

A survey of college-bound high school graduates regarding circadian preference, caffeine use, and academic performance

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Abstract

Background This study examines the relationships between circadian preference and caffeine use with academic performance and hours spent studying for recent high school graduates entering their first year of college.

Method Entering first-year college students enrolled at 90 baccalaureate-level institutions across the USA were invited to complete the Beginning College Survey of Student Engagement (BCSSE) and the Composite Scale of Morningness (CSM) as well as answer questions regarding caffeine consumption. Surveys were administered on each campus during the summer months of 2013. Only those that graduated from a US high school in the spring of 2013 were included in this study. The final sample for this study included 25,200 students that completed the BCSSE, CSM, and questions regarding caffeine consumption.

Results Evening types (E-types) were significantly less likely to report earning A/A-'s in high school and less likely to study 16 or more hours per week compared to intermediate or morning types (M-types) ($p < 0.05$). Overall, entering first-year students reported an average of 1.1 servings of caffeine per day, with 39 % reporting no caffeine consumption. M-types were more likely to consume no caffeine (54 %) compared to E-types that also indicated no daily caffeine (31 %) ($p < 0.05$). However, E-types were approximately 2.5 times more likely to consume three or more daily servings of caffeine (18 %) compared to M-types that consume the same amount (7 %) ($p < 0.05$). M-types that consumed no caffeine reported the highest grades with nearly 64 % reporting they earned mostly A's or A-'s in high school. However, the apparent advantage that morning types had over evening types

regarding high school grades was completely ameliorated once three or more servings of caffeine were consumed per day.

Conclusions This study provides additional information to educators and health professionals to create programs and provide resource to help adolescents better understand the impact of their sleep behaviors and use of caffeine on their academic performance.

Keywords Circadian preference · Caffeine use · Academic performance · Students

Introduction

It is well-established that many adolescents experience changes in their circadian rhythm toward a preference for evening activities (E-type) [1]. Unlike those that prefer to wake up early and go to bed early (M-types), E-types find it difficult to get up in the morning and prefer going to bed later in the evening [2]. Studies have found that this circadian preference is associated with academic performance, with a bias toward M-types earning higher grades as well as experiencing fewer deleterious behaviors such as falling asleep in school, grogginess, and aggression compared to E-types [3, 4]. As such, there has been much discussion across the USA regarding the start of school time and the need for students to get more sleep, especially given that many adolescents are experiencing a phase delay [5].

Many factors, however, likely contribute to this change in circadian preference among adolescents. Genetics, maturation, personality as well as environmental factors such as working, studying, parental-set bedtimes, athletics, co-curricular activities, and the use of internet and video games all contribute to the individual differences manifested in circadian preferences [6]. This change in circadian preference also coincides with decreased total sleep times reported by

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adolescents [7]. The deleterious effects of decreased sleep among adolescents include among others, increased depression, daytime sleepiness, decreased motivation, decreased cognitive functioning, increased aggression, and accidents [8, 9]. Though research has shown decreased academic performance associated with evening types [10], it is not well understood the relationship between sleep behaviors and the hours spent studying for school that contributes to academic performance. Research has shown the positive effect that time devoted to studying has on the academic performance of adolescents [11].

Coinciding with this phase delay, many adolescents also report increased caffeine use [12]. Adolescents perceive the use of caffeine products as a way to enhance energy and offset insufficient sleep [13]. There is also evidence that increasing the use of caffeine by adolescents is associated with decreased academic performance and increased sleepiness [14, 15]. However, little is known on how caffeine use and circadian preference relate to academic performance and study time.

Collectively, there is little known about how circadian preference, hours spent studying, and caffeine use are related to academic performance of adolescents. This study examines the relationships between circadian preference and caffeine use with academic performance and hours spent studying for recent high school graduates entering their first year of college.

Method

Survey instrument

The data for this study are from the 2013 administration of the *Beginning College Survey of Student Engagement* (BCSSE) published by the Center for Postsecondary Research, Indiana University. BCSSE is administered as a paper or web survey to incoming first-year students during Orientation, Welcome Week, other institution organized activities, or sent by email prior to the start of the fall classes. In addition to the core survey items, students offered the web version also had the opportunity to answer additional questions that assessed their circadian preference and caffeine consumption.

