Published in final edited form as:

Addiction. 2011 January ; 106(1): 170–177. doi:10.1111/j.1360-0443.2010.03112.x.

EVENING TYPES ARE MORE OFTEN CURRENT SMOKERS AND NICOTINE DEPENDENT - A STUDY OF FINNISH ADULT TWINS

U. Broms, PhD^{1,2}, J. Kaprio, MD, PhD^{1,2,3}, C. Hublin, MD, PhD⁴, M. Partinen, MD, PhD^{5,6}, P.A.F. Madden, PhD⁷, and M. Koskenvuo, MD, PhD¹

¹Department of Public Health, Hjelt Institute, University of Helsinki, Finland ²Department of Mental Health and Alcohol Abuse Services, National Institute for Health and Welfare Helsinki, Finland ³Institute for Molecular Medicine Finland FIMM, Helsinki, Finland ⁴Finnish Institute of Occupational Health, Helsinki, Finland ⁵Helsinki Sleep Clinic, Vitalmed Research Center, Helsinki, Finland ⁶Department of Neurology, University of Helsinki, Finland ⁷Department of Psychiatry and Midwest Alcoholism Research Center, Washington University School of Medicine, St Louis, MO, USA

Abstract

Aim—To examine the association between diurnal type and smoking status and nicotine dependence (ND).

Design—Cohort study using random-effects model regressions for repeated longitudinal panel data were used to analyze smoking status by diurnal type. Regression analyses examined the association between diurnal type and ND.

Participants—23289 same-sex adult twin individuals from Finnish Twin Cohort. Nicotine dependence was studied in a subsample of 676 twin individuals.

Measurements—Subjects were classified by self-report into four categories: morning type, somewhat morning type, somewhat evening type, evening type (in 1981). Smoking status was defined as current and ever smoking (in 1975, 1981 and 1990). ND was measured by DSM-IV and Fagerström Test for Nicotine Dependence (FTND) (during 2001–2005).

Findings—Evening types of both genders were much more likely to be current (OR= 2.91, 95 % CI 2.50, 3.38) and lifetime smokers (OR=2.67, 95 % CI 2.96, 4.07) compared to morning types. Evening types were less likely to stop smoking. The risk of nicotine dependence assessed by DSM-IV criteria was higher among evening types (OR=2.78, 95 % CI 1.64, 4.72). Evening types scored 0.59 (95 % CI 0.01, 1.17) points higher than morning types on the FTND. Adjustment for potential confounders did not change these associations.

Conclusions—Being an evening type is independently associated with a higher risk of being a current smoker, being more highly dependent on cigarettes, and a lower likelihood of stopping smoking. Understanding the cause of these associations could elucidate the causes of tobacco addiction.

Corresponding author: Ulla Broms, PhD Department of Public Health, Hjelt Institute, University of Helsinki POBox 41, 00014 University of Helsinki, Finland ulla.broms@helsinki.fi Tel: +358-40-4151278 Fax: +358-9-19127570.

Conflict of interest statement: The authors declare no conflict of interest

Keywords

Adults; current smoking; diurnal type; DSM-IV nicotine dependence; eveningness; Fagerström Test for Nicotine Dependence

Introduction

Studies among humans have found inter-individual differences in variation of alertness according to time of day/night. This has led to characterization by 'diurnal type', which differentiates individuals on an axis of 'evening type' to 'morning type' [1,2]. Morning types prefer to get up earlier than evening types and, in addition, their alertness rises earlier in the morning. Epidemiological studies estimate that among young adults the prevalence of both morning and evening types varies between 10 and 25%. In our nationwide Finnish Twin Cohort of adult twins [3] most adults were intermediate types, with 30% being morning types and 10% evening types.

Studies of the association between smoking and diurnal type are scarce. Finnish adolescents who were morning types were twice as likely to cease smoking [4]. A study of Japanese university students found that evening types were more likely to be smokers than morning types were [5]. Neither study took into account potential confounders, such as mood and alcohol use, which have been associated with diurnal type [6,7]. Given the scarcity of such studies, we explored whether smoking status and nicotine dependence (ND) levels differed by diurnal type in a large adult cohort, and whether the association was independent of major confounders.

