per month(4). Our question with this study was: Could a later high school start time provide a similar amount of benefit as a prescription preventive? To detect a difference of 1.5 headache days/month (SD=3) between groups, we calculated we would need 84 high schoolers per arm, with 90% power and $\alpha=0.05$. Assuming that some respondents would not fully complete the survey, we aimed to recruit at least 100 subjects per group: i.e. 100 with start times of 8:30 AM or later, and 100 with school start times before 8:30 AM. As only about 18% of schools start at 8:30 AM or later, once we had fully recruited the earlier start-time group, we targeted recruitment advertisements to run in those states that have a higher proportion of schools with later start times (specifically California and Minnesota). For cost efficiency, the survey for earlier school start time closed once an adequate sample was obtained, and subsequently only those subjects with a school start time of 8:30 AM or later could proceed to the survey.

Statistical methods:

All outcome measures and covariates were derived from participants' self-reported responses in the survey. The primary outcome measure was headache days per month. This was asked as "How many headache days did you have in the last month?" and respondents could select a number between 0-30. Secondary outcome measures included: 1) hours of sleep on a typical school night, 2) typical bedtime on a school night, 3) typical wake-up time on a school day, 4) number of missed breakfasts in a typical school week, 5) acute headache medication days per month and 6) PedMIDAS score (Pediatric Migraine Disability Assessment Scale(16)).

The primary predictor of interest was high school start time, dichotomized as before versus at/after 8:30 AM. Additional univariate analyses examined the effect of total hours of sleep per night (as a continuous variable, then dichotomized into <8 hours versus ≥ 8 hours of sleep), and consumption of breakfast.

Initially, descriptive statistics and summaries were calculated overall and by group using means and standard deviations or medians and ranges for continuous variables and frequencies and percentages for categorical variables. All outcome variables were examined for linearity and for those that were skewed median (interquartile range) was also reported. Additional univariate analyses examined the effect of total hours of sleep per night (as a continuous variable, then dichotomized into <8 hours versus ≥ 8 hours of sleep), and consumption of breakfast on the outcome variables. Outcome variables were compared between groups using Mann Whitney tests and Chi-squared tests for continuous and categorical variables respectively. Analyses were two-tailed with a level of significance of $p<0.05$. Results were rounded to the degree of precision with which they were measured. Univariate linear or logistic regression analysis was used to assess differences in groups with

respect to an outcome variable adjusting for potential confounding variables. Analyses were performed using SAS 9.4 (Cary, NC).

Results:

A total of 900 adolescents screened online for the study. Of these, 894 indicated whether their school start time fell before or after 8:30 AM. In keeping with national trends(14), the majority attended a high school that started before 8:30 AM: 682/894 (76.3%) vs. 212/894(23.7%) who attended a school that started at 8:30 AM or later. Two-hundred and thirteen were excluded. Reasons for exclusion were: not meeting migraine criteria ($n=120$), not attending high school outside of the home ($n=63$), not being in 9th to 12th grade ($n=23$), not living in the U.S. ($n=4$), and not providing assent ($n=3$). An additional 18 met inclusion criteria, however the before 8:30 AM start time sample had already filled at the time that they screened so they were not linked to the survey. The other 669 passed the eligibility questions and were brought to the survey screen. Of these, 355 of the adolescents elected not to proceed. The remaining 258 took the survey, but 2 were subsequently excluded for missing information on school start time.

The remaining 256 constituted the analysis set. One-hundred and fifteen were in the 8:30 AM or later group (late start) and $n=141$ were in the before 8:30 AM group (early start). Baseline data and pairwise comparisons are shown in Table 1. There were no differences between the two groups in terms of age, sex, and likelihood of attending public vs. private school. Mean (SD) age for the group overall was 16 (1) years; range 13 to 18 years.

