Nightmares Associated with the Eveningness Chronotype

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Abstract Relations between common nightmares and chronobiological factors remain poorly understood. The possibility that nightmare frequency and distress are associated with chronotype ("morningness-eveningness") was investigated in a sample of respondents to an Internet questionnaire. Over a 4½-year period, a total of 3978 subjects (mean age = 26.5 ± 11.6 yrs; age range = 10-69; 2933 female, 1045 male) submitted responses to single items about chronotype and nightmares as well as to other demographic variables. Analyses of chronotype and nightmares items by age and gender replicated most previous findings for these measures—validating their further assessment—and uncovered abrupt increases in nightmare distress between ages 10-19 and 20-29 for females and ages 30-39 and 40-49 for males. Most important, there was a strong association between nightmares and eveningness for female subjects. The latter was expressed as a linear association between nightmare frequency and increasing eveningness and a cubic association between nightmare distress and increasing eveningness; the *definite evening* types displayed the most severe nightmares. The effect for nightmare frequency was independent of age and sleep duration but was eliminated when nightmare distress was covaried. For females, the nightmare/eveningness association appeared at ages 20 to 29 for the *definite evening* type and only later, at ages 30 to 39, for the *moderate evening* type. Findings are consistent with the possibility that nightmares are the expression of a more general pathological factor that is characteristic of eveningness and that is responsible for affective symptoms such as neuroticism and depression. This pathological factor appears to be expressed in late adolescence/early adulthood, and relative morningness may be a protective factor delaying its onset. The well-established circadian modulations of cognitive, social, and affective tasks that are influenced by chronotype may extend to the memory and affective processes of sleep—including dreaming. This chronotypic influence, together with a likely gender difference in the neurophysiological substrate of emotional processing, may result in the differential occurrence of nightmares for female evening types.

Key words chronotype, eveningness, nightmares, parasomnias, gender, age, sleep duration

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Relations between idiopathic nightmares and chronobiological factors remain largely unexplored. Indirect evidence suggests that nightmares may be shaped by chronobiological processes that influence normal dreaming, especially the ultradian stage oscillations of REM and non-REM (NREM) sleep and the circadian variations of REM sleep propensity (Nielsen, 2009, for review). The most vivid dreaming takes place during REM sleep, occurring near the early morning peak of REM propensity—which is also when most nightmares occur.

Individual differences in chronotype, or an individual's preference for the timing of daily activities, are associated with markers of circadian physiology such as the peak, amplitude, or period of core body temperature, melatonin, and cortisol (Baehr et al., 2000; Duffy et al., 1999; Horne and Ostberg, 1976). Evening types habitually wake up at a later clock time than do morning types but also wake up at an earlier circadian phase, closer to the nadir of the core body temperature (CBT) rhythm (Baehr et al., 2000; Duffy et al., 1999; Mongrain et al., 2004). Since the acrophase of REM sleep propensity is time locked to the CBT minimum, it is possible that evening types are more likely than morning types to awaken from, and subsequently recall, the most intense dreams (and nightmares) coincident with this acrophase. A related possibility stems from the fact that eveningness is correlated with sleep duration (Giannotti et al., 2002; Korczak et al., 2008); longer sleep may entail proportionally more morning REM sleep and a greater likelihood of recalling vivid dreams or nightmares.

On the other hand, relative morningness is known to vary with demographic factors such as age, gender, and geography that are also robustly associated with nightmares. Morningness decreases with age (Taillard et al., 2004; Tonetti et al., 2008) and is more characteristic of females (Adan and Natale, 2002). The fact that nightmares also decrease with age and are more frequent for females (Nielsen and Petit, 2008) suggests that they may be more closely related to the morningness than the eveningness chronotype. So too does the finding that nightmares are more prevalent in countries that have earlier rise times (Janson et al., 1995).

In sum, findings support opposing possibilities about nightmares and chronotype. However, because no studies have yet directly linked measures of nightmare frequency or distress with circadian physiology, such possibilities remain speculative. The present study explores this question by determining if measures of nightmare severity are related to self-reported morningness-eveningness in a large sample of Internet respondents. Age, gender, "feeling best" time of day, habitual dream recall, and habitual sleep duration were also examined as possible mediators of a nightmare-chronotype association.

MATERIALS AND METHODS

Responses were from a questionnaire available in both English and French on our laboratory Web site between December 11, 2003, and June 4, 2008 (http://www.jtkresearch.com/dreamlab/). From the pool of 4511 respondents, individuals were excluded if they gave extreme estimates of nightmare recall (>93/month) or dream recall (>124/month) (.6%), failed to estimate their chronotype or nightmare recall frequency (8.8%), indicated they were <10 or >69 years old (1.1%), estimated they slept <2 or >17 h per night (0.8%), and failed to specify gender (.5%). A total of 3978 records (mean age = 26.5 ± 11.6 years; age range: 10-69 years), or 88.2% of the original response set, were retained for analysis. Of these, 2933 were female (mean age = 26.5 ± 11.2; range: 10-69) and 1045 were male (mean age = 26.7 ± 12.7; range: 10-69; t_{3976} = 0.695, p = 0.487).