Methods

Subjects

The Finnish Twin Cohort study was initiated in 1974. The cohort was compiled from the Central Population Registry of Finland and includes all same-sex twin pairs born before 1958 with both members alive in 1967 [8]. Questionnaire studies were carried out in 1975, 1981 and 1990, with response rates of 89%, 84% and 77%, respectively. In 1990, the questionnaire was sent only to those born 1930–1957, and with both co-twins resident in Finland and who had responded to at least one previous survey. The present study used information from subjects who had participated in the three surveys and provided information on diurnal type in 1981 and smoking status in all three surveys (1975 $n=21798$, 1981 $n=23289$ and 1990 $n=11516$).

The data on nicotine dependence were taken from a subgroup of the cohort who were identified as heavy smokers: The Nicotine Addiction Genetics Finland study. These individuals were recruited into the NAG Finland study and interviewed by telephone using trained interviewers during 2001–2005 [described in detail 9–11]. A total of 676 twin individuals from the older cohort with diurnal status information from 1981 participated in the NAG study. Their mean age was 56.6 years (22% women).

The Finnish Twin Cohort study was approved by the Ethics Committee of the Helsinki Department of Public Health, and the NAG study (28.2.2001/136/E3/01) by the Ethics Committee (Institutional Review Board) of the Hospital District of Helsinki and Uusimaa.

Assessment

Diurnal type as an independent variable was determined by a question in the 1981 survey based on the Diurnal Type Scale [3,12]: "Will you try to estimate to what extent you are a

morning or evening person?" The responses were: 1) "I am clearly a morning person (morning bright and evening sleepy)", 2) "I am to some extent a morning person", 3) "I am to some extent an evening person (morning sleepy and evening bright)" and 4) "I am clearly an evening person".

Smoking behaviour was assessed comprehensively in the 1975, 1981 and 1990 questionnaires. Current smokers were classified as those who had smoked at least 5–10 packs of cigarettes over their lifetime and who were smoking daily or almost daily at the time of the study. Those responding positively to the question: "Have you smoked more than 5–10 packs of cigarettes in your lifetime?" were asked: "Do you smoke or have you ever smoked cigarettes regularly, say daily or almost daily, during your lifetime?" Current smokers were registered as those who were smoking at the time of the survey, and were asked how much they smoked as follows: "How many cigarettes do you smoke daily on average?" The alternatives were: none, less than 5, 5–9, 10–14, 15–19, 20–24, 25–39, and over 40. Former smokers were asked how much they used to smoke, using the same alternatives. Ever smokers were defined as those who had been current or former smokers in at least one of the three questionnaires. A group of current heavy smokers (over 20 cigarettes per day) was also defined.

In the Finnish Adult Twin Cohort study life satisfaction [13] and heavy drinking (defined as more than 5 bottles of beer, a bottle of wine or half a bottle of spirits on the same occasion at least once a month) [14,15] were used as potential confounders. Both confounders were measured in the same way in all three questionnaires. Life satisfaction is highly correlated (>0.6) with the Beck Depression Inventory scale [13]. Life satisfaction was used as a continuous variable.

In the NAG study, smoking behaviour was assessed using symptoms of nicotine dependence in the DSM-IV [16] and the Fagerström Test for Nicotine Dependence (FTND) [17]. Diagnostic DSM-IV nicotine dependence criteria [16] were measured by SSAGA (Semi-Structured Assessment for the Genetics of Alcoholism) [18], modified for use in Finnish and Australian populations and with the section on nicotine use and dependence based on the Composite International Diagnostic Interview [19]. DSM criteria are assessed from psychiatric diagnostic interview and operationalized as seven clusters, measuring loss of control with respect to smoking behaviour. A diagnosis of nicotine dependence requires the presence of at least three criteria during a 12-month period. In these analyses DSM-IV nicotine dependence was used as a dichotomous variable: having diagnosed nicotine dependence or not. The FTND was used as continuous variable points from 0 to 10, more points meaning higher nicotine dependence, but also as a dichotomous variable so that nicotine dependence was defined as having a score of 4 or more as used in case-control studies [20,21]. The maximum number of alcoholic drinks consumed in a 24-hour period was assessed in the NAG interview [22]. A diagnosis of alcohol dependence (yes/no) was assessed using the DSM-IV symptoms and the number of symptoms of depression assessed using DSM-IV criteria, which were both considered potential confounders.

