# Morning versus Evening Circadian Tendencies: Suicidality and Risk Propensity during the Transition to Adulthood

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People in the transitional period to adulthood who exhibit a circadian tendency toward eveningness (E-types) follow a delayed sleep schedule, increasing activity later in the day and both going to sleep and getting up later compared to morning-types (M-type).  The circadian tendency toward eveningness during this transitional period has been associated with a wide range of adverse effects, including poor self-regulation, increased rates of substance use, impulsivity, depression, anxiety and emotional instability and more aggressive and antisocial behavior.  We utilized public data from the National Longitudinal Study of Adolescent Health and analyzed a subsample of participants in the transitional period to adulthood aged18-21 (n=2143).  Participants were interviewed at four waves over the course of 15 years and were analyzed on indices of sleep chronotype, risk taking propensity and suicidality. Participants who endorsed higher rates of eveningness showed higher risk taking propensity (p<.05) and suicidality (p<.001).  Eveningness was a significant predictor of suicidal ideation (p=.05). Explanations of these findings and the subsequent implications will be discussed at length.

*Keywords:* circadian preference, sleep chronotype, suicidality, emotion regulation

The transition to adulthood is a growing period characterized by changes in physical, mental, and emotional health.  During the transition to adulthood young adults exhibit superior health relative to other periods; however, it is also a critical period for the development of healthy behavioral habits, and can be a defining period for development of later negative health outcomes. Susceptibility to psychopathological illnesses is highest during this period (Dahl, 1996; Cicchetti, Rogosch, & Toth, 1994).  Recent research also highlights increasing rates of childhood obesity occurring during this critical period (Ebbeling, Pawlak, & Ludwig, 2002; Kosti & Panagiotakos, 2006).

During this period circadian rhythms are particularly vulnerable to various external and internal influences which significantly affect health during later life.  Those who are transitioning to adulthood require more sleep on average than older adults (Carskadon, 1990).  Sleep deprivation during this phase can lead to lowered academic performance (Gruber et al., 2010), decreased performance in memory tasks (Lim & Dinges, 2010), decreased ability to regulate mood (Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010), and poor dietary habits (Nedeltcheva, Kilkus, Imperial, Schoeller, & Penev, 2010).

*Evening Circadian Tendency* The current study aims to examine a related, but often overlooked, sleep construct that may also contribute to negative health outcomes—that is, an evening circadian tendency. Individuals with an evening

circadian tendency (E-types) are phase advanced, sleeping long into the day and becoming most active at night. In comparison, individuals with a morning circadian tendency (M-Types), prefer to wake early in the morning and find it challenging to remain awake past their ordinary bedtime (Webb & Bonnet, 1978). Like most people in the transition to adulthood period, E-types operate on a daily fixed schedule and must rise early in the morning; this often results in sleep deprivation. School usually starts early in the morning for most teens which further exacerbates the problem (Wolfson, Spaulding, Dandrow, & Baroni, 2007). As sleep phase is delayed the biological clock shifts as well. This shift has an effect on biological functions that rely on a normal sleep phase such as metabolism and cognitive functioning in the frontal lobe (Carskadon, Acebo, & Jenni, 2004).

Carskadon and colleagues (1993) hypothesized that there may be a link between biological mediation of phase delay and puberty. The view is theoretically plausible because melatonin, the neurochemical compound that plays a vital role in the regulation of the sleep-wake cycle, has been found to induce the production of gonadotrophin-inhibitory hormone (GnIH), a hormone that inhibits the production of gonadotropine releasing hormone (GnRH) (Ubuka, Bentley, Ukena, Wingfield, & Tsutsui, 2005). GnRH is broadly responsible for the development of the gonads starting at puberty. Melatonin has been found to have an inverse relationship with GnRH secretion over the span of pubertal development (Tsutsui, 2005). This means that we could naturally expect to see huge links in timing of sleep phase during pubertal development just as Carskadon (1993) suggested even though this sort of research is in its infancy.

