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Morningness-Eveningness, Chronotypes and Health-Impairing Behaviors in Adolescents

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Abstract

The impact of diurnal preferences on health-related behaviors is acknowledged but relatively understudied. The aim of this study was threefold: (1) testing the measurement model of the Hungarian version of the reduced Horne-Östberg Morningness-Eveningness Questionnaire (Hungarian Version of the rMEQ); (2) estimating chronotypes and their prevalence; and (3) analyzing the relationship between morningness-eveningness/chronotypes and health-impairing behaviors, including smoking, alcohol use, and physical inactivity in adolescents. Self-reported data on the Hungarian version of the rMEQ, smoking, alcohol use, and physical inactivity obtained from Hungarian high-school students (ninth grade, N = 2565) were analyzed with confirmatory factor analysis (CFA), latent profile analysis (LPA), structural equation modeling, and analysis of variance (ANOVA). A one-factor model of morningness was supported, which included rising time, peak time, retiring time, and self-evaluation of chronotype. Morningness was significantly associated with a lower likelihood of smoking and alcohol use, and also with a lower level of physical inactivity. Using LPA, the authors identified three chronotypes: intermediate type (50.7%), morning type (30.5%), and evening type (18.8%). Compared to the evening-type participants, intermediate- and morning-type participants were significantly less likely to experiment with smoking, to smoke nondaily, and to smoke daily. Moreover, both intermediate- and morning-type students reported less lifetime alcohol use and less physical inactivity than evening-type students. Chronopsychological research can help to understand the relatively unexplored determinants of health-impairing behaviors in adolescents associated with chronotype.

Keywords

Adolescent; Alcohol; Chronotype; Morningness-eveningness; Physical inactivity; Smoking

INTRODUCTION

Different sleep-wake patterns and their relationship with biological, psychological, and behavioral variables are studied in both animals and humans (Korczak et al., 2008; Marpegan et al., 2009). Morningness-eveningness refers to the individual differences in diurnal preferences, sleep-wake pattern for activity, and alertness in the morning and evening (Susman et al., 2007). Individuals who are characterized by a more extreme position toward morningness are usually known as “early larks,” whereas those who show a more extreme eveningness are known as “night owls.” Larks are early risers, perform mentally

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and physically at their best in the morning hours, and go to bed early in the evening. Owls stay up late at night, rise at a later time in the morning, and perform best mentally and physically in the late afternoon or evening (Randler, 2008). These two preferences are assumed to have special biological, genetic, psychosocial, and contextual components (Susman et al., 2007).

Many operationalizations of diurnal preferences apply self-report questionnaires (Adan & Almirall, 1991; Caci et al., 2009; Horne & Östberg, 1976; Roenneberg et al., 2007). The Morningness-Eveningness Questionnaire (Horne & Östberg, 1976) was originally used for distinguishing between the two extreme diurnal types: morning type and evening type (Chelminski et al., 2000), and since then this questionnaire has been modified several times (e.g., Adan & Almirall, 1991). The Morningness-Eveningness Questionnaire (Adan & Almirall, 1991) measures the preferred time of rising and bedtime, as well as physical and mental performance and alertness after rising and after different activities (Chelminski et al., 2000). Exploratory factor analysis revealed four factors: peak time, morning affect, retiring, and rising time (Caci et al., 2009). The reduced Horne and Östberg Questionnaire (rMEQ, Adan & Almirall, 1991) is one of the most commonly used measures of individual preferences in 24-h rhythms. Instead of the full 19-item questionnaire, the rMEQ contains five self-report items and measures one dimension of morningness-eveningness (Chelminski et al., 2000).

Two competing approaches are present in the current studies focusing on morningness-eveningness. The first approach identifies a typology in diurnal preferences (Natale & Cicogna, 2002), but there is no agreement about the number of types. In some research, two types—morning and evening—are studied (Horne & Östberg, 1976), whereas in some other research three or more types—morning, intermediate, and evening—are studied (Natale & Cicogna, 1996). Horne and Östberg (1976) propose cut-off scores to distinguish five types, from definitely morning type through three intermediate types to definitely evening type. These cut-off scores for an apparently continuous variable might vary among different research studies (Natale & Cicogna, 2002) and also depend on age, sex, culture, and other variables (Caci et al., 2009). The other approach treats morningness-eveningness as a continuum between the two extremes. Natale and Cicogna (2002) provided arguments for the use of the morningness-eveningness continuum. Moreover, psychometric analysis also revealed that morningness-eveningness scales are multidimensional (Caci et al., 2009), which raises the question of the usefulness of a single score and its associated typology to understand the chronopsychological characteristics of individuals and groups.

Chronobiological and chronopsychological research studies have documented that some important individual differences (Tankova et al., 1994) are associated with morningness-eveningness, such as age (Paine et al., 2006), sex (Muro et al., 2009; Paine et al., 2006), working schedule (Pearson, 2004; Randler, 2008), or personality (Adan et al., 2010a, 2010b; Digdon & Howell, 2008; Muro et al., 2009; Tonetti et al., 2009). Research has revealed that eveningness is related to higher neuroticism (Tonetti et al., 2009), lower self-control and self-regulation, as well as greater procrastination (Digdon & Howell, 2008), higher novelty seeking, and lower harm avoidance (Adan, et al., 2010a). On the other hand, morningness is linked with higher conscientiousness (Tonetti et al., 2009), as well as general and work activity (Muro et al., 2009). The association between diurnal preferences and several personality traits might be a putative pathway between morningness-eveningness and behaviors.

