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Morningness/Eveningness, pubertal timing, and substance use in adolescent girls

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Abstract

The purpose was to examine the associations between Morningness/Eveningness (M/E; a measure of sleep-wake preference) and alcohol, cigarette, and marijuana use as well as the interaction of M/E and pubertal timing. The data represent baseline measures from a longitudinal study examining the association of psychological functioning and smoking with reproductive and bone health in 262 adolescent girls (11-17 years). The primary measures used for this study were pubertal timing (measured by age at menarche), the Morningness/Eveningness scale, and substance use (alcohol, cigarettes, and marijuana). Multiple group path modeling showed that there was a significant interaction between pubertal timing and M/E on cigarette use. The direction of the parameter estimates indicated that for the early and on-time groups, Evening preference was associated with more cigarette use. For the late timing group the association was not significant. The results point to the need to consider sleep preference as a characteristic that may increase risk for substance use in adolescents.

Keywords

sleep preference; puberty; alcohol use; marijuana use; nicotine use

1. Introduction

Substance use is a substantial problem in adolescence. The latest findings from the Monitoring the Future study still show widespread substance use among adolescents in the United States. Twenty percent of 12th graders reported smoking in the past 30 days whereas 45% reported any lifetime use (Johnston et al., 2009). Marijuana use among high school students increased, with over 11% of 8th graders and 32% of 12 graders reporting use in the last year while 14% and 45% reported use at some time in their life. Although alcohol use

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among adolescents has decreased since its peak in the mid-1990's, 32% of 8th graders and over 65% of 12th graders still report use in the last year (Johnston et al., 2009).

Early initiation of substance use in adolescence is a risk factor for later substance abuse and has been linked to other negative events such as motor vehicle accidents, drug abuse, unwanted pregnancies, depression, and suicide (Grant and Dawson, 1997; Grant, 1998; Grant and Dawson, 1998). In addition, substance use tends to be associated with psychopathology. Individuals who use substances report higher rates of disruptive behavior disorders, depressive symptoms, and externalizing problems (Fergusson et al., 2007; Lansford et al., 2008).

Substance use can be affected by a number of factors. One factor that may increase the risk is the adolescent's sleep/wake preference. Sleep preference (Morningness versus Eveningness) is based on chronobiology and circadian rhythms (Tankova et al., 1994; Young and Kay, 2001). Individual differences in sleep preference are often viewed on a continuum with the extremes of the scale being referred to as Morning or Evening type. Morning types awaken early, are refreshed upon awakening, and go to bed early, whereas Evening types have difficulty rising in the morning, are tired when awakening, and stay up late. Morning types prefer doing mental and physical activity in the morning, whereas evening types prefer these activities later in the day (Goldstein et al., 2007). Evening types have irregular sleep-wake schedules; they go to bed later, wake up later, sleep more on weekends than on school nights, and complain of sleep debt compared to Morning types (Giannotti et al., 2002). Younger children tend to be Morning types, although as they enter adolescence, particularly puberty (Randler, 2008b; Tonetti et al., 2008), the preference shifts to Evening type; they begin going to sleep later and will stay asleep later when permitted (Wolfson and Carskadon, 1998; Cavallera and Giudici, 2008). Eveningness has been found to affect various areas of functioning. Evening types have more attention problems, emotional problems, and depressive symptoms as well as lower self-control and poorer school achievement than Morning types (Giannotti et al., 2002; Digdon and Howell, 2008; Gaspar-Barba et al., 2009; Pabst et al., 2009). Eveningness is also associated with health problems such as menstrual symptoms, asthma, and migraines (Bruni et al., 2008; Ferraz et al., 2008; Negriff and Dorn, 2009).