Delayed sleep phases are already known to affect social, behavioral, and emotional function in teens. It leads to poor academic performance (Randler & Frech, 2009; Wolfson & Carskadon, 2003), increased impulsivity (Adan, Natalie, Caci, & Prat, 2010), poor emotional regulation (Gau, Shang, Merikangas, Chiu, Soong, & Chang, 2007) and poor eating habits (Nedeltcheva et al., 2010). Delayed sleep phases have also been linked with various psychopathological illnesses, including depression (Campos-Hirata, Lima, de Bruin, Nobrega, Wenceslau, and de Bruin, 2007; Randler, 2011); anxiety disorder (Gau et al., 2007), suicidality (Gau et al., 2007) and ADHD (Caci, Bouchez, & Bayle, 2009). Furthermore, past research has shown that delayed sleep phases place many adolescents at moderate to high risk for obesity, heart disease, cancer and immune system malfunction in adulthood (Ayas, White, Manson et al., 2003; Kanterman & Ronnenberg, 2009).

*Study Aims* The current study will investigate the extent to which E-types and M-types differ in response to items measuring suicidality and risk propensity and the extent to which being an E-type can predict suicidality and risk propensity. There is good reason to believe that E-types and M-types will differ in suicidality and risk propensity given past research that has demonstrated that E-types and M-types differ biologically (e.g. in terms of their physiological rhythms), and emotionally (e.g. in terms of emotion regulation). E-types and M-types also differ on the endogeneity of their sleep phases such that the cyclic rhythms of physiological variables such as alertness, core body temperature, heart rate, and hormone secretion all vary as a function of sleep chronotype (Baehr et al. 2000; Monk et al., 1997; Bailey & Heitkemper, 1991; Giannotti, Cortesi, Sebastiani, and Ottaviano, 2002). Behavioral and performance rhythms have also been noted to differ across sleep chronotypes (Carrier & Monk, 2000). In a study to determine the relationship between circadian preferences, regularity of sleep patterns, sleep problems, and daytime behavior Giannotti and colleagues (2002) assessed a nationally representative sample of Italian adolescents ranging from 14.1-18.6 years of age. One of the studies' findings was that E- and M-types differ significantly in the reporting of emotional problems such that having an evening circadian preference significantly increased the likelihood of reporting emotional difficulties. For these reasons we compare a large nationally representative sample of E-types and E-types on indices of suicidality and risk propensity. We evaluate data from the National Longitudinal Study of Adolescent Health (NLSAH) which assessed a nationally representative sample of adolescent students in America across 14 years into adulthood.

## METHOD

*Participants and Recruitment* The current study used data from the National Longitudinal Study on Adolescent Health (ADD Health). ADD Health is a national longitudinal survey of school-aged students in grades 7-12 that ran from 1994 to 2008. Four separate waves of data were collected over a span of 15 years. The survey objective was to investigate how health-related behaviors in adolescence affected behaviors and wellbeing in later adulthood.

Survey procedures (Resnick et al., 1997) were reviewed and approved by the Institutional Review Board at the University of North Carolina. The first wave of data (1994-1995) focused on factors that may influence adolescent health and risk factors; it included more than 90,000 students and over 100

school administrators who completed surveys administrated in school.  A subset of 20,745 adolescents and 17,670 parents completed in-home surveys.  The second wave of data (1996) included 14,738 of the adolescents from the first wave who had yet to graduate from high school, including those who dropped out.  The third and fourth waves of data (2001-2008) focused on how experiences during the transition to adulthood (i.e. ages 18-21) are related to decisions, health, and behavior in later adulthood each included more than 15,000 of the adolescents from the first wave.

## OUTCOME MEASURES

*Risk Propensity* Risk propensity can loosely be defined as the degree to which a person is willing to take a chance or react with behavioral impulsivity with either regard or complete disregard for the consequences of that action.  The construct of risk propensity was measured using two survey items.  Participants first responded to the statement, "I like to take risks," using a 5-point Likert scale.  Then, they responded to the second statement, "When making a decision I tend to go with my 'gut feeling' without regard for the consequences that may follow my decision", which was also measured on the same Likert scale ranging from 1(strongly agree) to 5 (strongly disagree).   Each of these two variables was included in Wave III and Wave IV surveys so we would be able to identify trends in these data.

*Suicidality* Suicidality is defined as the act of engaging in suicidal ideation of any sort.  The construct of suicidality was assessed using two survey items.  Participants first responded to the question, "In the past 12 months have you thought about committing suicide?" Answers were recorded on a nominal scale and coded 0 (no) and 1 (yes).  Participants then responded to the second question, "In the past 12 months how many times have you actually attempted to commit suicide?" Answers were recorded on an ordinal scale ranging from 1 (once) to 5(five or more times).  Each of these items was included in Wave III and Wave IV surveys.