The focus of the present study is on the link between diurnal preferences and health-impairing behaviors among adolescents. Diurnal preferences are associated with several habitual or nonhabitual behaviors, including food intake among adolescents (Fleig &

Randler, 2009), sleeping behaviors among university students (Nakade et al., 2009; Suen et al., 2008), problematic behaviors in adolescents (Goldstein et al., 2007) and among 4–6-year-old children (Yokomaku et al., 2008), smoking (Adan & Sánchez-Turet, 1995; Adan et al., 2004; Nakade et al., 2009; Wittmann et al., 2010), drug use (Adan, 1994; Díaz-Morales & Sánchez-López, 2008), or physical activity and inactivity (Campos Hirata et al., 2007; Schaal et al., 2010). Several studies have revealed that morningness-eveningness is associated with smoking status in both adults (Adan, 1994; Ishihara et al., 1985; Mecacci & Rocchetti, 1998; Taillard et al., 1999; Wittmann et al., 2006) and adolescents (Giannotti et al., 2002). It was found that eveningness is associated with the tendency to consume more psychoactive substances (Díaz-Morales & Sánchez-López, 2008; Fleig & Randler, 2009). Whereas eveningness is associated more with health-impairing behaviors, morningness tends to be linked with health-improving behaviors, including physical activity in adolescents (Schaal et al., 2010).

However, the majority of these studies have relied on adult or young adult samples. Therefore, it would be important to focus on the adolescent population in order to understand the associations between chronotype, i.e., morningness-eveningness, and health-impairing behaviors in a younger population. The present study—the Budapest Adolescent Smoking Study—provided the opportunity to understand these associations in a large sample of adolescents. This report had four aims. The first was to examine the psychometric properties of both the original and the Hungarian version of the reduced Horne-Östberg Morningness-Eveningness Questionnaire (rMEQ; Adan & Almirall, 1991) in a large adolescent sample. The second was to identify chronotypes empirically and estimate their distribution in the adolescent population. The third was to test the associations between morningness-eveningness and health-impairing behaviors, such as smoking, alcohol consumption, and physical inactivity. The fourth was to test the link between chronotype and health-impairing behaviors. Based on our literature review, our hypothesis was that morningness would be associated with lower likelihood of smoking, alcohol use, and physical inactivity in adolescents.

METHODS

Participants and Procedure

The present study involved the first wave of a school-based longitudinal study called the Budapest Adolescent Smoking Study. The two-stage cluster sampling method is described in more detail elsewhere (Urbán, 2010). In the first wave (between October and December 2008), 70 schools and 106 classes participated, representing both general high schools and vocational schools across Budapest. A total of 2565 ninth-grade high-school students (mean age = 15.3 yrs, SD = 0.56 yrs; 1251 boys and 1314 girls) took part in this study. The study was approved by the Institution Review Board of Eötvös Loránd University and was conducted in accordance with the policies of the Ethics Committee of the Hungarian Psychological Association and international chronobio-logical standards (Portaluppi et al., 2010).

Measures

Morningness-Eveningness—We used the Hungarian version of the reduced Horne-Östberg Morningness-Eveningness Questionnaire (rMEQ; Adan & Almirall, 1991). The original scale consists of five items referring to rising time, peak time, retiring time, morning freshness, and self-evaluation of chronotype. We added another item in order to measure morning fatigue/freshness on free days when the participants are not pressed to get up on time. We added this extra item to make the distinction between working/school and free days, which is emphasized in the conceptualization of chronotypes (Roenneberg et al., 2003;

Wittmann et al., 2006). We used similar response options to the original scale, and recoded responses in order to measure towards morningness preference. Therefore, a higher score refers to the preference for an earlier rising time, earlier peak time, and earlier retiring time. In the case of morning affect items, we used the original response options, from very tired (coded 1) to very refreshed (coded 4). Internal consistency (Cron-bach α) of the French version of this scale was 0.69 in French university students (Caci et al., 2009).

Smoking—Self-reported smoking behavior was assessed by the Hungarian version of smoking-related questions from the Youth Risk Behavior Survey 2009 (CDC, 2008). In the current analysis, we asked two major questions: “Have you ever tried a cigarette, if only a few puffs?” “Have you smoked at least one cigarette in the past 30 days and if so how many?” In the structural equation modeling (SEM) analysis, we used the following dummy smoking-status variables: tried smoking (yes/no); nondaily smoking or smoking during the last month (yes/no); daily smoking (yes/no).

Alcohol Use—Self-reported alcohol intake was assessed by the question: “How many times have you consumed alcohol in your life?” (Likert scale from 0 = never to 6 = more than 40 times). We created a linear measure according to the following coding schemata: never was coded 0; 1–2 times was coded 1.5; 3–5 times was coded 4; 6–9 times was coded 7.5; 10–19 times was coded 14.5; 20–39 times was coded 30; and more than 30 times was coded 35.

Physical Inactivity—Inactivity was assessed by two questions related to time spent watching television and playing computer games unrelated to a school task on an average school day. Response options were “I do not watch TV (or play computer games) on an average school day” (coded 0); “less than 1 hour per day” (coded 1); “1 hour per day” (coded 2); “2 hours per day” (coded 3); “3 hours per day” (coded 4); “4 hours per day” (coded 5); “5 or more hours per day” (coded 6). We used the Hungarian translation of questions from the Youth Risk Behavior Survey 2009 (CDC, 2008).

Statistical Analysis

In order to support the factor structure and test item performance of the Hungarian short version of the Morningness-Eveningness Questionnaire (rMEQ; Adan & Almirall, 1991), we performed several confirmatory factor analyses (CFA). The first analysis was performed on the original five items, and the second analysis included all six items. Analysis was performed with the MPLUS 5.2. program. Since our sample was a complex one, we performed CFA with maximum likelihood parameter estimates with standard errors and chi-square test statistics that were robust to the normality and non-independence of observations (Muthén & Muthén, 1998–2007, p. 484). We applied four fit indices in these analyses, including the comparative fit index (CFI), the Tucker Lewis index (TLI), the root mean square error approximation (RMSEA), and the standardized root mean square residual (SRMR). The satisfactory degree of fit required the comparative fit index (CFI) to be greater than 0.95; the second fit index was the Tucker Lewis index (TLI), which was acceptable around 0.90; and the third fit index was the root mean square error approximation (RMSEA), which indicated excellent fit if its value was below 0.05. The value of RMSEA around 0.08 indicated adequate fit, and a value above 0.10 signified poor fit. The standardized root mean square residual (SRMR) implied a good fit if its value was below 0.08.