There was wide variability within the groups and while those in the later school start time group had a lower average number of headache days per month, this difference was not statistically significant: 7(5) vs. 8(7), $p=0.985$. The mean difference in headache days between groups was -0.8 with a 95% CI of $(-2.3$ to $0.7)$ days. The proportion taking a migraine preventive, 18/115 (15.7%) vs. 27/141 (19.1%) ($p=0.465$), was similar between groups, as was the mean(SD) number of days of acute headache medication use: 5 ± 4 vs. 5 ± 6 , ($p=0.480$). Mean(SD) PedMIDAS score in the late start group was also lower than in the early start group, though this was not statistically significant: 30 ± 35 vs. 39 ± 50 , $p=0.189$. The distribution of PedMIDAS severity grades also did not differ between groups (see Table 2).

Bedtime on a school night was 20 minutes earlier in the late start time group (11:16 PM vs. 11:36 PM, median) though this difference was not statistically significant, $p=0.327$. Median wake-up time was 29 minutes later in the late start time group (6:38 AM vs. 6:09 AM, $p<0.0001$). Median total hours of sleep were 5.6 (IQR 5.0-6.6) in the late start time group vs. 5.6 (IQR 4.5-6.4) in the early start time group, $p=0.058$. Total hours of sleep did not correlate with headache days per month (see Figure).

School start time was not associated with likelihood of eating breakfast. Approximately 90% in both groups missed breakfast at least once a week, and the average frequency of missed breakfasts was approximately 3 out of 5 school-days (see Table 1). Late start participants

had about a 13 minute longer average commute time to school (41(21) vs. 28(16) min, $p < 0.0001$).

In exploratory *post-hoc* analyses, findings did not differ among 1) those who had <15 headache days per month vs. 15 headache days per month, 2) those who were in lower grades (grades 9 and 10) versus higher grades (grades 11 and 12), or 3) girls vs. boys. In univariate linear regression modeling, missing breakfast and sleeping at least 8 hours per night did not have a significant effect on migraine frequency (see Table 3). However, there was a significant relationship between less than 8 hours of sleep and skipping breakfast in the early start time group ($p = 0.002$) but not in the late start time group ($p = 0.145$). Overall, fewer than 10% did not miss breakfast at least once a week and only a small percentage of participants in either group got at least 8 hours of sleep per night.

Discussion:

In this study, we did not find an effect of later school start time on headache frequency in high-schoolers with migraine. However, median high school start time differed by less than an hour between the late start and early start groups. This difference may not be large enough to be clinically significant. Perhaps the current AAP recommendations do not go far enough as 8:30 AM is still relatively early for adolescents who have a physiologically delayed sleep phase. It might be akin to asking adults to arrive at work at 5:30 AM instead of 5:00 AM—both are still too early for the majority of adults' circadian physiology.

Notably, only about 1 in 8 high schoolers with migraine in either group got the recommended minimum of 8 hours of sleep per night. Concordant with our results, previous studies investigating delayed start schools have shown that while late start students have longer total sleep time, they are still not achieving the recommended amount of sleep(17-20). The American Academy of Sleep medicine recommends that teenagers get 8-10 hours of sleep per night for optimal health(12), and there is no reason to think that teenagers with migraine need less sleep than their peers. In fact, existing literature in adults suggests that adequate sleep is associated with lower migraine frequency in adults(10). However, somewhat surprisingly, total sleep time was not correlated with headache days per month in this study. Perhaps other features of sleep, such as quality of sleep, or variability vs. consistency of sleep schedule, are what is important in migraine in adolescents.

School start time is likely not the only factor contributing to inadequate sleep in high schoolers with migraine. Both groups reported having approximately 4 hours of homework each night. Furthermore, while late start students did have later wake up times, they also had longer commute times compared to their early start peers. If improvements in high school start time are offset by increased travel time to school, little improvement in total sleep time can be made. Moreover, skipping breakfast has been associated in adolescents with a higher likelihood of having headaches(21). Approximately 90% of high school students in both groups in our study reported missing breakfast at least once a week. It could be postulated that with substantially later start times, adolescents might be more likely to eat breakfast. As things currently stand, students may be continuing to sleep through breakfast given limited total sleep time or have less time to eat in the morning with their increased commute time.