The following demographic information was requested: age, gender, income, occupation, education, mother tongue, religion, and political preference. To assess typical nightmare frequency, an open-ended question was posed: *How many nightmares do you recall in a typical month?* This 1-month retrospective estimate slightly underestimates values obtained prospectively from daily home logs (Zadra and Donderi, 2000). To assess nightmare distress, the following question was posed: *Typically, how distressed by your nightmares are you?* (1 = *not at all* to 5 = *very*). Distress is partially independent from nightmare frequency and correlates with psychopathology and intent to seek treatment (Belicki, 1992). Dream recall frequency was assessed with an item as for nightmares: *How many dreams do you recall in a typical month?* To assess chronotype, items 18 and 19 from the Morningness-Eveningness Questionnaire (MEQ; Horne and Ostberg, 1976) were administered:

#18: At what time of the day do you think that you reach your "feeling best" peak (choose one)? (24 response choices: 12:00 AM to 11:00 PM in 1-h increments)

#19: A morning person is someone who performs and feels better in the morning hours of the day whereas an evening person is someone who performs and feels better in the late afternoon or evening. Which ONE of these types do you consider yourself to be?

1. Definitely a "morning" type
2. Rather more a "morning" than an "evening" type
3. Rather more an "evening" than a "morning" type
4. Definitely an "evening" type

In one factor analysis of the MEQ, items 18 and 19 were among 3 items that loaded most strongly on the principal factor—the "time of greatest efficiency"; the 2 items are also sensitive to gender differences (Adan and Natale, 2002). The items constitute 2 of the 5 items of the MEQ short form (rMEQ), whose classification correlates highly (.73) with that of the MEQ (Chelminski et al., 2000). In the present study, respondents used item 19 to classify themselves as 1 of 4 chronotypes: definitely morning (Def-AM), moderately morning (Mod-AM), moderately evening (Mod-PM), or definitely evening (Def-PM). Item 18 was used to cross-validate item 19 with a "feeling best" hour of the day estimate. A similar 1-item categorization has adequate test-retest reliability ($r = .84$; $K = .80$), correlates with a 13-item morningness scale, and predicts differences in melatonin phase advance (Gibertini et al., 1999).

To assess typical sleep duration, an open-ended question was posed: *How many hours of sleep do you have on a typical day?* Other items not reported here concern the frequency of typical dream themes, the types and intensities of traumatic experiences, emotional attachment style, and social anxiety. The time and date of submission of each questionnaire was logged automatically. Participants were informed on the Web site that results would be used in a research study and published.

Statistical analyses were organized in 3 sets. The first examined the single-item chronotype measure in relation to demographic factors such that its validity might be determined relative to existing research. Predictions were drawn from this research: morningness will be characterized by an earlier feeling best time of day than would eveningness, chronotype will shift toward increased morningness with age, females will show greater morningness than males, and morningness will be inversely related to sleep duration.

The second set of analyses examined the validity of 2 nightmare (NM) severity measures: nightmare frequency and nightmare distress. Existing research again provided clear hypotheses about the distribution of nightmare frequency as a function of gender and age: logNM frequency will be higher for females than for males, and frequency will decrease monotonically with age (Nielsen and Petit, 2008). Changes in nightmare distress with age have not yet been studied, although research suggests it should correlate with nightmare frequency and be higher for females.

The third set explored relations between chronotype and nightmare severity, again taking into account gender and age differences. Most evidence suggests that nightmares should be associated with eveningness, although gender and age may moderate this association. The large sample size permitted a detailed analysis of chronotype for female subjects in particular because stronger associations with nightmares were observed for this group.

Chi-square, analysis of variance (ANOVA), analysis of covariance (ANCOVA), and t test analyses were conducted using the following independent variables: gender, age range (10-19, 20-29, 30-39, 40-49, 50-69), age (as covariate), typical sleep duration (covariate), and feeling best time of day (0-23, covariate). When sample variances were unequal, nonparametric tests were conducted to interpret contrasts and simple effects.

RESULTS

Chronotype, Demographics, and Feeling Best Time of Day

The principal spoken languages of the sample were English (47.5%) and French (47.3%). The proportion of subjects by age range was as follows: 10 to 19, 33.7% (n = 1341); 20 to 29, 33.7% (1341); 30 to 39, 16.0% (636); 40 to 49, 11.6% (460); and 50 to 69, 5.0% (200). There was no gender difference for age.

The MEQ item 19 classified 15.2% (603) of the sample as Def-AM, 21.0% (836) as Mod-AM, 34.0% (1352) as Mod-PM, and 29.8% (1187) as Def-PM.