In past research, different traditions were used to determine chronotypes. One entailed the application of predetermined cut-off scores (e.g., Horne & Östberg, 1976; Martin & Marrington, 2005); however, these scores seemed arbitrary due to small and specific—

usually young adult—samples and unclear statistical and procedural information. Another tradition entailed the application of the lowest 10 and highest 10 percentiles (Livosky et al., 1992; cf. Natale & Cicogna, 2002) or z-scores to distinguish the extreme morning and evening types (Mecacci & Zani, 1983). This approach also implied the assumption regarding the distribution of different chronotypes. The most important disadvantage of this approach is that these cut-off scores would be specific to the samples used in these studies. The third used a median split method to distinguish two chronotypes; however, median split should be avoided in case of a continuous score (MacCallum et al., 2002). Due to these difficulties, we selected another approach, namely a person-oriented statistical framework, seeking subtypes of adolescents that exhibit similar patterns of activity and alertness in the morning and evening. Therefore, we performed a latent profile analysis with one to six classes in order to determine how many types can be identified with the Hungarian version of the rMEQ and the class membership of the participants. The latent profile analysis (Collins & Lanza, 2010; Vermunt & Magidson, 2002) is a latent variable analysis with a categorical latent variable—in this case chronotypes—and continuous manifest indicators, such as rMEQ items. In the process of determining the number of latent classes, we used the Bayesian information criteria parsimony index, the minimization of cross-classification probabilities, entropy, and the interpretability of clusters. In the final determination of the number of classes, we also used the likelihood-ratio difference test (Lo-Mendell-Rubin adjusted likelihood-ratio test [LRT]), which compares the estimated model with a model having one less class than the estimated model (Muthén & Muthén, 1998– 2007). A low p value ($p < .05$) indicates that the model with one fewer class is rejected in favor of the estimated model.

In order to test the association between morningnesseveningness with smoking, alcohol consumption, and physical inactivity, we applied both a structural equation modeling (SEM) framework and a chronotype approach. In the SEM analysis, we applied the weighted least squares (WLSMV) estimation method in MPLUS 5.2. (Muthén & Muthén, 1998–2007). In the chronotype approach, we used the class membership identified in latent profile analysis as a predictor of health-impairing behaviors in both linear and binary logistic regression while age and sex were controlled.

RESULTS

Sample Characteristics

The basic statistics of the study variables are presented in Table 1. Being female is significantly associated with earlier retiring time ($r = 0.18$, $p < .001$) and self-evaluation favoring eveningness ($r = –0.07$, $p < .01$). Age is significantly associated with later rising time ($r = –0.05$, $p < .02$) and lower morning freshness on free days ($r = –0.07$, $p < .001$). However, the effect size of these associations is small. We also compared morning freshness on school days and free days and found that morning freshness is significantly higher on free days ($t = 41.3$, $df = 2416$, $p < .0001$).

Morningness-Eveningness—Confirmatory Factor Analyses

We performed a confirmatory factor analysis on the original five-item version of rMEQ (Adan & Almirall, 1991) and tested a one-factor solution. The fit indices indicated an inadequate degree of fit ($\chi^2 = 110.5$; $df = 5$; CFI = 0.869; TLI = 0.739; RMSEA = 0.093 [0.078–0.108]; SRMR = 0.042). The fit indices did not support the one-factor measurement model. Inspection of factor loadings revealed that the morning affect item had a low factor loading (0.27), whereas the range of the other four factor loadings varied between 0.45 and 0.65. The internal consistency of the original five-item version measured by the Cronbach's α was 0.56 in this sample.

We tested the one-factor solution of the Hungarian six-item version of rMEQ and found also an unacceptable level of model fit (χ^2 = 217.4; *df* = 9; CFI = 0.776; TLI = 0.626; RMSEA = 0.097 [0.086–0.108]; SRMR = 0.055). The Cronbach α of this version was 0.54 in this sample.

Since the one-factor measurement models did not provide adequate level of fit to the data, we also tested the two-factor measurement model. The two-factor model involved separate morningness and morning freshness factors in a confirmatory factor analysis framework. The degree of model fit was close to an acceptable level (χ^2 = 109.2; *df* = 8; CFI = 0.895; TLI = 0.804; RMSEA = 0.072 [0.060–0.084]; SRMR = 0.038). Examination of modification indices (Brown, 2006) suggested freeing the error covariance between "At approximately what time in the evening do you feel tired, and, as a result, in need of sleep?" and "At approximately what time of day do you usually feel your best?" Error covariance implies here that these two items have further covariance that the latent variable cannot explain. This covariance reflects that a later peak time involves later retiring time. After freeing this error covariance, the degree of model fit increased to an acceptable level: χ^2 = 47.8; *df* = 7; CFI = 0.958; TLI = 0.910; RMSEA = 0.049 [0.036–0.068]; SRMR = 0.027. The standardized factor loadings of the final model are presented in Table 2. The first factor represents "Morningness," with a higher factor score reflecting morningness, and a lower factor representing eveningness. The second factor represents "Morning Freshness," with a higher factor score representing higher morning freshness. The correlation between these factors is 0.27 ($p < .0001$). Factor determinacies are 0.78 and 0.92, respectively. Although this model represents that morningness and morning freshness are related but separate constructs, morning freshness is identified only by two items, and the factor loading of one item is less than optimal. Internal consistency of this two-item scale is low at 0.37. Therefore, in the final step we tested the one-factor solution of the morningness construct by leaving out the two morning freshness items, and we also kept the error covariance between "At approximately what time in the evening do you feel tired, and, as a result, in need of sleep?" and "At approximately what time of day do you usually feel your best?" The degree of model fit was adequate (χ^2 = 0.53; *df* = 1; CFI = 1.00; TLI = 1.00; RMSEA = 0.000 [0.000–0.048]; SRMR = 0.003), and the range of factor loadings was between 0.40 and 0.70. The internal consistency (Cronbach α) of this scale was 0.55 in this sample.