Statistical analyses

As a longitudinal data set, the adult twin data provided information on participants' smoking status over a 15-year period (1975, 1981, 1990) as longitudinal panel data. Using random-effects model regressions for repeated data [23], we analyzed the risk of current smokers *vs.* non-smokers (dependent variable) and ever smokers *vs.* never smokers (dependent variable) by diurnal type groups (morning type, somewhat morning type, somewhat evening type, evening type), using the morning type group as reference group. Prior to the repeated measures analyses, we also conducted cross-sectional analyses of each survey smoking

status in relation to diurnal status. We also examined whether the risk of quitting smoking by 1990 among current smokers in 1981 differed by diurnal type.

Regression analyses of all twin individuals examined the association between diurnal type and nicotine dependence / smoking cessation. Logistic regression was performed using diurnal type as an independent variable and DSM-IV nicotine dependence or smoking cessation as a dependent variable. Linear regression was used when the dependent variable was continuous FTND. The data analyses were performed with Stata 9.0 statistical software [24]. Because the data consisted of twin pairs rather than unrelated individuals, robust estimates of variance [25] were used with the 'cluster' option in Stata to derive correct standard errors and p-values.

Results

Basic characteristics

We had information on diurnal type from the 1981 questionnaire on 24331 participants (48 % were men); 21844 had responded to the 1975 questionnaire and 11541 to the 1990 survey. The mean age of participants in 1981 was 40.9 years (SD 13.7). Thirty per cent (29.7 %) of participants were morning types, 27.7 % somewhat morning types, 32.7% somewhat evening types and one tenth (9.9%) were evening types. Age at smoking initiation in 1981 was 18.9 years (SD 4.8). Thirty per cent of current smokers and 23% of former smokers in 1981 smoked 20 cigarettes or more per day. In the NAG study, more than half of the subjects were nicotine dependent measured by DSM-IV (57 %) and FTND (cut point ≥ 4) (58 %), reflecting the over-sampling of heavy smokers. The mean FTND was 4.1 (SD 2.2) (score from 0 to 10). The distribution of smoking status by diurnal type classes of the questionnaires in 1975, 1981 and 1990 is presented in Table 1 and shows higher rates of smoking among evening types. The percentages of DSM-IV ND affected in each diurnal type groups indicate that 73 % of evening types were DSM-IV ND and FTND mean score was 4.7 (SD 2.4) among evening types.

Longitudinal panel analyses among current and ever smokers

Panel analyses based on the longitudinal repeated measures information from 1975, 1981 and 1990 health questionnaires indicated that the odds of being a current smoker among evening types was almost three (age-gender adjusted OR= 2.91, 95 % CI 2.50, 3.38) times higher, and of being an ever smoker more than two and half (age-gender adjusted OR=2.67 95 % CI 2.96, 4.07) times higher compared to morning types (Table 2). Gender by diurnal type interactions were significant ($p < 0.001$) for both current and ever smoking, so gender specific analyses were done. The risk of current and ever smoking was higher among women than men (current smoking: men age-adjusted OR=2.73 95 % CI 2.22, 3.36; women: age-adjusted OR=3.37 95 % CI 2.71, 4.19 ever smoking men: age-adjusted OR=2.69 95 % CI 2.12, 3.40; women: age-adjusted OR=3.22 95 % CI 2.58, 4.02).

In addition we used life satisfaction (continuous variable) and heavy drinking (dichotomous variable) (both measured at all three time points) as potential confounders. All odds ratios for current and ever smoking decreased only marginally as shown among evening types in Table 3.

Current heavy smokers (more than 20 cigarettes per day) were examined separately ($n=5040$, 80 % men). The age-gender adjusted odds ratio for current heavy smoking was 2.33 (95 % CI 1.89, 2.74) for evening types compared to morning types. As gender by diurnal type interactions were significant ($p < 0.02$) gender specific analyses were done, indicating a two-fold odds for men (OR=2.04, 95 % CI 1.58, 2.63) and three-fold odds for women (OR=3.04, 95 % CI 2.12, 4.36). When adjusted for life satisfaction the odds ratio for

current heavy smoking decreased marginally from 2.33 to 2.22 (95 % CI 1.80, 2.74), for heavy drinking it decreased to 2.26 (95 % CI 1.83, 2.79) and with both confounders it fell to 2.17 (95 % CI 1.76, 2.68) among evening types compared to morning types.