Interpretation of the results of the CHAMP study highlighted the possibility that lifestyle counseling may play a role in improvement in migraine frequency in young people(6). However, we need robust research to determine whether this is in fact the case, and if so, to shape evidence-based clinical recommendations regarding lifestyle. To our knowledge, this is the first study to investigate the role of school start time on migraine frequency in high schoolers. Strengths of the study include the national recruitment strategy using social media and collection of all data during a single two-week period to prevent temporal effects from fluctuations due to school vacations, etc. There are also several limitations. All data were self-reported and recall-based. Migraine status was not confirmed by a clinician; however, this was necessary for practical purposes and ICDH-3 criteria were used to craft the survey questions. Teenagers in this study had a relatively high number of migraine days and may not be representative of the full distribution of high school students with migraine. Since study advertisements asked about headaches and school start time, perhaps those with less frequent migraine were less likely to click on the advertisement. If these non-responders would have disproportionately been in the late start time group, this would have biased results toward the null. Although the survey was designed to take less than 10 minutes to complete, many of the adolescents who met eligibility criteria elected not to complete it. It is difficult to know whether this group differed from the group who did complete the study. Future studies should seek feedback from adolescents regarding how to design optimally engaging online surveys for this age group.

Finally, this study may have been underpowered to detect a difference in headache days per month given the smaller than expected effect size combined with the larger variance. We had assumed a difference of 1.5 headache days per month with a standard deviation of 3; however, we observed a difference of 1 headache day per month (rounded to the precision of the measurement) with a standard deviation of approximately 6. The higher variance may be because we did not limit the upper end of headache days per month, whereas the trial upon which the power calculation was based limited participants to those with fewer than 15 headache days per month. A revised power calculation suggests that 445 respondents per group would be needed to have 80% power to detect a difference of 1 headache day per month, assuming a standard deviation of 6 and $\alpha=0.05$.

Conclusions:

This study did not find that a high school start time of 8:30 AM or later was associated with lower migraine frequency. A larger study is needed, as this degree of high school start time delay may still have a modest effect on migraine frequency. Importantly, the study showed that high schoolers with migraine get insufficient sleep. While our study showed no association between total sleep time and headache frequency, this real-world sample appears to be heavily skewed towards adolescents with insufficient sleep. It is also possible that some of the “healthy habits” we recommend do not actually impact migraine frequency. As with all interventions or recommendations for migraine treatment in this age group, formal studies are needed to determine whether they truly have efficacy in adolescents. Otherwise, empty promises run the risk of alienating teenagers, damaging the doctor-patient relationship, and ultimately blaming the patient for poor migraine control.

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Abbreviations:

| | |
|-----------------|--|
| CHAMP | Childhood & Adolescent Migraine Prevention |
| AAP | American Academy of Pediatrics |
| CDC | Centers for Disease Control and Prevention |
| Min | Minute |
| SD | Standard deviation |
| IQR | Interquartile range |
| PedMIDAS | Pediatric Migraine Disability Score |