Morningness and Its Association With Health-Related Behaviors—A Structural Equation Model

To test the association between morningness and health-related behaviors, we used a structural equation model that included only the Morningness factor as a latent variable, due to the psychometric problems of the Morning Freshness factor. In this model, we tested if morningness predicts simultaneously the experimentation with smoking, 30-day smoking, everyday smoking, alcohol use, and two indicators of physical inactivity, namely time spent watching TV and Internet use. Morningness was a latent variable, and all other variables were observed ones; sex and age were controlled in the analysis. The degree of fit of the overall model was good (χ^2 = 203.4; *df* = 27; $p = .0001$; CFI = 0.95; TLI = 0.88; RMSEA = 0.051). We report here the unstandardized regression coefficients using probit regression, which is derived by the weighted least square model estimation (WLSMV). "Morningness" significantly predicted lower probability of all binary outcome variables, including experimentation with smoking ($B = –0.56$, $z = 8.00$, $p < .0001$), smoking during the last 30 days ($B = –0.65$, $z = 9.11$, $p < .0001$), and daily smoking ($B = –0.65$, $z = 7.54$, $p < .0001$). Morningness also predicted lower level of alcohol use ($B = –8.52$, $z = 9.10$, $p < .0001$), less time spent watching TV ($B = –0.33$, $z = 4.16$, $p < .0001$), and less time spent on the Internet ($B = –0.93$, $z = 9.42$, $p < .0001$). Therefore, adolescents with a higher morningness score are less likely to have tried smoking, smoked a cigarette during the past 30 days, or reported

daily smoking. They also reported lower life-time alcohol use and less time spent watching TV or using the Internet.

Identifying Chronotypes—A Latent Profile Analysis

To identify the latent classes of chronotypes, we performed a latent profile analysis with all six items of the Hungarian version of the rMEQ. We estimated one to six class solutions. The information-based criteria and entropy of each solution is presented in Table 3. The Akaike information criteria (AIC), Bayesian information criteria (BIC), and sample size–adjusted BIC declined as more latent classes were added. However, we noted a leveling-off after the three-latent-class solution. Based on entropy, the three- and four-latent-class solutions reached the maximum level. Examination of the four-latent-class solution revealed that the fourth latent class is very small (N = 23; less than 1% of the sample). Based on these considerations, we selected the three-latent-class solution. The profile plot of the classes is presented in Figure 1. The most prevalent class (N = 1246; 50.7%) is the intermediate type; the second most prevalent class is the morning type (N = 751; 30.5%); and the least prevalent is the evening type (N = 462; 18.8%).

Chronotypes and Health-Related Behaviors

We also examined the concurrent prediction of health-related behaviors based on chronotype membership. Three binary logistic regressions were calculated to predict three smoking indicators with control for age and sex. Compared to evening-type participants, intermediate- and morning-type participants were significantly less likely to experiment with smoking (odds ratio [OR] = 0.63 [0.50–0.81] and OR = 0.42 [0.32–0.54], respectively), to have smoked a cigarette during the past 30 days (OR = 0.65 [0.52–0.82] and OR = 0.38 [0.29– 0.49], respectively), or to be a daily smoker (OR = 0.32 [0.22–0.47] and OR = 0.55 [0.40–0.74], respectively).

With the continuous variables, we performed a series of analysis of variance (ANOVA) to test the differences between chronotypes in life-time alcohol use, time spent on TV viewing, and Internet use. A significant main effect was found in the frequency of life-time alcohol use ($F(2, 2403) = 58.4$, $p < .0001$), and the post hoc analysis revealed that the three groups were significantly different ($M_{evening} = 20.2$, $M_{intermediate} = 12.8$, $M_{morning} = 12.0$). Evening-type students consumed alcohol more frequently than any other type of student. A significant main effect was found in the time spent on the computer and computer games other than school assignments ($F(2, 2440) = 17.2$, $p < .0001$), and the post hoc analysis revealed that the three groups were significantly different ($M_{evening} = 2.37$, $M_{intermediate} = 2.00$, $M_{morning} = 1.83$). Evening-type students spent more time on computer games than any other type of student. We did not detect a significant main effect in TV viewing ($F(2, 2436) = 1.60$, ns).

DISCUSSION

The first aim of this study was to explore the psychometric properties of the Hungarian version of the reduced Horne-Östberg Morningness-Eveningness Questionnaire (rMEQ; Adan & Almirall, 1991). The original rMEQ contains five items; in our version, we added another item to describe morning freshness on free days. Our aim was to provide evidence on the one-factor measurement model of the Hungarian version of the reduced Horne-Östberg Morningness-Eveningness Questionnaire. However, from the confirmatory factor analyses, we found that each morning freshness item had a low factor loading on the morningness factor, implying that morning freshness would not be an essential component of the morningness-eveningness construct. Nevertheless, the morningness-eveningness could be identified with four items: rising time, peak time, retiring time, and self-evaluation.