In 1981 among current smokers (n=2966), evening types had decreased risk of smoking cessation by 1990 (age-gender adjusted OR=0.73, 95 % CI 0.60, 0.89) compared to morning types. No significant diurnal type by gender interaction was observed (p=0.18). We confirmed the same result using NAG data, collected some 20 years later. Diurnal type in 1981 predicted smoking cessation by 2001–2005 (age-gender adjusted OR=0.48, 95 % CI 0.25, 0.92), with no diurnal type by gender interaction (p=0.84). There was only a minor change in the odds ratio for the association between diurnal type in 1981 and later smoking cessation after adjusting for DSM-IV alcohol dependence, maximum alcohol drinks per day, or number of DSM-IV depression symptoms.

The risk of nicotine dependence as judged by DSM-IV criteria was greatly elevated among evening types (age-gender adjusted OR=2.78, 95 % CI 1.64, 4.72) (Table 4), and evening type scored higher on the FTND scale (beta=0.59, 95 % CI 0.01, 1.17) (Table 5) compared to morning type. Diurnal type by gender interactions were non-significant in the NAG subset when the dependent variable was nicotine dependence by DSM-IV (p=0.08) or FTND (p=0.55). The DSM-IV nicotine dependence odds ratio decreased slightly when adjusted for DSM-IV alcohol dependence, from 2.78 to 2.67 (95 % CI 1.55, 4.61), and did not change when adjusted for maximum drinks, or number of DSM-IV depression symptoms. The FTND nicotine dependence linear regression coefficient decreased from 0.59 to 0.42 (95 % CI -0.17, 1.01) when adjusted for DSM-IV alcohol dependence and to 0.50 (95 % CI -0.06, 1.07) when adjusted for maximum drinks per day. When adjusting for number of DSM-IV depression symptoms, the regression coefficient was 0.52 (95 % CI -0.04, 1.08).

Discussion

Evening types of both genders were much more likely to be current and ever smokers compared to morning types. Evening types had an increased risk of persistent smoking. The risk for DSM-IV ND was greatly elevated among evening types, who also had higher FTND scores compared to morning types, indicating that the evening type is strongly associated not only with being a smoker but also with a higher risk of ND. These associations remained after adjustment for alcohol use and dependence, and measures of depression and depressed mood.

A study among Japanese university students [5] and a Finnish study of adolescents [4] indicated that there is an association between evening types and smoking, but neither study evaluated the role of potential confounders. Diurnal type is associated with anxiety [26] and depression [6,27–30], while depression is associated with a higher prevalence of smoking and a lower rate of smoking cessation [31,32]. We adjusted our analyses using two measures of mood: diagnosis of depression in the NAG data and life satisfaction in the Finnish Twin Cohort, and found that the association of diurnal type with smoking remained significant both in the large cohort and the subsample. Adjustment for life satisfaction, a measure of mood that is highly correlated with depression assessed on the Beck Depression Inventory [13], did not change our results, suggesting that depression does not mediate the relationship between diurnal type and ND.

Given that smoking and ND are highly associated with alcohol use and dependence, we also adjusted the risks for ND and smoking cessation for alcohol use, maximum drinks per day and DSM-IV alcohol dependence. The minor changes in risk estimates indicated that alcohol does not account for the association of diurnal type with smoking and ND.

Although diurnal type and smoking has not been investigated in many studies, the relationship between smoking and sleep has been explored extensively. A review of 52 papers involving animal and human data [33] indicates that nicotine influences sleep and mood by various neurotransmitter systems. Sleep problems are more frequent among smokers and smoking is associated with insomnia and sleep apnoea syndrome. Sleep disturbances during withdrawal after quitting are a risk for relapse or continuing consumption [33]. Active smokers have withdrawal symptoms resulting in nocturnal sleep-disturbing nicotine craving [34]. However, there are inconsistencies in findings due to variation in methodologies and study samples [33]. Sleep deprivation increases smoking at least in current smokers with ND [35]. There is a strong negative association between smoking and sleep duration [36]. Smokers have longer sleep latency and lighter sleep [37,38]. Additionally, smokers had more daytime sleepiness, minor accidents and depression, and high daily caffeine intake [37].

The association between diurnal type and smoking or nicotine dependence could be partly explained by nicotine's pharmacological properties. Nicotine is a stimulant and this could make smokers more alert and stay up later. If this were the case, smoking cessation would result in a lower tendency to be an evening type. However, our study assessed diurnal type only once, so we cannot examine this possibility.