In addition to the various other problematic behaviors evidenced by Evening types, an Evening preference may also increase the risk of substance use. Previous research has found that Eveningness is related to antisocial behavior in both pre- and early pubertal adolescents (Susman et al., 2007). Adolescents with Evening preference may stay out later, attend late night parties, or need substances such as nicotine or caffeine to counteract the effects of erratic sleep patterns. Evidence showed that individuals with Evening preference consume more alcohol and nicotine than Morning types (Adan, 1994; Wittmann et al., 2006; Randler, 2008a) and these associations appear to be stronger in adolescents than adults (Wittmann et al., 2006). Other studies showed that Evening type adolescents tend to use alcohol and nicotine more frequently than Morning types (Giannotti et al., 2002) and to use more habitually (Gau et al., 2007).

Pubertal timing is another factor found to affect the initiation and prolonged use of substances. In particular, there is a strong association between early pubertal timing and early use of cigarettes and alcohol for both males and females (Ge et al., 2006b; Bratberg et al., 2007; Westling et al., 2008; Downing and Bellis, 2009). In one study early developing females were 3.7 times more likely to have tried cigarettes, alcohol, and marijuana than non-early maturers (Lanza and Collins, 2002), whereas another showed that girls with early puberty reported smoking their first cigarette about 7 months earlier than girls with later puberty (Wilson et al., 1994). Similarly, early maturers were found to use alcohol, cigarettes,

and marijuana with more regularity and frequency than non-early maturers (Tschann et al., 1994). Early maturing girls also initiated alcohol use at a younger age than later maturing girls (Deardorff et al., 2005), and early maturation was related to more alcohol use (Wichstrom, 2001).

Overall, there is substantial evidence that early pubertal timing puts an adolescent at increased risk for substance use. However, one study found late timing to be associated with more alcohol use in a sample of 11-17 year old girls (Marklein et al., 2009). Still others report a pubertal timing effect on substance use when moderators such as parenting, peer substance use, or school and neighborhood context were considered (Foshee et al., 2007). Moderators provide useful information about conditions that may amplify or alleviate the risks associated with early puberty. Identifying the early roots of substance use with regard to the risk factors of sleep preference and timing of puberty may inform early substance use prevention. In particular, early timing may increase the risk of substance use for adolescents with Evening preference, more so than early maturers with Morning preference. For Evening-types, a proclivity for late night activities may provide more exposure and opportunity for substance use. In addition, being an early maturer may increase the risk for substance use because early pubertal timing is linked to more exposure to older peers and deviant peers who may be engaging in substance use (Stattin and Magnusson, 1990; Haynie, 2003; Lynne et al., 2007).

There is substantial evidence that both early pubertal timing and Evening preference are individually associated with substance use. However, the studies showing an association between Eveningness and substance use have all been conducted on samples outside of the United States and no studies have examined the interaction effect between Morningness/Eveningness and pubertal timing on substance use. Therefore, the aims of this study were a) to examine the associations between Morningness/Eveningness and alcohol, cigarette, and marijuana use and b) to examine the interaction between pubertal timing and sleep preference on substance use in adolescent girls. It was hypothesized that Eveningness would be associated with greater use of all three substances, and that girls with Evening preference and early pubertal timing would show higher substance use than on-time or late maturing girls.

2. Methods

2.1. Participants

Participants included adolescent girls (N = 262) enrolled in an ongoing longitudinal study on smoking, mood, and their potential effects on bone and reproductive health (Dorn et al., 2008). Data for the present study were from the first assessment which took place from December 2003 to October 2007. Girls were primarily Caucasian (62.8%) or African American (32.8%). The remaining 5.3% of the girls represented mixed-race or other race/ethnicities and were combined with the African American group. Participants were recruited from an urban teen health clinic and the surrounding community. Enrollment was by age cohorts of 11, 13, 15, and 17 years old as well as an eligibility questionnaire based on five previously defined levels of smoking experience ranging from “not even a puff” to daily smoking. Exclusion criteria were based on factors relevant to the ongoing study and included: 1) pregnancy or breast feeding within 6 months, 2) primary amenorrhea (>16 years) or secondary amenorrhea (< 6 cycles/year), 3) body mass index < the 1st percentile or body weight > 300 pounds, 4) medication/medical disorder influencing bone health, and 5) psychological disabilities impairing comprehension or compliance. This study received approval from the Institutional Review Board of the affiliated hospital. Parents provided consent and the adolescent provided assent.