Distributions of feeling best times by chronotype appear in Figure 1; peak (modal) times were 9:00 AM for Def-AM, 10:00 AM for Mod-AM, 2:00 PM for Mod-PM, and 8:00 PM for Def-PM; medians were 9:00 AM, 10:00 AM, 3:00 PM, and 6:00 PM, respectively. The Mod-PM group was bimodal, with a secondary peak (7:00 PM) close to that of the Def-PM group.

Chronotype by Age, Gender, and Duration of Sleep

A one-way ANOVA with chronotype as an independent measure revealed that the Def-AM group was older (32.7 ± 13.0 years) than the Mod-AM group

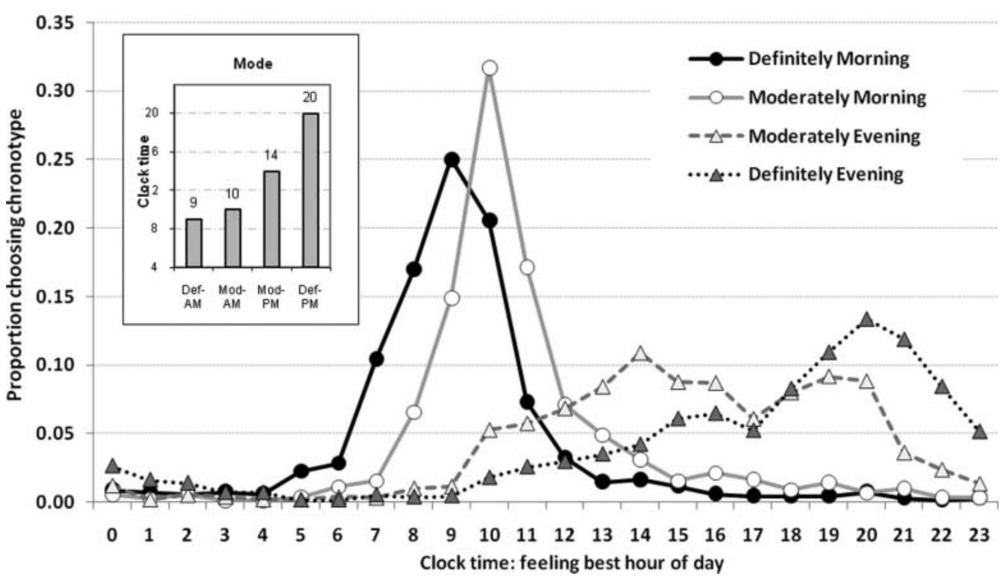

Figure 1. Proportion of subjects in each of 4 self-rated chronotype groups (Morningness-Eveningness Questionnaire [MEQ] item 19) who selected each of 24 h of the day as their feeling best hour (MEQ item 18). Inset displays modal feeling best clock time for the 4 groups. Morning types consistently selected earlier times than did evening types.

(27.8 ± 11.9), which was in turn older than both the Mod-PM (24.5 ± 10.8) and Def-PM (24.8 ± 10.2) groups (Tamhane t; all $p < 0.0000005$), which did not differ.

A dichotomous chronotype variable (morning type: Def-AM + Mod-AM, evening type: Def-PM + Mod-PM) was examined, for males and females separately, for adjacent pairs of age ranges. As shown in Figure 2, the percentage of female evening types decreased monotonically from ages 10-19 to 40-49, while the percentage of males decreased from ages 20-29 to 40-49. More females than males were evening types at ages 10 to 19 ($p = 0.056$); the opposite was true at ages 20 to 29 ($p = 0.003$). Peak prevalence of female evening types was age 16 (Fig. 2, inset), while for males it was age 20.

A 4 × 5, Chronotype × Age Range ANOVA on sleep duration revealed an age range main effect ($F_{4,\,3956}$ = 44.524, $p < 0.0000005$; decreasing linear trend: $F_{1,\,3971}$ = 65.812, $p < 0.0000005$). A marginal interaction ($F_{12,\,3956}$ = 1.683, $p = 0.064$) was due to a simple effect exclusive to ages 10 to 19: sleep duration decreased linearly with increasing eveningness ($F_{1,\,1337}$ = 13.029, $p = 0.0003$): Def-AM = 8.31 ± 1.95 h, Mod-AM = 8.28 ± 1.41 h, Mod-PM = 8.05 ± 1.49 h, and Def-PM = 7.75 ± 1.83 h.

Nightmare Frequency and Distress

A high positive skew (3.172) of the nightmare recall distribution warranted log-transformation (log (frequency + 1); logNM) for subsequent analyses. Dream recall frequency was similarly skewed (2.471) and log-transformed.