The analysis of internal consistency of the four-item morningness-eveningness scale also revealed that this scale had a somewhat smaller internal consistency value (0.55) than the usually accepted level (0.70). On the one hand, methodologists emphasize that when a scale has other desirable properties, such as meaningful content coverage of some domain and reasonable unidimensionality, low reliability may not be a major barrier to its use (e.g., Schmitt, 1996). On the other hand, due to the lower reliability of the morningness-eveningness scale, we could underestimate the associations between morningness and other variables. In our case, we corrected for the lower reliability by using morningness as a latent variable in the analyses of the associations between morningness and observed variables. Structural equation modeling provided the opportunity to estimate the relationship among variables, adjusting for measurement error (Brown, 2006; DeShon, 1998). Nevertheless, the low reliability of the morningness scale is not optimal. Therefore, further scale development should provide a more reliable version for adolescent research.

The second aim was to test the chronotype approach in adolescents. We used latent profile analysis, which can be regarded as a person-oriented framework seeking subtypes of adolescents that exhibit similar patterns of activity and alertness in the morning and evening. We identified three latent classes, or so-called types, namely evening type, intermediate type, and morning type. The distribution of these chronotypes provides evidence that the majority of adolescents could be classified as intermediate type. Morning type was second in frequent, and the least frequent one was evening type. Using different methods to measure morningness-eveningness, one study also reported higher prevalence of the morningness type in Italian adolescents (Giannotti et al., 2002); another study reported a near-Gaussian distribution (Roenneberg et al., 2007); and yet another study stated that 60–70% of the population is of the intermediate type (Natale & Cicogna, 2002). However, there is a change in chronotypes around the end of adolescence towards eveningness (Roenneberg & Merrow, 2007). Therefore, comparisons between adolescent and adult samples might be problematic. Moreover, latitude also seems to be influential in the distribution of chronotypes in the population, given that Borisenkov (2010) reported a significant northward trend towards a higher prevalence of the late chronotype compared to a Central European sample.

The third aim was to test the association between morningness-eveningness as a continuum, or chronotypes as discrete categories, and health-impairing behaviors, such as alcohol use, smoking, as well as TV watching and playing on the computer as two indicators of spending time in physical inactivity. Stronger preferences towards morningness predicted a lower likelihood of experimental, nondaily and daily smoking, less frequent alcohol consumption, and less time spent in physical inactivity, including TV viewing and playing computer games. Our study reinforced previous evidence (Adan, 1994; Schaal et al., 2010; Wittmann et al., 2010) of the association between chronotypes and health-related behaviors. In the present analysis, however, we could demonstrate the associations in one multivariate model where morningness-eveningness as a continuum was used.

Similar results were found when we employed the chronotype approach. Our results demonstrated that being a morning type is protective, whereas being an evening type is a risk factor for smoking, alcohol use, and physical inactivity. Similar findings were reported by earlier research (Adan, 1994; Monk et al., 2004; Wittmann et al., 2006). Smokers tended towards eveningness and had a greater difference in wake-up times between week days and free days (Adan & Sánchez-Turet, 1995; Adan et al., 2004). The research on the link between smoking and chronotypes is still in its early stage, and it provokes more questions. Further research should attempt to replicate these findings and explain the causal chain behind them.

Only a very few investigations focused on the association between morningness-eveningness and physical inactivity. In this study, we found that time spent in physical inactivity, including TV watching and playing computer games, was predicted by "morningnesseveningness." This result is in accordance with previous research findings (Schaal et al., 2010) that suggest these activities are related to eveningness because of an exogenous, social contextual influence. However, using the chronotype approach, we also found that evening-, intermediate-, and morning-type students differed in the amount of time spent on the computer and playing computer games. Evening-type students spent almost an hour longer on a daily basis using the computer for non-school-related tasks than morning-type students. Unexpectedly, we could not detect any difference in time spent in watching TV between the chronotype groups.

Different pathways can explain the association between morningness-eveningness or chronotypes and health-related behaviors. The first hypothetical pathway is through personality traits, such as novelty seeking (Adan et al., 2010), conscientiousness (Tonetti et al., 2009), and self-control (Digdon & Howell, 2008). The second pathway is through the links between morningness-eveningness and the physiological markers of endogenous circadian rhythmicity (Duffy et al., 2001; Giannotti et al., 2002; Korczak et al., 2008). These associations reflect the possible impact of the phase delay of physiological functioning on behaviors. Certain health-impairing behaviors, such as smoking, might compensate the physiological functioning associated with more eveningness (Korczak et al., 2008). The third possible pathway is related to the construct of social jetlag, which is the misalignment of social and biological time (Wittmann et al., 2006). Social jetlag is suggested as a possible mediator (Adan, 1994; Wittmann et al., 2006, 2010) between diurnal preferences, drug use, and physical inactivity. Drug use might be a self-medication of the negative impact of social jetlag; on the other hand, drug use and physical inactivity can also increase social jetlag with the disturbance of circadian rhythmicity, quality of sleep, and distorted sleep-wake patterns (e.g., Adan & Sánchez-Turet, 1995; Adan et al., 2004; Roehrs & Roth, 2001; Zhang et al., 2008).

According to the problematic behavior theory (Jessor & Jessor, 1977; Zamboanga et al., 2004), problematic behaviors in adolescents help them to reach the normative development purposes and cope with stress. The misalignment of social and biological time, or a misfit between chronotype, namely evening type and school demands, might cause stress, which requires coping efforts possibly leading to adaptive and maladaptive coping, such as drug use. In line with this reasoning, a recent study (Wittmann et al., 2010) reported that smoking and alcohol use mediate between late chronotype and decreased psychological well-being in adults. Further studies are required to test these mediations in adolescents as well.

The present study is not without limitations. First, the present sample is limited to urban adolescents, and, therefore, its generalizability to rural and minority adolescents is restricted. Second, the direction of causal relationships is uncertain owing to the cross-sectional analysis. Third, this study is based only on self-report measures, which might be prone to memory and response biases. Fourth, the reliability of the reduced Horne-Östberg Morningness-Eveningness Questionnaire is not optimal. When the continuous morningnesseveningness score is used, the associations should be corrected due to its high measurement error (DeShon, 1998).