2.2. Procedures

Participants came to an urban children's hospital for their study visits. A physical examination was conducted by a physician or nurse practitioner trained in the procedures. During that time, a standardized interview was also conducted focusing on menstrual history followed by administration of the Morningness/Eveningness questionnaire. Other measures included in the visit were not the focus of this study. Administration of the Diagnostic Interview Schedule for Children (DISC) (Shaffer et al., 2000) followed, which assessed substance use.

2.3. Measures

2.3.1. Pubertal timing—Age at menarche (years, months) was obtained through clinician interview. Early, on-time, and late timing groups were created based on the sample distribution within Caucasian and non-Caucasian racial groups in this study. Plus and minus one standard deviation (SD) from the mean are typically used as cut-offs for the timing groups (Ge et al., 2006a). Girls who were 1 SD or more below the mean (within their racial group) were coded as early-timing, and those that were 1 SD or more above the mean were coded as late-timing; all remaining girls were coded as on-time. For the Caucasian group the cut-offs for the early and late groups were 11.52 and 13.74 years respectively, whereas for the non-Caucasian group the cut-offs were 10.67 and 13.34 years respectively.

At Time 1, 209 (80%) of the sample were menarcheal. For the remaining 53 premenarcheal girls, age at menarche was obtained from a subsequent data collection time point. Six premenarcheal girls withdrew before the Year 2 visit and thus could not be assigned to a timing group. At Year 4, three premenarcheal girls remained. Based on their chronological age and our stated criterion, they were placed in the late timing group.

2.3.2. Morningness/Eveningness—Morningness/Eveningness (M/E) was assessed via the Morningness/Eveningness scale for children (Carskadon et al., 1993). Ten questions assessed preferred time of day for activities (e.g. waking time, bedtime, test taking). The scale ranged from 10- 42 with lower scores indicating Evening preference. In this sample the scores ranged from 13-38 with acceptable internal consistency reliability ($\alpha = 0.78$).

2.3.3. Substance Use—Substance use (past year) was measured by questions from the alcohol, tobacco, and marijuana modules of the DISC (Shaffer et al., 2000). Research coordinators trained in the administration of the DISC completed the computer interview with the adolescents. Responses (never tried, experimentation, and use) were defined based on items from the alcohol, tobacco, and marijuana modules as modeled by others (Pajer et al., 2007).

Adolescent alcohol use was coded as: 0 = never tried alcohol in their lifetime *excluding a sip*, 1 = experimented with alcohol in the past year (more than one but less than six drinks), or 2 = consumed alcohol in the past year (six or more drinks).

Adolescent cigarette use was coded as: 0 = never smoked cigarettes in their lifetime, 1 = experimented with cigarettes in the past year (at least a puff, but not more than once a week for a month or longer), or 2 = regular smokers in the past year (smoked at least once a week for a month or longer).

Adolescent marijuana use was as: 0 = never used marijuana in their lifetime, 1 = experimented with marijuana in the past year (more than one but less than six times), or 2 = smoked marijuana in the past year (six or more times).

2.3.4 Covariates—The covariates included in the data analyses were age, race, and socioeconomic status (SES). The Hollingshead scale was used as an index of SES with higher scores indicating higher SES (Hollingshead, 1976). Parents reported on questions regarding SES. In the current sample the mean SES score was 35.90 (blue collar/working class) with a range of 14-66 (possible range=13-66).

2.4. Data Analysis

Descriptive statistics were examined and mean differences between the pubertal timing groups on M/E were tested with analysis of variance (ANOVA). Path modeling using Amos 7.0 (Arbuckle, 2006) and the asymptotically distribution-free estimation method was used to test the study hypotheses. First, to examine the associations between M/E and substance use for the total sample, M/E was modeled as the independent variable with alcohol, cigarette, and marijuana use as the three dependent variables (Figure 1). Main effects were included between M/E and each substance use variable. The covariates were age, race (Caucasian/non-Caucasian), and socioeconomic status (Hollingshead, 1976). Second, to examine the interaction effect between M/E and pubertal timing on substance use, the previous model was simultaneously fit to all three pubertal timing groups using multiple group path modeling. First an unrestricted model was fit simultaneously to all groups then the parameter estimate to each substance use variable, in turn, was restricted to be equal across groups. A significant decrement in model fit as indicated by the chi-square difference test demonstrated whether the restricted parameter was significantly different between the groups, signifying an interaction effect.