A 2 × 5, Gender × Age Range ANOVA revealed that logNM varied with both variables (interaction: $F_{4,\,3966}$ = 4.433, p = 0.001); the gender difference obtained for every age range (all $p < 0.01$) except ages 50 to 69. In addition, for both males ($p < 0.02$) and females ($p < 0.000001$), changes in logNM recall with age were best described by decreasing linear trends (Fig. 4, left panel).

Nightmare distress scores were available for 1665 respondents (M: 3.26 ± 1.33) and correlated positively with logNM for the whole sample (r_{1665} = .508), for males (r_{324} = .493), and for females (r_{1341} = .496) (all $p < 0.0000005$). Correlations obtained at all age ranges (all $p < 0.0000005$) but were lowest for ages 10 to 19 (r_{509} = .442) and highest for ages 50 to 69 (r_{76} = .693).

A 2 × 5, Gender × Age Range ANOVA with nightmare distress as a dependent variable revealed main effects for age range ($F_{4,\,1655}$ = 4.600, $p = 0.001$), gender ($F_{1,\,1655}$ = 8.474, $p = 0.004$), and an interaction ($F_{4,\,1655}$ = 3.741, $p = 0.005$). As shown in Figure 3 (right panel), nightmare distress increased with age for both sexes. For females, it increased abruptly between ages 10-19 and 20-29 (Fig. 3, right panel, a); for males, it increased much later and even more abruptly, between ages 30-39 and 40-49 (Fig. 3, right panel, b).

Chronotype and Nightmare Severity

Nightmare frequency. A 2 × 4, Gender × Chronotype ANOVA on logNM revealed main effects for gender (females > males: $F_{1,\,3968}$ = 62.294, $p < 0.0000005$) and chronotype ($F_{3,\,3968}$ = 3.358, $p = 0.018$) and a marginal interaction ($p = 0.124$; Fig. 4, left panel). For females, the chronotype simple effect was best described by an increasing linear trend ($F_{1,\,2927}$ = 22.341, $p = 0.000002$; Fig. 4, left panel) with increasing

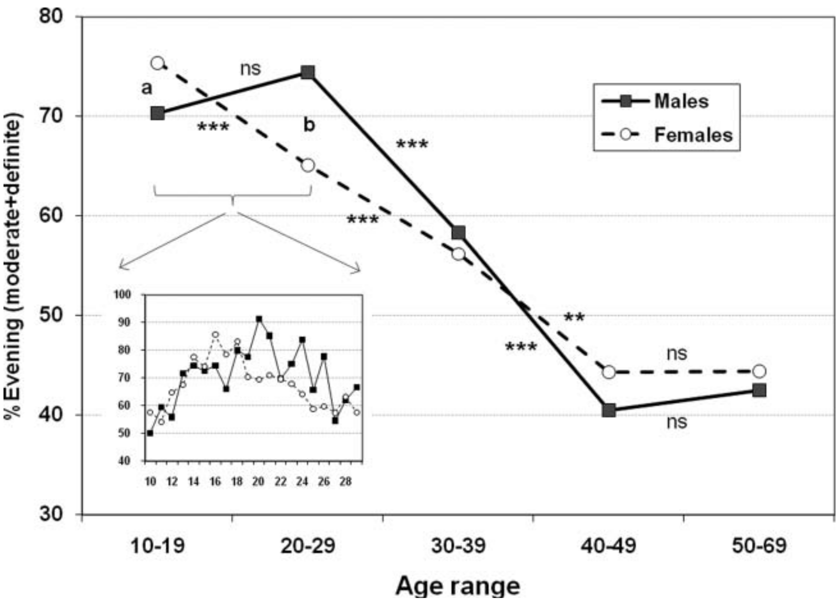

Figure 2. Percentage of subjects in the evening groups (moderately + definitely) as a function of gender and age. (a) Fewer males than females aged 10 to 19 years were evening types ($p = 0.056$), whereas (b) more males than females aged 20 to 29 years were evening types ($p = 0.003$). These effects reflect the fact (inset) that females reached a peak prevalence of eveningness (85.5%) at age 16, while males reached the peak at age 20 (91.4%). Chi-square probabilities values are shown for within-gender comparisons of chronotypes by adjacent age ranges. **$p < 0.001$. ***$p < 0.000001$.

eveningness. For males, there was no chronotype simple effect ($F_{3,1041} = 0.602$, $p = 0.613$) and no linear trend.

Controlling nightmare distress as a covariate eliminated the interaction trend ($p = 0.419$) but not the gender ($F_{1,1656} = 12.198$, $p = 0.0005$) or chronotype ($F_{3,1656} = 4.069$, $p = 0.007$) main effects. For females, covarying age and sleep duration did not eliminate the chronotype simple effect ($F_{3,2925} = 4.384$, $p = 0.004$) and linear trend ($p = 0.001$). Nor did covarying dream recall (simple effect: $F_{3,2926} = 5.117$, $p = 0.002$; linear trend: $p = 0.0001$). Covarying nightmare distress did eliminate the chronotype simple effect for females ($F_{3,1336} = 1.446$, $p = 0.228$) and reduced the linear trend ($p = 0.045$).