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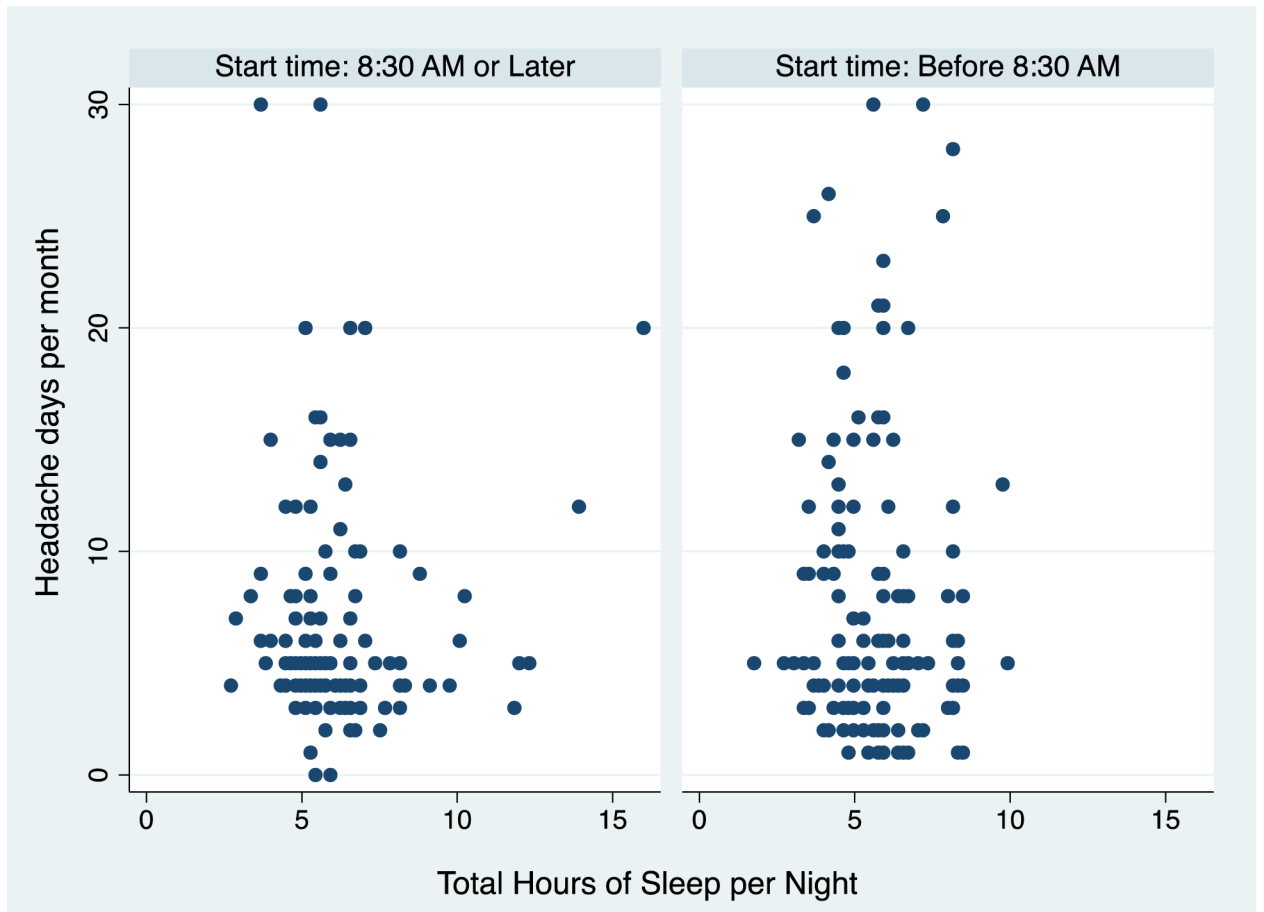


Figure:
Scatter Plot of Headache Days per Month as a Function of Hours of Sleep per Night in the 8:30 AM or Later School Start Time Group vs. Before 8:30 AM Group.

Table 1:

Sociodemographic and clinical characteristics of U.S. high schoolers with migraine: $n=115$ respondents whose high schools start at 8:30 or later vs. $n=141$ who start before 8:30 AM