3. Results

3.1. Descriptive Statistics

The descriptive statistics can be found in Table 1. Mean differences in M/E between the pubertal timing groups were tested and no significant differences were found ($F(2, 256) = 1.04, p > 0.05$).

3.2. Morningness/Eveningness and Substance Use: Total Sample

The first aim was to examine the associations between M/E and alcohol, cigarette, and marijuana use for the total sample. The path model was fully saturated producing a perfect fit to the data. There were significant associations between M/E and all three types of substance use. (See Figure 1 and Table 2). The direction of all path coefficients indicated that Evening preference was associated with more substance use.

3.3. Interaction Effect of Morningness/Eveningness and Pubertal timing on Substance Use

The second aim examined the interaction between M/E and pubertal timing on substance use. The model fit was good for the unrestricted model ($\chi^2 = 19.34(12)$; RMSEA=0.05; CFI=0.99). There was a marginally significant decrement in model fit when the path from M/E to cigarette use was constrained to be equal across groups ($\Delta\chi^2 = 5.59(2), p = 0.06$) indicating an interaction effect between M/E and pubertal timing. The critical ratios of differences test indicated that the parameter between M/E and cigarette use was significantly different for the early versus late groups ($CR = 2.47, p = 0.01$), a trend for the on-time and late groups ($CR = 1.79, p = 0.07$), and not different between the early and on-time group. For the early and on-time groups there was a significant relationship between M/E and cigarette use (early: $\beta = -0.33, p < 0.01$; on-time: $\beta = -0.16, p < 0.05$) whereas for the late group the association was not significant ($\beta = 0.06, p = 0.54$). This indicates that for the early group a five point (1 SD) shift toward Eveningness was associated with a 30% increase in the risk for moving towards a higher substance use category. In the on-time group a five point (1

SD) shift toward Eveningness was associated with a 15% increase in risk for a higher substance use category. There were no other significant moderating effects of pubertal timing group. (See Table 2).

4. Discussion

This study examined the associations between Morningness/Eveningness and alcohol, cigarette, and marijuana use in adolescent girls and the interaction between Morningness/Eveningness and pubertal timing on substance use. As hypothesized, the results showed that for the total sample Evening preference was associated with higher use of all three substances. In addition, for early and on-time maturers, Eveningness was associated with more cigarette use than for late maturers. However, there were no significant differences in the association between M/E and alcohol or marijuana use by pubertal timing group.

4.1. Eveningness and Substance use

Greater substance use by Evening types may be a result of a combination of factors. Late-to-bed youth tend to have less parental supervision (Gau and Soong, 2003; Cousins et al., 2007), which combined with their inclination to stay up later and possible selection of substance using peers (Donovan and Jessor, 1985) may increase their risk for substance use (Stattin and Kerr, 1999). Alternatively, adolescents may adopt Eveningness patterns in order to pursue interests that are more supported by a late night lifestyle (Stattin and Kerr, 1999). Lastly, mood problems such as depressive symptoms are associated with Evening preference (Gau et al., 2007; Pabst et al., 2009) and comorbidity of depression and substance use has often been found (Armstrong and Costello, 2002; Volkow, 2004).