This study provided evidence that both the morningness-eveningness dimension and chronotypes are useful approaches to study adolescents' diurnal preferences in future research. We demonstrated the adequate, but not optimal, psychometric properties of a short morningness-eveningness scale. We also demonstrated that three chronotypes (morning, intermediate, and evening types) could be differentiated in a large sample of adolescents.

Furthermore, our results supported previous findings, as well as our tentative hypothesis, about the association between morningness-eveningness and health-impairing behaviors, such as smoking, alcohol consumption, and physical inactivity. The present research highlighted that evening-type adolescents have a higher risk of health-impairing behaviors. The replication and extension of these findings are required in further research to explain the complex associations between circadian typology and addictive and/or other negative health-related behaviors. Further research should focus on mediation and moderator variables of these associations.

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REFERENCES

Adan A. Chronotype and personality factors in the daily consumption of alcohol and psychostimulants. Addiction. 1994; 89:455–462. [PubMed: 8025504]

Adan A, Almirall H. Horne & Östberg Morningness-Eveningness Questionnaire: a reduced scale. Pers. Individ. Diff. 1991; 12:241–253.

Adan A, Sánchez-Turet M. Smoking effects on diurnal variations of cardiovascular parameters. Int. J. Psychophysiol. 1995; 20:189–198. [PubMed: 8788221]

Adan A, Prat G, Sánchez-Turet M. Effects of nicotine dependence on diurnal variations of subjective activation and mood. Addiction. 2004; 9:1599–607. [PubMed: 15585051]

Adan A, Lachica J, Caci H, Natale V. Circadian typology and temperament and character personality dimensions. Chronobiol. Int. 2010a; 27:181–193. [PubMed: 20205565]

Adan A, Natale V, Caci H, Prat G. Relationship between circadian typology and functional and dysfunctional impulsivity. Chronobiol. Int. 2010b; 27:606–619. [PubMed: 20524804]

Borisenkov MF. Human chronotypes in the north. Human Physiol. 2010; 36:348–352.

Brown, TA. Confirmatory factor analysis for applied research. Guilford Press; New York: 2006. p. 475

Caci H, Deschaux O, Adan A, Natale V. Comparing three morningness scales: age and gender effects, structure and cut-off criteria. Sleep Med. 2009; 10:240–245. [PubMed: 18387342]

Campos-Hirata F, Colares Oliveira Lima M, Meireles Sales de Bruin V, Ribeiro Nóbrega P, Wenceslau GP, Carvalhedo de Bruin PF. Depression in medical school: the influence of morningness-eveningness. Chronobiol. Int. 2007; 24:939–946. [PubMed: 17994347]

CDC (Centers for Disease Control and Prevention). [27 August 2008] Youth Risk Behavior Survey. 2008. Available at http://www.cdc.gov/yrbss.

Chelminski I, Petros TV, Plaud JJ, Ferraro FR. Psychometric properties of the reduced Horne and Östberg questionnaire. Pers. Individ. Diff. 2000; 29:469–478.

Collins, LM.; Lanza, ST. Latent class and latent transition analysis. Wiley; Hoboken, NJ: 2010. p. 285

DeShon RP. A cautionary note on measurement error corrections in structural equation models. Psychol. Methods. 1998; 3:412–423.

Díaz-Morales JF, Sánchez-López MP. Morningness-eveningness and anxiety among adults: a matter of sex/gender? Pers. Individ. Diff. 2008; 44:1391–1401.

Digdon NL, Howell AJ. College students who have an eveningness preference report lower self-control and greater procrastination. Chronobiol. Int. 2008; 25:1029–1046. [PubMed: 19005903]

Duffy JF, Rimmer DW, Czeisler CA. Association of intrinsic circadian period with morningness-eveningness, usual wake time, and circadian phase. Behav. Neurosci. 2001; 115:895–899. [PubMed: 11508728]

Fleig D, Randler C. Association between chronotype and diet in adolescents based on food logs. Eat. Behav. 2009; 10:115–118. [PubMed: 19447353]

Giannotti F, Cortesi F, Sebastiani T, Ottaviano S. Circadian preference, sleep and daytime behavior in adolescence. J. Sleep Res. 2002; 11:191–199. [PubMed: 12220314]

Goldstein D, Hahn CS, Hasher L, Wiprzycka UJ, Zelazo PD. Time of day, intellectual performance, and behavioral problems in Morning versus Evening type adolescents: is there a synchrony effect? Pers. Individ. Diff. 2007; 42:431–440.

Horne JA, Östberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int. J. Chronobiol. 1976; 4:97–110. [PubMed: 1027738]

Ishihara K, Miyasita A, Inugami M, Fukuda K, Yamazaki K, Miyata Y. Differences in the time or frequency of meals, alcohol and caffeine ingestion, and smoking between “morning” and “evening” types. Psychol. Rep. 1985; 56:391–396. [PubMed: 3923509]

Jessor, R.; Jessor, SL. Problem behavior and psychological development: a longitudinal study of youth. Academic Press; New York: 1977.

Kerkhof GA. The 24-hour variation of mood differs between morning- and evening-type individuals. Percept. Mot. Skills. 1998; 86:264–266. [PubMed: 9530746]

Korczak AL, Martynhak BJ, Pedrazzoli M, Brito AF, Louzada FM. Influence of chronotype and social zeitgebers on sleep/ wake patterns. Braz. J. Med. Biol. Res. 2008; 41:914–919. [PubMed: 18982197]

Livosky, M.; Mitchell, KJ.; Sugar, JA. The influence of circadian variations on cognitive performance.. Poster presented at 33rd Annual Meeting of the Psychonomic Society; St. Louis. 13–15 November; 1992.