Of course it is also possible that evening types are more prone to addiction and/or pleasure than others. Nicotine is a direct agonist of the nicotinic acetylcholine receptors of the brain and it activates both the mesolimbic dopamine system and endogenous opioid peptide systems. The association of smoking and evening type could be explained by genetic and environmental aspects of the dopamine and/or opioid systems, which are key elements in feelings of pleasure and also in development of addiction. It is known, for example, that persons with attention deficit hyperactivity disorder are mostly evening types and more prone to develop addictions than others [39]. In addition it should also be noted that evening type smokers may be more exposed to smoking environment and also to smoking cues as they may be more likely to stay out longer in bars and restaurants. This factor may influence their smoking behavior and their greater difficulties to quit smoking.

The Finnish Twin Cohort data have several strengths. The longitudinal and population based data permitted use of repeated measures and a panel design, giving more power for analyses. Based on the previous research the Finnish Twin Cohort is representative of the smoking behavior of Finnish population. For example lung cancer incidence is an excellent indirect measure of smoking behavior in a population. Among the Finnish Twin Cohort, lung cancer incidence did not differ from the population [40]. In NAG data we measured ND with two widely used and established measures: DSM-IV ND [16] and FTND [17]. The validity of self-reported diurnal type was shown by Koskenvuo [3] using questions on how fully awakened participants were and quality of sleep during a six-year follow-up.

One limitation of the study is that smoking status was not confirmed biochemically in these data sets. Smoking status was asked at three time points in the Finnish Twin Cohort and later in the NAG study. In addition in a Finnish population based study [41] smoking status was very reliable when confirmed by cotinine. Another limitation is that ND was not measured in the entire Finnish Twin Cohort in any questionnaire. At that time, assessing ND was not common and the study data focused on a broad range of health behaviour factors. In the NAG study ND was measured with comprehensive measures but should be noted that number of participants is much smaller compared to Finnish Twin Cohort. There was no association between the FTND measure of addiction and diurnal type. This could be because this test focuses on smoking soon after morning awakening.

It should also be noted that the larger data set analyzed for this study, the Finnish Twin Cohort, was collected 20 to 35 years ago and smoking prevalence and patterns have changed from the time of data collection. Smoking prevalence is anyhow on the same level in the Finnish Twin Cohort as it has been in other population based data collections in Finland by National Institute for Health and Welfare [42]. Smoking patterns of the participants may not fully reflect the smoking patterns commonly observed today e.g., more people smoke fewer cigarettes per day, there are more non-daily smokers and there are more women smokers compared to earlier times. Also similarly, there are multiple changes in environmental smoking restrictions by law that may change people's patterns of consumption, which may have differential effects by diurnal type. However, the cross-sectional analyses in 1975, 1981 and 1990 all showed consistent and similar associations of smoking with diurnal type. Furthermore, our subsample of smokers assessed for nicotine dependence was studied after 2000, and the association with diurnal type measured more than 20 years earlier was strong.

Acknowledgments

The study was supported by the Juho Vainio Foundation and the Yrjö Jahnsson Foundation to UB, and by NIH grant DA12854 to PAFM and Academy of Finland grants to JK and MK. The study forms part of the research programme of the Academy of Finland Center of Excellence in Complex Disease Genetics supervised by JK.