Overall, during puberty the architecture of sleep changes dramatically: there is a decrease in the amount of REM sleep, greater daytime sleepiness, and a shift toward phase delay (later bedtime and later awakening) (Carskadon et al., 1993; Dahl and Lewin, 2002). Although the present study did not examine sleep or sleep problems in particular, the findings of other studies suggest that sleep problems in general increase vulnerability to substance use (Johnson and Breslau, 2001; Wong et al., 2004). Other studies have found that in adults, Evening types scored higher on several measures of propensity towards risk-taking (Killgore, 2007) whereas in adolescents sleep habits resulting in insufficient sleep were associated with more risk taking behaviors including alcohol, cigarette, and marijuana use (O'Brien and Mindell, 2005). The evidence demonstrates that there may be a number of aspects of sleep (i.e. insufficient sleep or Evening preference) that increase the risk for substance use. Although studies show sleep problems are associated with more substance use (Johnson and Breslau, 2001; Wong et al., 2004; O'Brien and Mindell, 2005), this is the first study to show that the Evening sleep chronotype is associated with substance use in an U.S. sample of adolescent girls. Studies conducted in countries outside the U.S may be characterized by cultural differences in the acceptability of the use of certain substances. Generalizing previous findings to American adolescents may not be appropriate. However, the results from this study concur with those conducted in other countries (Adan, 1994; Giannotti et al., 2002; Gau et al., 2007; Randler, 2008a) showing that Eveningness is associated with more alcohol, cigarette, and marijuana use.

4.2. Eveningness, Early Pubertal Timing, and Substance Use

Overall the literature shows that separately early pubertal timing and Evening preference are associated with more substance use (Adan, 1994; Tschann et al., 1994; Wichstrom, 2001; Lanza and Collins, 2002; Gau et al., 2007), however no studies have examined the interaction effect between the two on substance use. Similar to Susman and colleagues (2007) we found no pubertal timing differences in sleep preference, however we did find

that the interaction between pubertal timing and sleep preference influences cigarette use. As expected, our results show that the association between Eveningness and cigarette use was stronger for the early and on-time pubertal timing groups than for the late group, with the late group showing a non-significant association. This demonstrates that being a late maturer is relatively protective. A similar pattern was found for alcohol and marijuana use, although the parameter estimates between pubertal timing groups were not significantly different. There is evidence that even infrequent experimentation with cigarettes in adolescence increases the likelihood of becoming a regular smoker in young adulthood (Chassin et al., 1990; Choi et al., 1997). Therefore identifying the risks for cigarette use in adolescence may help intervene in the development of long-term use. Early pubertal timing is thought to increase substance use because early maturers may have more opportunities to be exposed to and participate in substance use. A similar explanation may apply for Eveningness and substance use. An early maturer with Evening preference may be more vulnerable than an on-time or late maturer with Evening preference because the early maturer may be drawn into older peer groups or deviant peer groups due to their mature physical appearance (Stattin and Magnusson, 1990; Caspi et al., 1993; Lynne et al., 2007). This may expose them to substance-using peers while they lack the cognitive and emotional maturity to deal with peer pressure. A strength of the current study was the examination of a widely understudied influence on adolescent substance use, namely Morningness/Eveningness. These results contribute to the understanding of sleep preference changes in adolescence as well as potential risk factors for substance use.

4.3. Limitations and Future Directions

Several limitations of this study should be noted. First the data were cross-sectional precluding any causal inferences. Therefore we cannot determine if Evening preference leads to increased substance use or if substance use alters sleep chronotype. Longitudinal data will allow examination of the associations between pubertal timing, sleep preference, and substance use as they change with advancing age. Specifically it will be important to examine whether Eveningness precedes substance use or if substance use alters sleep preference. Of particular concern is the increased risk for substance abuse linked to early initiation and the persistence of substance use into adulthood. Second, all measures were self-report which may introduce bias. However for the concepts considered herein (i.e. sleep preference, age at menarche, substance use) the adolescents' self-report is likely the most accurate. In addition, measures of self report M/E have been validated against temperature, hormonal profiles, actigraphy, and sleep logs (Kerkhof, 1985; Bailey and Heitkemper, 1991; Gibertini et al., 1999; Baehr et al., 2000; Tonetti, 2007) indicating that self report of this construct is accurate. We also did not examine possible psychiatric comorbidity with substance use. As depression and substance use are correlated in many studies and are linked to both Eveningness and early pubertal timing, there is likely more complexity to these associations than can be gleaned from the current findings. In addition many other variables have been linked to substance use and we could not include all the possible risk factors for substance use.