MacCallum RC, Zhang S, Preacher KJ, Rucker DD. On the practice of dichotomization of quantitative variables. Psychol. Methods. 2002; 7:19–40. [PubMed: 11928888]

Marpegan L, Leone MJ, Katz ME, Sobrero PM, Bekinstein TA, Golombek DA. Diurnal variation in endotoxin-induced mortality in mice: correlation with proinflammatory factors. Chronobiol. Int. 2009; 26:1430–1442. [PubMed: 19916840]

Martin PY, Marrington S. Morningness-eveningness orientation, optimal time-of-day and attitude change; evidence for the systematic processing of a persuasive communication. Pers. Individ. Diff. 2005; 39:367–377.

Mecacci L, Rocchetti G. Morning and evening types: stress-related personality aspects. Pers. Individ. Diff. 1998; 25:537–542.

Mecacci L, Zani A. Morningness–eveningness preferences and sleep-waking diary data of morning and evening types in student and worker samples. Ergonomics. 1983; 26:1147–1153. [PubMed: 6686817]

Monk TH, Buysse DJ, Potts JM, DeGrazia JM, Kupfer DJ. Morningness-eveningness and lifestyle regularity. Chronobiol. Int. 2004; 21:433–441.

Muro A, Gomà-i-Freixanet M, Adan A. Morningness-eveningness, sex, and the alternative five factor model of personality. Chronobiol. Int. 2009; 26:1235–1248. [PubMed: 19731115]

Muthén, LK.; Muthén, BO. Mplus user's guide. 5th ed.. Muthén & Muthén; Los Angeles, CA: 1998–2007.

Nakade M, Takeuchi H, Kurotani M, Harada T. Effects of meal habits and alcohol/cigarette consumption on morningness-eveningness preference and sleep habits by Japanese female students aged 18–29. J. Physiol. Anthropol. 2009; 28:83–90. [PubMed: 19346668]

Natale V, Cicogna P. Circadian regulation of subjective alertness in morning and evening ‘types’. Pers. Individ. Diff. 1996; 20:491–497.

Natale V, Cicogna P. Morningness-eveningness dimension: is it really a continuum? Pers. Individ. Diff. 2002; 32:809–816.

Paine SJ, Gander PH, Travier N. The epidemiology of morningness/eveningness: influence of age, gender, ethnicity, and socioeconomic factors in adults (30–49 years). J. Biol. Rhythms. 2006; 21:68–76. [PubMed: 16461986]

Pearson, KA. Master's thesis. Naval Postgraduate School; Monterey , CA: 2004. Circadian rhythms, fatigue, and manpower scheduling..

Portaluppi F, Smolensky MH, Touitou Y. Ethics and methods for biological rhythm research on animals and human beings. Chronobiol. Int. 2010; 27:1911–1929. [PubMed: 20969531]

Randler C. Differences between smokers and nonsmokers in morningness-eveningness. Soc. Behav. Pers. 2008; 6:673–680.

Roehrs T, Roth T. Sleep, sleepiness, and alcohol use. Alcohol Res. Health. 2001; 25:101–109. [PubMed: 11584549]

Roenneberg T, Merrow M. Entrainment of the human circadian clock. Cold Spring Harb. Symp. Quant. Biol. 2007; 72:293–299. [PubMed: 18419286]

Roenneberg T, Wirz-Justice A, Merrow M. Life between clocks: daily temporal patterns of human chronotypes. J. Biol. Rhythms. 2003; 18:80–90. [PubMed: 12568247]

Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn M, Merrow M. Epidemiology of the human circa-dian clock. Sleep Med. Rev. 2007; 11:429–438. [PubMed: 17936039]

Schaal S, Peter M, Randler C. Morningness-eveningness and physical activity in adolescents. Int. J. Sport Exerc. Psychol. 2010; 8:147–159.

Schmitt N. Uses and abuses of coefficient alpha. Psychol. Assess. 1996; 8:350–353.

Suen LKP, Hon LKE, Tam WWS. Association between sleep behavior and sleep-related factors among university students in Hong Kong. Chronobiol. Int. 2008; 25:760–775. [PubMed: 18780202]

Susman EJ, Dockray S, Schiefelbein VL, Herwehe S, Heaton JA, Dorn LD. Morningness/eveningness, morning-to-afternoon cortisol ratio, and antisocial behavior problems during puberty. Dev. Psychol. 2007; 43:811–822. [PubMed: 17605516]

Taillard J, Philip P, Bioulac B. Morningness/eveningness and the need for sleep. J. Sleep Res. 1999; 8:291–296. [PubMed: 10646169]

Takeuchi H, Morisane H, Iwanaga A, Hino N, Matsouka A, Harada T. Morningness-eveningness preference and mood in Japanese junior high school students. Psychiatry Clin. Neurosci. 2002; 56:227–228. [PubMed: 12047569]

Tankova I, Adan A, Buela-Casala G. Circadian typology and individual differences. A review. Pers. Individ. Diff. 1994; 16:671–684.

Tonetti L, Fabbri M, Natale V. Relationship between circadian typology and big five personality domains. Chronobiol. Int. 2009; 26:337–347. [PubMed: 19212845]

Urbán R. Smoking outcome expectancies mediate the association between sensation seeking, peer smoking, and smoking among young adolescents. Nicotine Tob. Res. 2010; 12:59–68. [PubMed: 19959571]

Vermunt, JK.; Magidson, J. Latent class cluster analysis. In Hagenaars JA, McCutcheon AL (eds.) Applied latent class analysis. Cambridge University Press; Cambridge: 2002. p. 89-106.