References

1. Horne JA, Östberg OA. A self-assessment questionnaire to determine mornigness-eveningness in human circadian rhythms. *Int J Chronbiol.* 1976; 4:97–100.
2. Kerkhof GA. Inter-individual differences in the human circadian system: a review. *Biol Psychol.* 1985; 20:83–112. [PubMed: 3888298]
3. Koskenvuo M, Hublin C, Partinen M, Heikkilä K, Kaprio J. Heritability of diurnal type: a nationwide study of 8752 adult twin pairs. *J Sleep Res.* 2007; 16:156–62. [PubMed: 17542945]
4. Heikkinen AM, Broms U, Pitkaniemi J, Koskenvuo M, Meurman J. Key factors in smoking cessation intervention among 15–16-year-olds. *Behav Med.* 2009; 35:93–9. [PubMed: 19812027]
5. 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 found between 'morning' and 'evening' types. *Psychol Rep.* 1985; 57:391–6. [PubMed: 4059451]
6. Hasler BP, Allen JJB, Sbarra DA, Bootzin RR, Bernert RA. Morningness–eveningness and depression: Preliminary evidence for the role of the behavioral activation system and positive affect. *Psychiatry Res.* 2010; 176:166–73. [PubMed: 20132992]
7. Spanagel R, Pendyala G, Abarca C, Zghoul T, Sanchis-Segura C, Magnone MC, et al. The clock gene *Per2* influences the glutamatergic system and modulates alcohol consumption. *Nat Med.* 2005; 11:35–42. [PubMed: 15608650]
8. Kaprio J, Koskenvuo M. Genetic and environmental factors in complex diseases: the older Finnish Twin Cohort. *Twin Res.* 2002; 5:358–65. [PubMed: 12537859]
9. Loukola A, Broms U, Mauni H, Widén E, Heikkilä K, Siivola M, et al. Linkage of nicotine dependence and smoking behaviour on 10q, 7q and 11p in twins with homogeneous genetic background. *Pharmacogenomics J.* 2008; 8:209–19. [PubMed: 17549066]
10. Saccone SF, Pergadia ML, Loukola A, Broms U, Montgomery GW, Wang JC, et al. Genetic linkage to chromosome 22q12 for a heavy-smoking quantitative trait in two independent samples. *Am J Hum Gen.* 2007; 80:856–66.
11. Broms U, Madden PA, Heath AC, Pergadia ML, Shiffman S, Kaprio J. The Nicotine Dependence Syndrome Scale in Finnish smokers. *Drug Alcohol Depend.* 2007; 89:42–51. [PubMed: 17174039]
12. Torsvall L, Åkerstedt T. A diurnal type scale. *Scand J Work Environ Health.* 1980; 6:183–90.
13. Koivumaa-Honkanen H, Kaprio J, Honkanen R, Viinamäki H, Koskenvuo M. Life satisfaction and depression in a 15-year follow-up of healthy adults. *Soc Psychiatry Psychiatr Epidemiol.* 2004; 39:994–9. [PubMed: 15583908]
14. WHO. WHO Global Status Report on Alcohol. WHO Press; Singapore: 2004. 2004

15. Kaprio J, Hammar N, Koskenvuo M, Floderus-Myrhed B, Langinvainio H, Sarna S. Cigarette smoking and alcohol use in Finland and Sweden: a cross-national twin study. *Int J Epidemiol.* 1982; 11:378–86. [PubMed: 6984028]
16. APA 1994 American Psychiatric Association. Diagnostic and statistical manual of mental disorders: DSM-IV. 4.th edn. American Psychiatric Association; Washington DC: 1994.
17. Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. The Fagerstrom Test for Nicotine Dependence: a revision of the Fagerstrom Tolerance Questionnaire. *Br J Addict.* 1991; 86:1119–27. [PubMed: 1932883]
18. Bucholz KK, Cadoret R, Cloninger CR, Dinwiddie SH, Hesselbrock VM, Nurnberger JI Jr, et al. A new, semi-structured psychiatric interview for use in genetic linkage studies: A report on the reliability of the SSAGA. *J Stud Alcohol.* 1994; 55:149–58. [PubMed: 8189735]
19. Cottler LB, Robins LN, Grant BF, Blaine J, Towle LH, Wittchen HU, et al. The CIDI-core substance abuse and dependence questions: cross- cultural and nosological issues. The WHO/ ADAMHA field trial. *Br J Psychiatry.* 1991; 159:653–8. [PubMed: 1756341]
20. Berrettini W, Yuan X, Tozzi F, Song K, Francks C, Chilcoat H, et al. Alpha-5/alpha-3 nicotinic receptor subunit alleles increase risk for heavy smoking. *Mol Psychiatry.* 2008; 13:368–73. [PubMed: 18227835]
21. Bierut LJ, Madden PA, Breslau N, Johnson EO, Hatsukami D, Pomerleau OF. Novel genes identified in a high-density genome wide association study for nicotine dependence. *Hum Mol Genet.* 2007; 16:24–35. [PubMed: 17158188]
22. Saccone NL, Kwon JM, Corbett J, Goate A, Rochberg N, Edenberg HJ, et al. A genome screen of the maximum number of drinks as an alcoholism phenotype. *Am J Med Genet.* 2000; 96:632–7. [PubMed: 11054770]
23. Twisk, JWR. *Applied Longitudinal Data Analysis for Epidemiology: A Practical Guide.* Cambridge University Press; Cambridge, UK; New York: 2003.
24. StataCorp. *Stata Statistical Software.* College Station; Texas: 2005.
25. Williams RL. A note on robust variance estimation for cluster-correlated data. *Biometrics.* 2000; 56:645–6. [PubMed: 10877330]
26. Broman JE, Hetta J. Sleep and wake in morning and evening types: an epidemiological survey. *J Sleep Res.* 1998; 7:31s.
27. Drennan MD, Klauber MR, Kripke DF, Goyette LM. The effects of depression and age on the Horne–Ostberg morningness–eveningness score. *J Affect Disord.* 1991; 23:93–8. [PubMed: 1753041]
28. Chelminski I, Ferraro FR, Petros TV, Plaud JJ. An analysis of the eveningness–morningness dimension in depressive college students. *J Affect Disord.* 1999; 52:19–29. [PubMed: 10357014]
29. Taillard J, Philip P, Chastang JF, Diefenbach K, Bioulac B. Is self-reported morbidity related to the circadian clock? *J Biol Rhythms.* 2001; 16:183–90. [PubMed: 11302560]
30. Murray G, Allen NB, Trinder J. Seasonality and circadian phase delay: prospective evidence that winter lowering of mood is associated with a shift towards eveningness. *J Affect Disord.* 2003; 76:15–22. [PubMed: 12943929]
31. Korhonen T, Broms U, Varjonen J, Romanov K, Koskenvuo M, Kinnunen T, Kaprio J. Smoking behaviour as a predictor of depression among Finnish men and women: a prospective cohort study of adult twins. *Psychol Med.* 2007; 37:705–15. [PubMed: 17181913]
32. Chaiton MO, Cohen JE, O'Loughlin J, Rehm J. A systematic review of longitudinal studies on the association between depression and smoking in adolescents. *BMC Public Health.* 2009; 22:356. Review. [PubMed: 19772635]
33. Jaehne A, Loessl B, Bárkai Z, Riemann D, Hornyak M. Effects of nicotine on sleep during consumption, withdrawal and replacement therapy. *Sleep Medicine Reviews.* 2009; 13:363–77. [PubMed: 19345124]
34. Wolter TD, Hauri PJ, Schroeder WJ, Wisbey JA, Croghan IT, Offord KP, et al. Effects of 24-hour nicotine replacement on sleep and daytime activity during smoking cessation. *Prev Med.* 1996; 25:601–10. [PubMed: 8888329]
35. Hamidovic A, de Wit H. Sleep deprivation increases cigarette smoking. *Pharmacol Biochem Behav.* 2009; 96:263–9. [PubMed: 19133287]