A gender effect was absent for the Def-AM group ($t_{601} = 1.394$, $p = 0.164$) but present for the Mod-AM ($t_{832} = 4.310$, $p = 0.00002$), Mod-PM ($t_{1350} = 5.661$, $p < 0.0000005$), and Def-PM ($t_{1185} = 5.576$, $p < 0.0000005$) groups. Covarying nightmare distress rendered the gender effect significant for the Def-AM group ($p = 0.007$) but diminished it for the Mod-AM ($p = 0.448$), Mod-PM ($p = 0.064$), and Def-PM ($p = 0.107$) groups.

Nightmare distress. A 2 × 4, Gender × Chronotype ANOVA on nightmare distress revealed a main effect for gender ($F_{1,1657} = 40.731$, $p < 0.0000005$; Fig. 4, right panel) but not for chronotype ($p > 0.205$) and no interaction ($p > 0.515$). Nevertheless, for females alone, the chronotype effect was evident ($F_{3,1337} = 5.413$, $p = 0.001$; Fig. 4, right panel) and conformed to a cubic trend ($F_{1,1337} = 6.967$, $p = 0.008$). The Def-PM group showed higher distress than the Mod-PM ($p = 0.00007$) and Def-AM ($p = 0.071$) groups, whereas the Mod-PM group showed lower distress than the Mod-AM group ($p = 0.036$). No effects were observed for males. The nightmare distress gender effect was present as a trend for the Def-AM group ($t_{195} = 1.804$, $p = 0.073$) and as a significant difference for the Mod-AM ($t_{337} = 3.254$, $p = 0.001$), Mod-PM ($t_{616} = 3.586$, $p = 0.0004$), and Def-PM ($t_{509} = 5.208$, $p < 0.0000005$) groups (see Fig. 4, right panel).

The abrupt increase in nightmare distress between ages 10-19 and 20-29 for females (Fig. 3, right panel, a) was further investigated, with t tests comparing age strata 10-19 and 20-29 for each of the 4 chronotypes. For females, the abrupt increase was apparent for the Def-PM type ($M_{20\text{-}29}$: 3.78 ± 1.17 vs. $M_{10\text{-}19}$: 3.13 ± 1.24; $t_{300} = -4.63$, $p < 0.00001$), the Mod-PM type (3.32 ± 1.30 vs. 3.01 ± 1.19; $t_{380} = -2.51$, $p = 0.013$), and the Mod-AM type (3.63 ± 1.14 vs. 3.07 ± 1.38; $t_{190} = -3.00$, $p = 0.003$) but not the Def-AM type (3.69 ± 1.30 vs. 3.29 ± 1.57; $t_{66} = -1.02$, $p = 0.312$). No contrasts were seen for males (all $p > 0.495$).

Effects of age. In light of the marked gender difference for chronotype, relations between nightmares, chronotype, and age were further investigated for males and females separately using 4 × 5, Chronotype × Age Range ANOVAs with logNM as the dependent measure. For males, only an age range main effect ($F_{4,1025} = 4.637$, $p = 0.001$) reflected a decrease in nightmare frequency with increasing age beginning at ages 10 to 19.

For females, a decreasing age range effect was also observed ($F_{4,2911} = 14.118$, $p < 0.0000005$) as was a main effect for chronotype ($F_{3,2927} = 3.381$, $p = 0.018$) but no interaction. Nonetheless, a meaningful pattern of change with age was apparent for the female groups (see Fig. 5 for details).