## PROCEDURE

*Defining E-types and M-types* Based on previous research, we utilized participants' sleep-wake times as proxies for chronotype (Mullin, Harvey, and Hinshaw, 2011; Eidelman et al., 2010).  We derived an estimate of chronotype from two Wave III (2002) survey items: (1) 'On days you don't have to get up at a certain time, what time do you usually get up?' and (2) 'On those days, what time do you usually go to sleep the night or day before?'   Based on previous research (Roenneberg, 2003; Benoit et al., 1981) we selected the midpoint between sleep onset and wake up time (midsleep) as an estimate of chronotype.  Midsleep has also been reported as the best phase anchor point for melatonin onset— the period of time during the day that the body prepares itself for sleep most notably through the secretion of higher levels of the neurohormone (Terman et al., 2001).  We then performed a tertile split on our sample based on midsleep such that we labeled the lower third as E-types —those with delayed sleep-wake times, and the upper third as M-types —those who have early sleep-wake times.  We did not include the middle third of the sample population in an attempt to avoid drawing arbitrary lines right down the middle between E- and M-type sleep-wake times.  We used the tertile split to get rid of the gray area in between E-types and M-types —those participants who fell into some middle ground between E- and M-type sleep-wake times.  As a result of excluding this group of participants, we can be more confident that those participants who are included as E- and M-types are accurately placed in each of the two groups, thus, strengthening our comparisons between the sleep chronotypes.

*Statistical Analysis* The primary aim of the current study is to see if being an E-type in Wave III could predict suicidal ideation and risk propensity in Wave IV. Ordinal and binary logistic regressions were used to evaluate the effects that being an E-type had on suicidality and risk propensity based on the aforementioned survey items utilized in this study.  To protect the statistical validity of our regression analysis we included participant responses from Wave III as predictors for answers to those same questions in Wave IV.   We appreciated the fact that participant responses from the past may be significant predictors to their responses later.  Simply put, we were in search of how strong the predictive influence of being an E-type was on suicidality and risk propensity when accounting for participant responses to Wave III items.  Chi-square tests were also used to evaluate the differences between E-types and M-types on a number of factors such as, race, and gender; t-tests were also used to compare difference in age between the two groups. An alpha level of 0.05 was used for all analyses.

| Table 1. Comparative Demographics | | | |
|---|---|---|---|
| | **E-Type** $(n = 1022)$ | **M-Type** $(n = 1112)$ | **Test Statistic** |
| Female | 507 | 698 | $x^2 = 37.53***$ |
| Male | 515 | 414 | |
| Mean Age (SD) | 20.04 (.83) | 20.13 (.82) | $t = -2.46**$ |
| Age Range | 18-21 | 18-21 | |
| **Ethnicity** | | | |
| Asian | 44 | 45 | $x^2 = 0.08$ |
| American Indian | 40 | 51 | $x^2 = 0.59$ |
| Caucasian | 705 | 741 | $x^2 = 1.29$ |
| Hispanic | 88 | 124 | $x^2 = 3.83*$ |
| African American | 238 | 281 | $x^2 = 1.16$ |
| Other | 52 | 58 | $x^2 = 0.02$ |
| $p < 0.05*$, $p<0.01**$, $p < 0.001***$ | | | |

| Table 2. Chi-Square Analysis of Survey Responses between M-Type and E-Type | | |
|---|---|---|
| **Wave III Item** | $x^2$ | **Significance** |
| I like to take risks | 28.38 | .00** |
| When making a decision I usually go with my 'gut feeling' without much thought about the consequences of that decision. | 8.09 | .08 |
| During the past 12 months, have you ever seriously thought about committing suicide? | 17.38 | .00** |
| During the past 12 months, how many times have you attempted suicide? | 2.79 | .72 |
| **Wave IV Item** | $x^2$ | **Significance** |
| I like to take risks | 16.03 | .00** |
| When making a decision I usually go with my 'gut feeling' without much thought about the consequences of that decision. | 9.03 | .06 |
| During the past 12 months, have you ever seriously thought about committing suicide? | 8.03 | .00** |
| During the past 12 months, how many times have you attempted suicide? | 7.30 | .12 |
| $p < 0.05*$, $p<0.01**$, $p < 0.001***$ | | |

RESULTS

*Participants* We utilized subsets of the samples from Wave III and Wave IV.  Our sample only included participants who ranged in age from 18-21 in Wave III.  Participants who completed both Wave III and Wave IV were included in the sample.  Thus, the final sample size was 2,134.  Table 1 shows detailed demographics of the subsample used in our study.  We observed a statistically significant difference in age between the two groups (t=-2.46, p<.01) such that the average age of the E-types was 20.04 years (SD=.83), and the average age of the M-types was 20.13 (SD=.83).  However, even though this result was statistically significant we are fairly certain that it is too small to be of any practical significance.