BCSSE collects data regarding the student's recent high school experiences, their college expectations, and attitudes toward their academic work in the first year of college. Two variables from the core survey of relevance include high school grades and hours spent studying. High school grades were collected by asking respondents, "What were most of your high school grades?" Response options included, A, A−, B+, B, B−, C+, C, C− or lower. For this study, high school grades were recoded into three categories as follows: A/A−, B+/B, and B− or lower. Study time was assessed by asking respondents, "During your last year of high school, about how

many hours did you spend in a typical 7-day week doing each of the following?", with the follow-up, "Preparing for class (studying, reading, doing homework, etc.)". Response categories included 0 h, 1–5, 6–10, 11–15, 16–20, 21–25, 26–30, and more than 30 h. For this study, study time was recoded into four categories as follows: 0–5, 6–10, 11–15 h, and 16 more hours.

Circadian preference was measured using the Composite Scale of Morningness (CSM) [16]. The CSM is based on the Morningness-Eveningness Questionnaire and the Diurnal Type Scale [17, 18]. This study used the reduced 13-item version of the CSM. Scores for the CSM range from 13 (extreme evening) to 55 (extreme morning) with a mid-point of 34. Using criteria established by its authors, upper and lower deciles established the evening and morning types. In this study, the evening types scored between 13 and 25, whereas morning types scored between 42 and 55. The CSM mean scale score was 33.6, with very low skewness (−0.043) or kurtosis (−0.029) and adequate internal consistency ($\alpha=0.820$). Data from the full and reduced CSM was found to be a valid measure of circadian preference [19].

Caffeine consumption was assessed by asking students, "In a typical day, how many coffee beverages (coffee, mocha, etc.), caffeinated sodas (Coke, Mountain Dew, etc.), and energy drinks (Monster, Red Bull, etc.) do you drink?" Also, "In a typical week, how many days do you take an energy supplement (e.g., "5-h Energy")?" This latter question was converted to a measure of daily intake and then combined with the previous question.

Study sample

Data are from 25,200 entering first-year college students enrolled at 90 baccalaureate-level institutions across the USA that completed both the BCSSE and the CSM as well as answered the two questions regarding caffeine consumption. Surveys were administered on each campus during the summer months of 2013. The total sample includes only those that graduated from a US high school in the spring of 2013. Sixty percent of the respondents were female. The ethnic/racial characteristics include 6 % Asian, 11 % African American/Black, 79 % Caucasian, 9 % Hispanic, 2 % American Indian, 3 % other (adds to more than 100 % since respondents could "select all that apply").

Data analysis

Given the ordinal nature of the two dependent variables (high school grades and hours studying), a columns proportions z test was used to analyze proportional differences. Due to the multiple comparisons, tests were adjusted for all pairwise comparisons within a row using a Bonferroni adjustment to reduce the chance of a type I error. All statistical analysis used

Statistical Package for the Social Sciences, version 21 (SPSS Inc., Chicago, IL).

Results

As indicated in Table 1, E-types were significantly less likely to report earning A/A–'s in high school compared to intermediate or M-types ($p<0.05$), but were significantly more likely to report earning B+/B's or B– or lower grades compared to M-types ($p<0.05$). E-types were also significantly more likely to report spending 0–5 h per week studying compared to intermediate or M-types ($p<0.05$) and significantly less likely to study 16 or more hours per week compared to intermediate or M-types ($p<0.05$). Overall results reveal that circadian preference is significantly related to high school grades and time spent studying, with M-types reporting higher grades and more time devoted to studying.

Overall, entering first-year students reported an average of 1.1 servings of caffeine per day, with 39 % reporting no caffeine consumption. For analysis, caffeine consumption was recoded to 0, 1, 2, or 3 or more servings per day. Results presented in Fig. 1 reveals that M-types were significantly more likely to consume no caffeine (54 %) compared to evening adolescents that indicate no daily caffeine (31 %) ($p<0.05$). At the other extreme, E-type adolescents were approximately 2.5 times more likely to consume three or more daily servings of caffeine (18 %) compared to M-types that consume the same amount (7 %) ($p<0.05$). Morning types showed the greatest variability in caffeine use with a difference of 47 % between the no caffeine group and the three or more servings per day group. Evening types showed the least variable with a difference of 13 % between these same two groups. As expected, the intermediate group primarily reported caffeine consumption between the E-type and M-type