Wittmann M, Dinich J, Merrow M, Roenneberg T. Social jetlag: misalignment of biological and social time. Chronobiol. Int. 2006; 23:497–509. [PubMed: 16687322]

Wittmann M, Paulus M, Roenneberg T. Decreased psychological well-being in late chronotypes is mediated by smoking and alcohol consumption. Subst. Use Misuse. 2010; 45:15–30. [PubMed: 20025436]

Yokomaku A, Misao K, Omoto F, Yamagishi R, Tanaka K, Takada K, Kohyama J. A study of the association between sleep habits and problematic behaviors in preschool children. Chronobiol. Int. 2008; 25:549–564. [PubMed: 18622815]

Zamboanga BL, Carlo G, Raffaelli M, Rivers PC. Problem behavior theory: an examination of the behavior structure system in Latino and non-Latino college students. Interam. J. Psychol. 2004; 38:253–262.

Zhang L, Samet J, Caffo B, Bankman I, Punjabi NM. Power spectral analysis of EEG activity during sleep in cigarette smokers. Chest. 2008; 133:427–432. [PubMed: 17925420]

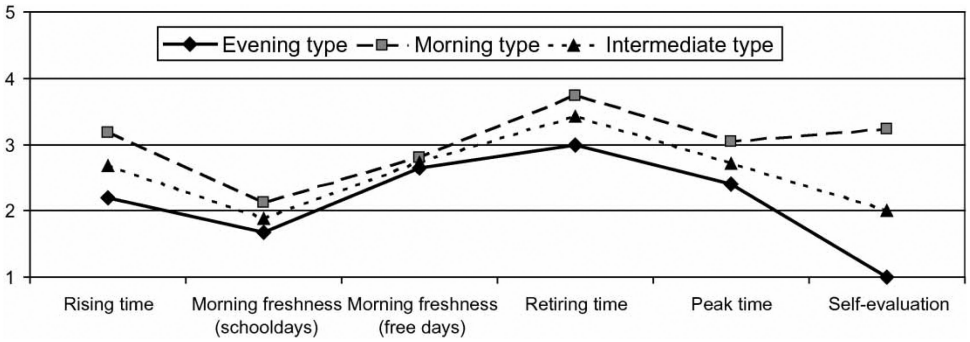

FIGURE 1.
Latent class analysis on items of Hungarian version of the rMEQ.

TABLE 1

Characteristics of study participants and distributions of response categories

Study variables	%	Codes	Mean	SD
Sex (female %)	51.2			
Age (yrs) mean, SD)			15.3	0.56
Items and response options of Hungarian version of the rMEQ				
Approximately what time would you get up if you were entirely free to plan your day?			2.71	1.10
5:00 am–6:30 am	6.8	5		
6:30 am–7:45 am	13.3	4		
7:45 am–9:45 am	34.9	3		
9:45 am–11:00 am	26.2	2		
11:00 am–12 noon	14.0	1		
Missing	4.8			
During the first half hour after you wake up in the morning, how do you feel on schooldays?			1.92	0.76
Very tired	29.5	1		
Fairly tired	46.2	2		
Fairly refreshed	17.2	3		
Very refreshed	2.3	4		
Missing	4.7			
During the first half hour after you wake up in the morning, how do you feel on weekend days?			2.74	0.81
Very tired	8.1	1		
Fairly tired	22.2	2		
Fairly refreshed	50.6	3		
Very refreshed	13.7	4		
Missing	5.3			
At approximately what time in the evening do you feel tired, and, as a result, in need of sleep?			3.44	0.91
8:00 pm–9:00 pm	10.0	5		
9:00 pm–10:15 pm	35.8	4		
10:15 pm–12:45 am	38.4	3		
12:45 am–2:00 am	7.2	2		
2:00 am–3:00 am	3.4	1		
Missing	5.3			
At approximately what time of day do you usually feel your best?			2.76	0.71
5–8 am	1.7	5		
8–10 am	6.9	4		
10 am–5 pm	59.4	3		
5–10 pm	27.8	2		
10 pm–5 am	3.6	1		
Missing	5.9			
One hears about “morning types” and “evening types.” Which one of these types do you consider yourself to be?			2.19	0.83
Definitely a morning type	6.9	4		
Rather more a morning type than an evening type	21.6	3		

Study variables	%	Codes	Mean	SD
Rather more an evening type than a morning type	46.9	2		
Definitely an evening type	17.9	1		
Descriptives for outcome variables				
Tried smoking (yes, %)	62.3			
Nondaily smoking or smoking during the last month (yes, %)	31.2			
Daily smoking (yes, %)	11.5			
Frequency of lifetime alcohol use (mean, SD)			15.4	13.1
Time spent TV watching (mean, SD)			2.48	1.56
Time spent playing computer games (mean, SD)			2.84	1.77

TABLE 2

Factor loadings of the confirmatory factor analysis of the Hungarian version of the rMEQ

	Confirmatory factor analysis (CFA)	
Item	**Factor 1 Morningness**	**Factor 2 Morning Freshness**
Self-evaluation	**0.71**	
Retiring time	**0.36**	
Peak time	**0.42**	
Rising time	**0.47**	
Morning freshness on schooldays		**0.96**
Morning freshness on free days		0.24
Factor determinacy	0.78	0.92

Salient factor loadings (>0.30) are in bold. The CFA model is a restricted model in which cross-loadings are fixed to zero, and empty cells represent the zero cross-loadings.

TABLE 3

Fit indices for the latent profile analysis of the Hungarian version of the rMEQ

Number of latent classes	AIC	BIC	SSABIC	Entropy	L-M-R test	*p*
2 classes	35567	35678	35618	0.568	901.0	.0001
3 classes	34527	34678	34595	0.978	1116.1	.0001
4 classes	34450	34641	34536	0.975	115.8	.0675
5 classes	34401	34633	34506	0.879	65.0	.1096
6 classes	not well identified					

AIC = Akaike information criteria; BIC = Bayesian information criteria; SSABIC = sample size–adjusted Bayesian information criteria. L-M-R test = Lo-Mendell-Rubin adjusted likelihood-ratio test value; $p = p$ value associated with L-M-R test.