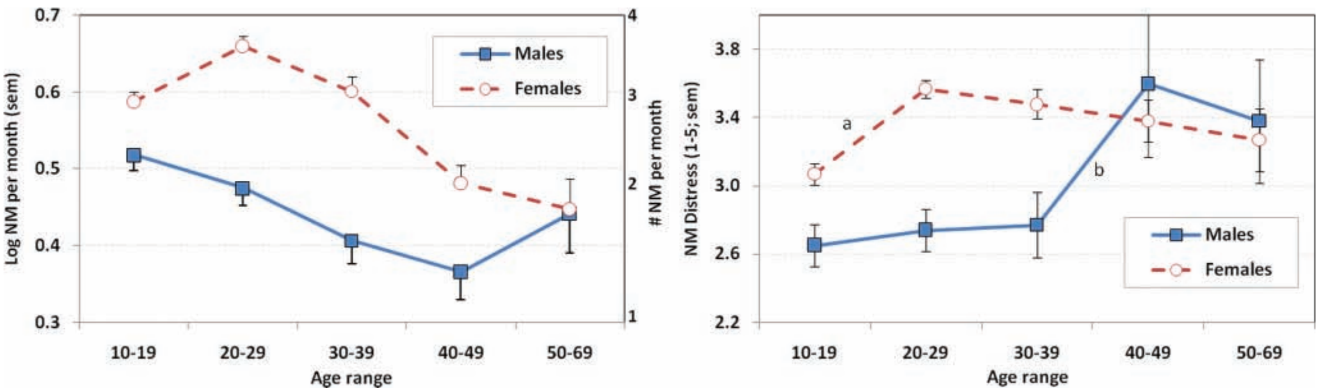

Figure 3. Nightmare (NM) severity measures as a function of gender and age. Left panel: log frequency (± SEM) **of nightmares per** month decreases linearly with age. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. ****$p < 0.00001$. **#Nightmares per month equivalent shown on secondary *Y*-axis. Right panel: nightmare distress** (± SEM) (1 = *not at all* **to 5** = *very*) **increases abruptly at different ages for the 2 sexes. (a) For females, ages 10 to 19 are lower than ages 20 to 29 ($p < 0.0000005$), 30 to 39 ($p < 0.0002$), and 40 to 49 ($p < 0.03$). (b) For males, ages 10 to 39 are lower than ages 40 to 49 (all $p < 0.05$) and 50 to 69 ($p < 0.032$, 0.054, 0.091).**

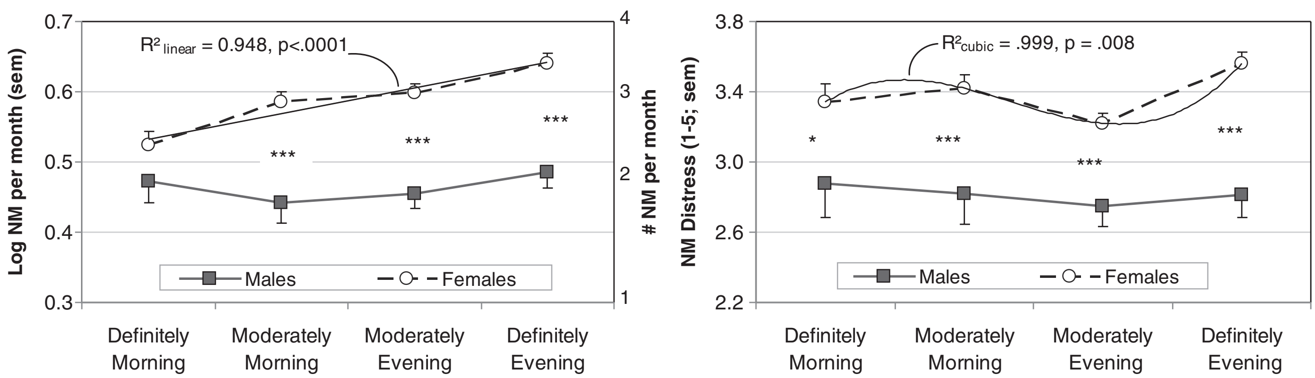

Figure 4. Nightmare (NM) severity measures as a function of gender and chronotype. Left panel: increasing log frequency of nightmares per month is linearly related to increasing eveningness for females. Right panel: increasing nightmare distress (1 = *not at all* **to 5** = *very*) **is related curvilinearly to increasing eveningness for females, with Def-PM types having the highest and Mod-PM types the lowest levels of distress. Gender differences are less salient for Def-AM than for Mod-AM, Mod-PM, or Def-PM groups on both nightmare measures.** *$p < 0.08$. ***$p < 0.001$.

DISCUSSION

Validity of Chronotype and Nightmare Measures

Validity of the single-item MEQ chronotype measure was supported by results that closely replicate several findings. First, the distribution of definite types (15.2% Def-AM, 29.8% Def-PM) compares well with estimates from other large samples using total MEQ scores (e.g., 15.8% morning, 24.5% evening [Adan and Natale, 2002] or 8.3% morning, 29.3% evening [Chelminski et al., 1997]). Second, the feeling best times for MEQ item 18 clearly distinguished the 4 chronotypes in the expected linear fashion. The bimodal distribution for Mod-PM subjects raises the possibility that the feeling best time item may be a more precise single-item choice for assessing eveningness than is the chronotype item. Third, the shift of chronotype prevalence toward increasing morningness with advancing age replicates the findings of others (Roenneberg et al., 2007; Taillard et al., 2004) and is especially consistent with the results in Figure 4 of Roenneberg et al. (2007). Fourth, the higher morningness ratings of females aged 20 to 29 (Fig. 2) replicate gender differences from several studies on primarily young undergraduates (Adan and Natale, 2002; Chelminski et al., 1997; Roenneberg et al., 2007)