*Group Differences in Sex and Race* Table 1 also shows results from chi-square analyses for observed differences between E-types and M-types on indices of sex and race.  We observed that there were significantly fewer female E-types, and fewer male M-types than expected; the data also showed that there were more female M-types and more male E-types than expected ($x^2$ = 37.53, p<.001).  This suggests that there is a strong association between being female and being an M-type, and being male and being an E-type.  Table 1 also reports statistical analysis on differences between E- and M-types in various ethnic groups.  We found that there are significantly fewer E-types that were of Hispanic origin than expected, and more M-types that were of Hispanic origin than expected ($x^2$ = 3.83, p =.05).  In all other chi-

| Table 3. Ordinal Regression Analysis of E-Type on Wave IV Responses | | | | | |
|---|---|---|---|---|---|
| **Wave IV Item** | **$R^2$** | **Predictors** | **Odds Ratio** | **Significance** | **CI** |
| I like to take risks | .21 | E-Type | .86 | .08 | -.32 -.02 |
| | | Wave III item | 2.38 | .00*** | .78 - .95 |
| When making a decision I usually go with my 'gut feeling' without much thought about the consequences of that decision. | .11 | E-Type | .96 | .65 | -.21 - .13 |
| | | Wave III item | 1.74 | .00*** | .47 - .63 |
| During the past 12 months, how many times have you attempted suicide? | | E-Type | 1.03 | .71 | -1.50 - 1.58 |
| | .16 | Wave III item | 3.61 | .00*** | .58 – 1.58 |
| p < 0.05*, p<0.01**, p < 0.001*** | | | | | |

| Table 4. Binary Logistic Regression of E-Type on Wave IV Suicidal Ideation item | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **B** | **Std. Error** | **Odds Ratio** | **Significance** | **CI** |
| E-Type | .38 | .19 | 1.47 | .05* | .99 – 2.16 |
| During the past 12 months, have you seriously thought about committing suicide? | -1.78 | .21 | .169 | .00*** | .11 - .25 |
| Constant | -1.35 | .23 | .25 | .00*** | |
| p < 0.05*, p<0.01**, p < 0.001*** | | | | | |

square analyses there were no differences between E-types and M-types regarding ethnicity.

*Group Differences in Suicidality and Risk Propensity* Table 2 shows chi-square analysis for observed differences between E-types and M-types on indices of suicidality and risk propensity based on self-reported responses to the items used to measure each construct. We found that significantly more E-types seriously thought about committing suicide during the 12 month period before they participated Wave III ($x^2$ = 17.38, p<.01) and in Wave IV ($x^2$ = 8.03, p<.01) during later adulthood compared to M-types . However, the data showed no significant difference in the amount of times E-types actually attempted suicide during the 12 month period before they participated in Wave III ($x^2$ = 2.79, p =.72) and Wave IV($x^2$ = 7.30, p =.12). Regarding risk propensity, the data showed marginally significant differences between E-types and M-types, such that, E-types reported being more likely to make a decision without regard for the consequences in later adulthood compared to M-types in Wave III ($x^2$ = 8.09, p =.08) and in Wave IV ($x^2$ = 9.03, p =.06). The data also showed that E-types are more likely to report that they enjoy engaging in risks in later adulthood compared to M-types at Wave III ($x^2$ = 28.38, p<.01) and at Wave IV ($x^2$ = 8.03, p<.01).