36. Palmer CD, Harrison GA. Association between smoking and drinking and sleep duration. *Ann Hum Biol.* 1980; 7:103–7. [PubMed: 7425536]
37. Phillips BA, Danner FJ. Cigarette smoking and sleep disturbance. *Arch Intern.* 1995; 155:734–7.
38. Zhang L, Samet J, Caffo B, Punjabi N. Cigarette Smoking and Nocturnal Sleep Architecture. *Am J Epidemiol.* 2006; 164:529–37. [PubMed: 16829553]
39. Koob, GF. Drug reward and addiction. In: Squire, LR.; Bloom, FE.; McConnell, SK., et al., editors. *Fundamental neuroscience. Second Edition ed.*. Academic Press; Amsterdam: 2003. p. 1127–43.
40. Verkasalo PK, Kaprio J, Koskenvuo M, Pukkala E. Genetic predisposition, environment and cancer incidence: A nationwide twin study in Finland, 1976–1995. *Int J Cancer.* 1999; 83:743–9. [PubMed: 10597189]
41. Vartiainen E, Seppälä T, Lillsunde P, Puska P. Validation of self reported smoking by serum cotinine measurement in a community-based study. *J Epidemiol Community Health.* 2002; 56:167–70. [PubMed: 11854334]
42. Helakorpi S, Martelin T, Torppa J, Vartiainen E, Uutela A, Patja K. Impact of the 1976 Tobacco Control Act in Finland on the proportion of ever daily smokers by socioeconomic status. *Prev Med.* 2008; 26:340–5. [PubMed: 18158177]

Table 1
Proportions of current and ever smokers by diurnal type among all subjects, and men and women, in the three surveys