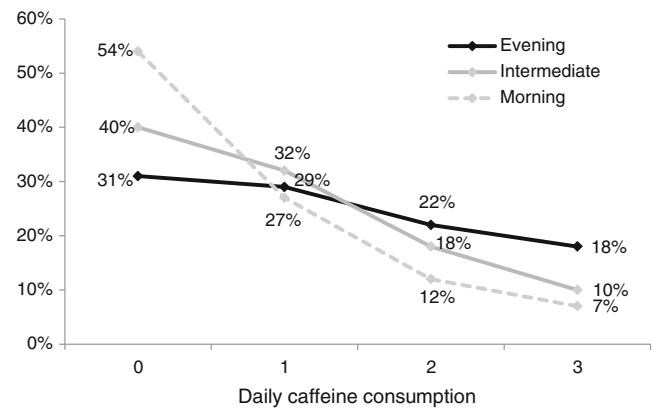


Fig. 1 Caffeine use by circadian preference

students. Overall, results reveal that caffeine use is significantly related to circadian preference.

As indicated in Table 2, those that reported no caffeine use were significantly more likely to report A/A– grades compared to those that consumed two or more servings of caffeine per day ($p<0.05$). Not surprisingly, those that consumed three or more servings of caffeine per day were twice as likely to report high school grades of B– or lower (11.2 %) compared to those that consumed no caffeine (5.9 %) ($p<0.05$). With regard to studying, approximately 31 % of the no caffeine group reported studying 11 or more hours per week, compared to 25 % of the three or more servings per day group ($p<0.05$). Overall results reveal that caffeine use is significantly related to high school grades and time spent studying, with higher caffeine use associated with lower grades and less time studying.

M-types that consumed no caffeine reported the highest grades with nearly 64 % reporting they earned mostly A's or A–'s in high school (Table 3). In addition, M-types that reported consuming one or two servings of caffeine per day reported the second and third highest grades compared to all other groups (59.4 and 59.5 %, respectively). However, there

Table 1 High school grades and hours studying by circadian preference

	CSM		
	Evening (E) (%)	Intermediate (I) (%)	Morning (M) (%)
A/A–	48.8 ^{IM}	52.9 ^M	60.6
B+/B	42.4 ^M	40.3 ^M	34.1
B– or lower	8.8 ^{IM}	6.8 ^M	5.3
Total	100.0	100.0	100.0
0–5 h	50.2 ^{IM}	42.9 ^M	37.5
6–10 h	25.9 ^I	28.9	27.9
11–15 h	11.4 ^{IM}	14.9	17.5
16+	12.4 ^{IM}	13.5	17.1
Total	100.0	100.0	100.0

A significant difference between column cells are indicated by a column heading (E, I, or M)

Table 2 High school grades and hours studying by caffeine consumption

	Caffeine (percent daily servings)			
	0	1	2	3+
A/A–	57.6 ²³	53.4 ²³	48.4 ³	43.4
B+/B	36.5 ²³	40.8 ³	43.0	45.5
B– or lower	5.9 ²³	5.8 ²³	8.6 ³	11.2
Total	100.0	100.0	100.0	100.0
0–5 h	41.1 ¹²³	43.1 ³	45.2	48.2
6–10 h	28.1	29.3	28.8	26.8
11–15 h	15.5 ³	14.5	14.3	13.1
16+	15.3 ¹²³	13.2	11.7	11.9
Total	100.0	100.0	100.0	100.0

A significant difference between column cells are indicated by a superscripted column heading (0, 1, 2, or 3)

Table 3 Percent high school grades and hours studying by circadian preference and caffeine consumption

	CSM	Evening				Intermediate				Morning			
	Caffeine	0	1	2	3+	0	1	2	3+	0	1	2	3+
A−/A		51.0	51.6	45.2	45.1	57.3 ¹²³	53.1 ²³	48.2 ³	43.3	63.7 ³	59.4 ³	59.5 ³	44.4
B/B+		42.0	41.8	44.3	41.6	36.8 ¹²³	41.2 ¹	43.4	46.2	31.3 ³	36.6	35.3	43.3
B− or lower		7.0 ³	6.6 ³	10.5	13.3	5.9 ²³	5.7 ²³	8.4 ³	10.5	5.0 ³	4.0 ³	5.2 ³	12.4
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0–5 h		48.2	49.7	51.2	53.6	40.7 ¹²³	43.0 ⁰³	45.0 ⁰	46.7	37.0	36.3	37.6	46.1
6–10 h		25.1	26.1	26.7	26.1	28.7	29.8	28.7	27.4	27.1	29.3	31.0	24.2
11–15 h		13.0	10.1	11.7	10.6	15.5	14.7	14.4	13.8	18.4	16.0	19.6	11.8
16+		13.8	14.1	10.4	9.7	15.1 ¹²³	12.6	11.9	12.1	17.5	18.4	11.8	18.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