*Long-term Relationship: E-type, Suicidality, and Risk Propensity* Table 3 shows the ordinal regressions for all three of our ordinal survey items in Wave IV. Identical survey items that participants responded to in Wave III were also included in the model so that the true predictive power of being an E-type during Wave III would be displayed in the each ordinal regression models. The data showed that being an E-type during Wave III was a marginally significant predictor (OR=.86, CI= -.32 - .02, p =.08) of responses to the Wave IV statement, "I like to take risks," over and above their response to the same Wave III survey item that was administered at an earlier time point which was a significant predictor (OR=2.38, CI= .78 - .95, p <.01). Being an E-type during Wave III was not a significant predictor of responses to the Wave IV statement, "When making a decision I usually go with my 'gut feeling' without much thought about the consequences of that decision," (OR= .96, CI= -.21 - .13, p =.65). The identical item in Wave III was a significant predictor however (OR=1.74, CI= .47 - .63, p <.01). Regression analysis also showed that being an E-type during Wave III was not a significant predictor of responses to the Wave IV question, "During the past 12 months, how many times have you attempted suicide," (OR=1.03, CI= -1.50 – 1.58, p =.71). However, the responses to the identical Wave III statement was found to be a

significant predictor of answers to the same question in Wave IV (OR =3.61, CI =.58 – 1.58, p <.01).

We ran a binary logistic regression for the suicidal ideation item shown in Table 4. Analysis shows that an E-type during Wave III was indeed a statistically significant predictor of the responses to the Wave IV suicidal ideation item over and above the predictive power of the Wave III questions (OR =3.61, CI = .99 – 2.16, p =.05). Participants responded to the statement, "During the past 12 months, how many times have you thought about committing suicide." We found that the corresponding Wave III item was also a significant predictor (OR =.169, CI = .11 - .25, p <.01).

## DISCUSSION

In line with our first aim, we found significant differences between E-types and M-types in responses to Wave III and in Wave IV items such that E-types tend to report taking risks and report seriously considering suicide more than M-types. However, we note that we cannot draw on any causal explanations for the significance we found when comparing E- and M-types through chi-square analyses. In regards to our second aim, being an E-type in Wave III was found to be a significant predictor of suicidal ideation in Wave IV over and above the Wave III response to the same question as recorded four years prior. The data suggests an important association between being an E-type during the transition to adulthood, suicidality, and risk propensity.

All of these results suggest that circadian rhythms during the transition to adulthood should be monitored closely, and attempts should be made to align their sleep-wake time with their early morning schedules. Although sleep-wake preference seems to be endogenous, it is malleable to an extent that has been found to be advantageous to those who are E-types (Skene & Arendt, 2006). Gross fixed daily schedules are not conducive to students who are considered E-types; the evidence suggests that this leads to sleep deprivation in E-types and puts them at a disadvantage academically, socially, and emotionally (Cassoff, & Monson, 2010; Talbot, McGlinchey, Kaplan, Dahl, and Harvey, 2010). This warrants some attention, given the evidence that being an E-type leads to sleep deprivation which further leads to compromised adult health outcomes such as immune system deregulation; hypertension; obesity; mood disorders; and cognitive decline (Durmer & Dinges, 2005; Gottlieb et al., 2006; Colton & Altevogt, 2006; Lange, Dimitrov, and Born, 2010; Benedetti & Colombo, 2011).

Future studies should investigate the influence that circadian preference during earlier developmental years has on long-term health as well as collect for extensive data on outcome measure.  Due to the fact that we analyzed data from a public research database we did not have control over what survey items were included in the study and when those survey items were administered. Despite the limitations, the current study reveals a clear influence of circadian preference on behavior.

Some of the fetal programming literature on animals suggests that prenatal stress can induce a circadian phase advance of locomotor activity as a result of modifications made to the hypothalamic-pituitary adrenal axis (Maccari, Darnaudery, Morely-Fletcher, Zuena, Cinque, and Van Reeth, 2003; Van Reeth, Dugovic, and Koehl, Weibel, and Maccari, 1999).  This is highly relevant because it hints at the fact that circadian rhythms of infants may be influenced by prenatal stress, leaving some infants disadvantaged in regards to their circadian preference before they are introduced to the world. Thus, it may be insightful to track a nationally representative sample of students from prenatal to adulthood years while collecting data on in utero stress hormone exposure, indices of sleep chronotype, and a myriad of other health factors. We also hope that future research will gather more extensive outcome measures, as it is beneficial to have multiple facets of a single construct represented in varying survey items.

In conclusion, these findings illustrate that sleep-wake patterns during the transitional stage to adulthood can importantly shape a person's future mental health. Further studying this relationship will prove important for devising policy interventions to help combat these negative effects.

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