An additional limitation may be the sample size for this study. Due to the nature of the pubertal timing variable there will inherently be more participants in the on-time group than in the early or late groups. However, many studies have used this variable with similar distributions and sample sizes to the current study, thus our confidence in this variable is supported. Additionally, because this was a secondary data analysis we may have limited statistical power, particularly in examining interaction terms. The non-significant interaction effects for marijuana and alcohol use may be due to difficulties in detecting interaction effects with unequal cell sizes and creating categorical variables from continuous ones (Aguinis et al., 2001; Frazier et al., 2004). Lastly, it should be noted that our sample was

drawn from a limited geographic region in the Midwestern United States, thus limiting the generalizability of the findings as this sample may not be representative of all adolescents in the US.

Future research should examine these variables to gain a clearer understanding of the multifaceted etiology of substance use. While we did not examine racial differences per se, we did control for race in the analyses. Supplementary analyses between racial groups did not show any racial differences in the association between M/E and substance use. Lastly, we cannot determine whether Evening preference leads to increased substance use due to social or environmental factors or if they are linked by a familial predisposition for substance use that may become exacerbated in Evening types. The results of this study illustrate two conditions (M/E and pubertal timing) that may amplify the risk for substance use in adolescents. Examination of other factors such as peer group influences, neighborhood characteristics and parental monitoring will clarify contextual processes that may further increase substance use.

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Figure 1.

Path diagram testing the relationship between Morningness/Eveningness and substance use for the total sample. Standardized path coefficients are shown. Covariates (age, race, SES) were omitted from the figure for simplicity. Lower scores on M/E indicate Evening preference. ** $p < 0.01$, * $p < 0.05$.

Table 1

Descriptive statistics for study variables

	N	Mean	SD	Range
Age (years)	262	14.93	2.17	11.07 - 17.99
SES	261	37.32	13.67	14 - 66
Age at menarche (years)	252	12.39	1.24	7.42 - 16.08
Morningness/Eveningness	260	26.41	5.14	12 - 38
	*	0	1	2
Alcohol use: <i>n</i>	135 (51.5%)	59 (22.5%)	67 (25.6%)	
Cigarette use: <i>n</i>	147 (56.1%)	38 (14.5%)	76 (29%)	
Marijuana use: <i>n</i>	182 (69.5%)	31 (11.8%)	48 (18.3%)	

* Note: for alcohol and marijuana 0 = no use, 1 = used 1-5 times, 2 = used ≥ 6 times; for cigarettes 0 = no use, 1 = smoked less than once a week, 2 = smoked at least once a week for a month or longer; alcohol, marijuana, and cigarette use from the Diagnostic Interview Schedule for Children; SES = socioeconomic status; Morningness/Eveningness-lower scores indicate Evening preference

Table 2

Parameter estimates for Morning/Eveningness and substance use from multiple group path modeling analyses between pubertal timing groups

	Morningness/Eveningness (M/E)					
	Early		On-time		Late	
	Unstandardized coefficient (SE)	Standardized coefficient t	Unstandardized coefficient (SE)	Standardized coefficient t	Unstandardized coefficient (SE)	Standardized coefficient t
Alcohol	-0.05 (.02)	-0.32*	-0.03 (.01)	-0.20**	-0.02 (.02)	-0.12**
Cigarettes	-0.06 (.02)	-0.33** ^a	0.03 (.01)	-0.16** ^b	0.01 (.02)	0.06 ^{a,b}
Marijuana	-0.04 (.02)	-0.30*	-0.02 (.01)	-0.11	-0.02 (.02)	-0.09*

Note: SE= Standard Error; Lower scores on M/E indicate Evening preference; coefficients with

^a superscript are significantly different

at $p < 0.01$, those with

^b superscript are significantly different at $p < 0.08$;

* $p < 0.05$,

** $p < 0.01$.