| | 8:30 AM or Later ($n=115$) | Before 8:30 AM ($n=141$) | <i>p</i>-value |
|--|--|--|-----------------------|
| Sociodemographics: | | | |
| Age, years; mean (SD) | 16(1) | 16 (1.0) | 0.631 |
| Grade; n (%) | | | |
| 9th | 7 (6.1%) | 7 (5.0%) | 0.161 |
| 10th | 18 (15.7%) | 25 (17.7%) | |
| 11th | 47 (40.9%) | 40 (28.4%) | |
| 12th | 43 (37.4%) | 69 (48.9%) | |
| Gender identity; n (%) | | | |
| Male | 24 (21.1%) | 18 (12.8%) | 0.076 |
| Female | 90 (78.9%) | 123 (87.2%) | |
| | 8:30 AM or Later ($n=115$) | Before 8:30 AM ($n=141$) | <i>p</i>-value |
| Migraine: | | | |
| Headache days in the last month; mean (SD) | 7(5) | 8(7) | 0.985 |
| Had 15 headache days in the last month; n (%) | 12 (10.5%) | 22 (15.7%) | 0.227 |
| Days of acute headache medication use in the last month; mean (SD) | 5(4) | 5(6) | 0.480 |
| Currently on a migraine preventive; n (%) | 18 (15.7%) | 27 (19.1%) | 0.465 |
| PedMIDAS score: | | | |
| mean (SD) | 30 (35) | 39 (50) | 0.189 |
| median (IQR) | 19 (10-34) | 23 (11-45) | |
| School: | | | |
| School start time (median, IQR) | 8:41 AM (8:31 to 8:55 AM) | 7:49 AM (7:13 to 8:05 AM) | NA |
| Attend a public high school; n (%) | 107 (93.0%) | 130 (92.2%) | 0.798 |
| Hours of homework on a typical school night; mean (SD) | 4.0 (2.0) | 4.0 (1.8) | 0.323 |
| | 8:30 AM or Later ($n=115$) | Before 8:30 AM ($n=141$) | <i>p</i>-value |
| Sleep: | | | |
| Typical bedtime on a school night; median (IQR in min) | 11:16 PM (86) | 11:36 PM (72) | 0.327 |
| Typical wake-up time on a school day; median (IQR in min) | 6:38 AM (55) | 6:09 AM (58) | <0.0001 |
| Total hours of sleep on a typical school night; median (IQR) | 5.6 (5.0-6.6) | 5.6 (4.5-6.4) | 0.058 |
| Students who get at least 8 hours of sleep on an average school night; n (%) | 15 (13%) | 17 (12%) | 0.792 |
| Morning routine: | | | |

| | 8:30 AM or Later (n=115) | Before 8:30 AM (n=141) | p-value |
|---|-------------------------------------|-----------------------------------|----------------|
| Leave home time needed to reach school on time (median, IQR in min) | 7:28 AM (28) | 7:02 AM (60) | <0.0001 |
| Duration of commute to school (minutes); mean (SD) | 41 (21) | 28 (16) | <0.0001 |
| Miss breakfast at least once during a 5-day school week; n(%) | 103 (90.4%) | 128 (90.8%) | 0.907 |
| Average number of breakfasts missed in a 5-day school week; mean (SD) | 3 (2) | 3 (2) | 0.591 |

SD=Standard deviation; min=minutes; IQR=Interquartile range; PedMIDAS=Pediatric Migraine Disability Score; NA=Not applicable. Results have been rounded to the degree of precision with which they were measured.

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Table 2:

Distribution of PedMIDAS severity grade in high-schoolers with migraine whose schools start at 8:30 AM or later ($n=115$) vs. high-schoolers with migraine whose schools start before 8:30 AM ($n=141$)

| | 8:30 AM or Later ($n=115$) | Before 8:30 AM ($n=141$) |
|---------------------------------|--|--|
| 0-10 (Little Disability) | 29 (25.2%) | 30 (21.3%) |
| 11-30 (Mild) | 52 (45.2%) | 56 (39.7%) |
| 31-50 (Moderate) | 18 (15.7%) | 25 (17.7%) |
| >50 (Severe) | 16 (13.9%) | 30 (21.3%) |

$p=0.399$

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Table 3:

Linear regression models examining predictors of headache frequency among high schoolers with migraine in the total sample ($n=255$), in exploratory *post-hoc* analyses

| Predictor variable: | Estimated effect on headache days per month | 95% CI |
|--|---|-------------|
| Missing breakfast one or more times per week | -1.5 days | -4.0 to 1.1 |
| Getting at least 8 hours of sleep on an average school night | -0.5 days | -2.8 to 1.7 |

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