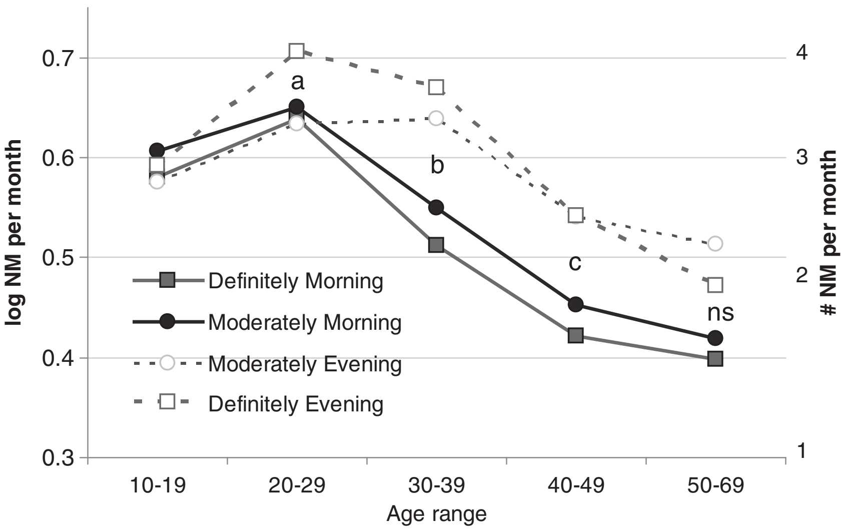

Figure 5. Monthly nightmare frequency (logNM) as a function of chronotype and age for 2931 female respondents. An association between logNM and eveningness begins with Def-PM (at ages 20-29) and then Mod-PM (at ages 30-39): (a) logNM is markedly higher for ages 20 to 29 than for ages 10 to 19 for the Def-PM group ($p = 0.001$) and marginally so for the Mod-PM group ($p = 0.059$) but not different for the 2 morning groups; the Def-PM group reports marginally more nightmares than the others ($p = 0.130$, 0.110, 0.022). (b) logNM is lower for ages 30 to 39 than for ages 20 to 29 for both Def-AM ($p = 0.027$) and Mod-AM ($p = 0.030$) groups but for neither evening group (both $p > 0.41$); the evening groups are elevated relative to the morning groups (Def-PM vs. others: $p = 0.005$, 0.024; Mod-PM vs. others: $p = 0.026$, 0.105). (c) For ages 40 to 49, logNM is marginally lower than for ages 30 to 39 for all 4 groups ($p = 0.096$, 0.105, 0.105, 0.058); differences between the Def-AM and 2 evening groups remain apparent for ages 40 to 49 ($p = 0.066$, 0.037), but differences for the Mod-AM group do not (both $p < 0.180$).

as does the absence of such a difference for the 10 to 19 age group (Giannotti et al., 2002). Others have found a similar gender difference for all ages using different MEQ items (Tonetti et al., 2008).

Validity of the 2 nightmare severity measures was similarly supported by consistencies with previous research. First, the gender difference replicates differences in nightmare prevalence and frequency reported for adolescents (Nielsen et al., 2000), adults (Hublin et al., 1999), and the general population (Ohayon et al., 1997). That logNM frequency was higher for females than males at all ages younger than 50 largely replicates our previous Internet study of 23,990 respondents (Nielsen et al., 2006). Second, age-related changes in logNM are consistent with prior findings (cf. Nielsen et al., 2006, Fig. 1), including an increase in nightmare frequency from 10-19 to 20-29 for females (Fisher et al., 1989; Nielsen et al., 2000), a further linear decrease after 20 to 29 (Klink and Quan, 1987), and a nadir after 60 (Wood et al., 1993). Third, the moderate correlations between nightmare frequency and nightmare distress measures observed in the present study are common in the literature (Blagrove et al., 2004). The abrupt increases in nightmare distress at ages 20 to 29 for females and 40 to 49 for males are new, however, and require further replication.

Relations between Chronotype and Nightmares

The present results demonstrate a clear gender-linked association between nightmare severity and the eveningness chronotype. In particular, nightmares are recalled more frequently and rated as more distressing by females who rate themselves as definitely evening types than by females who tend more toward morningness. This relation does not hold for males. That the association for females is independent of dream recall frequency suggests that evening types are not reporting more nightmares simply because their proclivity to awaken closer to the REM propensity acrophase (Baehr et al., 2000; Duffy et al., 1999; Mongrain et al., 2004) affords them better recall of the vivid and emotional dreaming—including nightmares—that occurs at this time. Similarly, that the observed association was also independent of typical sleep duration further mitigates an explanation based on evening types having longer sleep episodes and thus more morning REM sleep and increased recall of REM-associated nightmares. Some possible connections to REM sleep cannot be excluded by the present findings, however. The fact that evening types have been found to have a greater proportion of REM sleep than morning types (Carrier et al., 1997) could reflect overall higher REM propensity and more intense dream experiences in this group. Similarly, because evening types can extend their sleep on weekends more than can morning types (Taillard et al., 1999), it is possible that the eveningness/nightmares association is due, at least in part, to more REM sleep and nightmares occurring on the weekends among evening types.