	Current			Ever		
	All	Men	Women	All	Men	Women
1975						
Morning type	26.6	38.4	17.0	47.7	69.6	29.7
Somewhat morning type	30.1	37.9	22.3	50.4	65.1	35.7
Somewhat evening type	35.2	43.2	28.0	53.8	67.7	41.3
Evening type	42.8	52.8	33.7	61.4	76.3	48.0
	n=21798	n=10304	n=11494	n=11307	n=10304	n=11494
1981						
Morning type	23.4	33.2	14.8	48.4	70.3	29.4
Somewhat morning type	26.6	34.7	18.2	51.5	66.6	35.6
Somewhat evening type	32.7	40.7	25.4	56.3	70.1	43.8
Evening type	40.4	50.6	30.6	63.3	78.5	48.6
	n=23289	n=11164	n=12125	n=12663	n=11164	n=12125
1990						
Morning type	21.2	27.0	16.9	47.2	62.4	35.9
Somewhat morning type	22.3	26.5	18.6	49.2	60.8	38.7
Somewhat evening type	28.6	33.7	24.4	54.4	66.1	44.9
Evening type	35.4	45.1	27.2	63.0	77.5	50.8
	n=11516	n=5201	n=6315	n=5988	n=5201	n=6315

Table 2

Logistic regression odds ratios (and 95 % confidence intervals) for risk of being current smoker (vs. non-smoker) and ever smoker (vs. never smoker). Panel analysis of smoking status by diurnal type for 1975, 1981 and 1990 survey data. Analyses were adjusted for age and sex.

	Current			Ever		
	All	Men	Women	All	Men	Women
Morning type	1.00	1.00	1.00	1.00	1.00	1.00
Somewhat morning type	0.96 (0.86, 1.07)	0.86 (0.74, 1.00)	1.11 (0.94, 1.31)	0.89 (0.80, 1.00)	0.78 (0.66, 0.92)	1.07 (0.90, 1.25)
Somewhat evening type	1.44 (1.29, 1.61)	1.23 (1.06, 1.42)	1.83 (1.56, 2.14)	1.28 (1.15, 1.43)	1.15 (0.97, 1.35)	1.59 (1.37, 1.86)
Evening type	2.91 (2.50, 3.38)	2.73 (2.22, 3.36)	3.37 (2.71, 4.19)	2.67 (2.27, 3.14)	2.69 (2.12, 3.4)	3.22 (2.58, 4.02)

Table 3

Logistic regression odds ratios (and 95 % confidence intervals) for risk of being current smoker (vs. non-smoker) and ever smoker (vs. never smoker) among evening types. Panel analysis of smoking status by diurnal type for 1975, 1981 and 1990 survey data. Reference group is morning type. Table shows analyses when risks were adjusted for age, sex, life satisfaction, heavy drinking.

Adjusted	Current			Ever		
	All	Men	Women	All	Men	Women
Age and sex	2.91 (2.50, 3.38)	2.73 (2.22, 3.36)	3.37 (2.71, 4.19)	2.67 (2.27, 3.14)	2.69 (2.12, 3.4)	3.22 (2.58, 4.02)
Age, sex and life satisfaction	2.72 (2.34, 3.15)	2.52 (2.04, 3.10)	3.18 (2.56, 3.96)	2.59 (2.21, 3.04)	2.55 (2.01, 3.25)	3.13 (2.50, 3.90)
Age, sex and heavy drinking	2.64 (2.27, 3.06)	2.54 (2.07, 3.13)	2.95 (2.37, 3.67)	2.46 (2.09, 2.90)	2.50 (1.95, 3.20)	2.89 (2.32, 3.62)
Age, sex, life satisfaction and heavy drinking	2.50 (2.15, 2.90)	2.38 (1.94, 2.93)	2.82 (2.26, 3.51)	2.41 (2.05, 2.84)	2.44 (1.90, 3.12)	2.81 (2.25, 3.52)

Table 4

Logistic regression analysis of DSM-IV nicotine dependence in the Nicotine Addiction Genetics study of smokers, and percentage of nicotine dependent individuals in each diurnal type group (N=676)

	N	% of DSM-IV ND	DSM-IV nicotine dependence	
			OR*	95%CI
Morning type	131	48	1.00	
Somewhat morning type	166	50	1.09	0.67, 1.75
Somewhat evening type	259	58	1.39	0.89, 2.18
Evening type	120	73	2.78	1.64, 4.72

* Adjusted for age and sex

Table 5

Linear regression analysis and mean of the Fagerström Test for Nicotine in the Nicotine Addiction Genetics study of smokers (N=668)

	FTND			
	N	Mean (0–10)	Regression coefficient*	95%CI
Morning type	127	4.0	0.00	
Somewhat morning type	165	4.0	0.02	–0.58, 0.53
Somewhat evening type	258	4.0	–0.05	–0.54, 0.43
Evening type	118	4.7	0.59	0.01, 1.17

Note: 8 persons had missing data on FTND

* Adjusted for age and sex