A significant difference between column cells are indicated by a subscripted column heading (0, 1, 2, or 3)

was a significant drop in grades for M-types that consumed three or more servings compared to the other M-types ($p < 0.05$). This pattern of highest grades associated with least caffeine intake was repeated for each of circadian preferences. Even though the differences between the “no caffeine” groups for each of the circadian preferences that received A’s or A–’s ranged from 51.0 to 63.7 %, there was a little range of scores for those that consumed three or more servings of caffeine regardless of circadian preference (44.3 to 45.1 %). For all three circadian groups, those that consumed three or more servings of caffeine were significantly more likely to earn B–’s or lower compared to their peers ($p < 0.05$).

There were relatively fewer differences regarding the number of hours studying. For instance, for E-types and M-types, there were no significant differences within each group regarding caffeine consumption and hours spent studying. For intermediate types, those that consumed three or more servings of caffeine per day were significantly more likely to study 0 to 5 h per week compared to those that consume one or no servings of caffeine ($p < 0.05$).

Discussion

This study set out to investigate the relationship between circadian preference, hours spent studying, and caffeine use with the academic performance of adolescents. Overall, this study found that morning-type adolescents reported significantly higher grades, spent significantly more time studying, and reported significantly lower caffeine use compared to evening-type students. Increasing caffeine use was also significantly related to decreasing grades and time spent studying across circadian preference groups. These results are consistent with other studies that found decreasing academic performance with evening types [10], with increasing use of caffeine

[13]. Prior studies have also found that increasing caffeine use is associated with a decreased sleep time [20] and that decreased sleep time is associated with evening types [10]. Thus, it is not surprising that this study found that evening types consumed more caffeine than M-types and that the lowest academic performance was found with evening types that consumed the most caffeine.

This study also found that morning types do study more than evening types. Roughly one-third of morning types reported studying 11 or more hours per week compared to about 25 % of evening types that reported that same. In addition, morning types consumed significantly less caffeine than evening types. This study found that the deleterious effects of caffeine appear to be stronger for morning types than for evening types regarding academic performance. Difference in caffeine consumption between evening types that reported A’s ranged from 50 % for no caffeine to 45 % for those that consumed three or more. However, the difference in caffeine consumption between morning types that reported A’s ranged from 64 % for no caffeine to 44 % for those that consumed three or more. In fact, the apparent advantage that morning types had over evening types regarding high school grades is completely ameliorated once three or more servings of caffeine are consumed per day. However, this result could also suggest that lack of sleep and thus the increased need for caffeine is the primary factor contributing to the decline in academic performance across circadian preference. Though that could be the case for evening types, that does not sufficiently explain the results for morning types. Other studies have shown that morning types are less likely to accumulate a “sleep debt” compared to evening types and thus are less likely to experience deleterious effects of sleepiness on academic performance [10]. Therefore, one reasonable explanation for the decline in academic performance of some morning types is increased caffeine consumption.

The results of this study are not without limitations. First, this is a cross-sectional, correlational study. As inherent in non-experimental studies, determining causation and temporal relationships is problematic. Second, since administration on each campus was handled locally by campus staff, some participants were recruited by email invitation, whereas others were requested to participate in large group administrations (e.g., at Freshman Orientation). Though calculating a response rate is not possible, institutions did attempt to collect data from all entering first-year students. Also, participants voluntarily chose to complete the survey; thus, the findings may be subject to selection bias. Third is the use of self-reported data and the possibility that the results are influenced by social desirability. Finally, the measurement of caffeine consumption for this study did not distinguish between varying levels of caffeine per serving across the many types of beverages. For instance, Red Bull is typically served in a 16-oz can with approximately 160 mg of caffeine, Diet Coke in a 12-oz can with approximately 38 mg caffeine, and Starbucks in a 16-oz cup with 259 mg caffeine [21–23].

In summary, this study found evidence that adolescent circadian preference is associated with caffeine use, academic studying, and academic performance. Specifically, this study found that morning types do report significantly higher grades in high school, but seem particularly vulnerable to the deleterious effects of caffeine on academic performance. Evening types do report lower academic performance, but do not appear as vulnerable to the negative effects of caffeine use on grades. This study provides additional information to educators and health professionals to create programs and provide resource to help adolescents better understand the impact of their sleep behaviors and use of caffeine on their academic performance.

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