The eveningness/nightmares association observed for females appears to vary with age. Nightmare frequency becomes associated with eveningness in the

20s for Def-PM types and in the 30s for Mod-PM types, and the association is subsequently maintained for older cohorts. The onset of this association is also linked to a relatively abrupt increase in nightmare distress, which was observed to occur in the 20 to 29 age stratum for females of all chronotypes except the Def-AM type—and this, several years earlier than for males. This pattern is consistent with the possibility that a psychopathological factor responsible for nightmares is expressed in late adolescence/early adulthood and that relative morningness may be a protective factor delaying its onset.

The finding that the nightmare frequency-eveningness association was largely eliminated when nightmare distress was statistically controlled is also consistent with the notion that nightmares are one expression of a more general pathological factor that is characteristic of eveningness. Nightmare distress, as opposed to nightmare frequency, reflects an underlying pathology of emotional processing that accounts for associations between nightmares and a variety of sleep and affective disorders (Nielsen and Levin, 2007). Similarly, eveningness is related to several such disorders—for example, sleep/wake irregularities and distress (Ong et al., 2007), neuroticism (Tonetti et al., 2009), bipolar disorder (Ong et al., 2007; Wood et al., 2009), and depressive symptoms (Chelminski et al., 1999).

Although the nature of this underlying pathophysiology remains unclear, there is agreement that morning and evening types differ in how effectively they perform on various cognitive, social, and affective tasks at different times of day (Carrier and Monk, 1999; Schmidt et al., 2007). Thus, chronotype modifies the phase and shape of circadian-modulated processes (Horne et al., 1980). Such modification may extend to the memory and affective processes of sleep (Born and Wagner, 2004; Stickgold and Walker, 2007), including processes of dream formation and nightmares. Presumably, eveningness reflects a dysfunctional influence over the latter processes. Furthermore, if the processes so modulated are themselves dependent on a sexually dimorphic neurophysiology, such as the amygdalar regions subserving emotion (Cahill, 2006), then the eveningness influence over these processes may also be gender specific. For example, that female evening types report less positive affect after waking in the morning than do female morning types whereas men show no such relation (Gibertini et al., 1999) may reflect chronotype- and gender-linked differences in the cross-night regulation of affective processes (Cartwright, 2005).

Such an explanation resembles the *internal coincidence* model of depression (Wehr and Wirz-Justice, 1981), which stipulates that mood in the depressed is affected by a phase-angle discrepancy between a phase-advanced circadian clock and the sleep-wake cycle. Accordingly, manipulations of the sleep-wake cycle, such as sleep deprivation or phase advance of the sleep period, may alleviate depressive symptoms (Berger et al., 2003). A similar model may account for nightmares among evening types, with the added stipulation that the emotional processes affected are based on neurophysiological differences that are more prone to disruption among females. Such an analogy raises the possibility of applying treatments successful for depression, such as sleep deprivation, bright-light therapy, or phase advance of the sleep period (Benedetti et al., 2001; Wu et al., 2009), in alleviating nightmares in this group.

Validity of Internet Samples

While the exact composition of Internet samples remains difficult, if not impossible, to ascertain, a growing body of research suggests that they constitute a valid source of personal information—and are perhaps superior to other sampling methodologies in some respects. The use of Internet surveys is increasing in the areas of sleep medicine and dreaming (Cheyne et al., 1999; Zavada et al., 2005) as it is in other areas that deal with sensitive personal information, such as sexual health (Ross et al., 2005) and illicit drug use (McCabe, 2004). Research suggests that people share information and experiences electronically that they might not disclose using traditional survey methodologies; furthermore, online survey methods may reduce social desirability and yea-saying biases (see review in Rhodes et al., 2003). In contrast, health-oriented Internet sites such as ours may attract disproportionately more individuals with serious health difficulties. Since females are more likely than males to seek help, especially for emotional problems (Moller-Leimkuhler, 2002), a gender bias in participation may have affected our main findings.

Nonetheless, online surveys have been validated against paper-and-pencil tests (Knapp et al., 2004), mail surveys (McCabe, 2004), and national population studies (Ross et al., 2005). High concordances between methods have been observed. However, there is a self-selection bias toward younger and more educated respondents (Ross et al., 2005). Online research also reaches respondents from hidden populations, reduces error and bias, and enables fuller participation since subjects control when they will complete surveys and feel less peer pressure to participate (Rhodes et al., 2003). Some studies suggest that frequent Internet users may bear a preponderantly evening chronotype (Esposito et al., 2001), but the fact that distributions of morning and evening types in the present results replicated those of larger population studies do not bear out this notion.

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