Original Investigation

Characteristics and health consequences of intermittent smoking: Long-term follow-up among Finnish adult twins

Tellervo Korhonen, Ulla Broms, Esko Levälahti, Markku Koskenvuo, & Jaakko Kaprio

Abstract

Introduction: The definition of a smoker as someone who smokes daily has been challenged. No consensus exists regarding whether intermittent smoking represents transition toward daily smoking or cessation or whether intermittent smokers consistently maintain their low tobacco use frequency. Although abundant evidence supports the adverse health consequences of daily smoking, less evidence is available on intermittent smoking.

Methods: We examined characteristics and health consequences of intermittent cigarette smoking among Finnish adult twins. We used longitudinal data of 21,340 persons with smoking status from questionnaires in 1975 and 1981 and data on lung cancer incidence from 1982 to 2004 from the Finnish Cancer Registry.

Results: We identified 641 consistent intermittent smokers comprising 3% of the study population. Consistent intermittent smokers had higher education, less use of other tobacco products, healthier lifestyles, and partly more favorable mental health profiles compared with lifetime regular smokers. However, in terms of other lifestyle factors, intermittent smokers compared mostly unfavorably with never-smokers, despite being better educated. Intermittent smoking showed substantial heritability. There were 213 incident lung cancer cases among all study subjects; only one case was found among the intermittent smokers. The sex- and age-adjusted hazard ratios of lung cancer were not significantly elevated for the intermittent smokers, but they were increased more than 10-fold for all other smokers.

Discussion: Although the present study did not find evidence of elevated lung cancer risk among intermittent smokers, compared with never-smokers, further studies should investigate

other health consequences of intermittent smoking, such as cardiovascular and nonmalignant pulmonary outcomes.

Introduction

Smoking behavior research has primarily targeted daily and regular smokers. However, the definition of a smoker as someone who smokes daily has been challenged recently, and more varied smoking patterns have been discussed (National Cancer Institute, 2007). No consensus exists regarding whether intermittent smoking represents a transitional stage toward cessation or whether those smokers consistently maintain their low frequency of tobacco use (Okuyemi et al., 2002).

In countries with decreasing overall smoking prevalence, the proportion of nondaily smokers has been increasing. For example, according to U.S. statistics, although the overall smoking prevalence decreased from 24% in 1999 to 21% in 2006, the proportions of intermittent smokers among all smokers increased from 18% to 20%, respectively (Centers for Disease Control and Prevention, 2001, 2007). During the same time in Finland, daily smoking rates decreased from 23% in 1999 to 21% in 2006, whereas the proportion of intermittent smokers in relation to the total population remained constant at 6% (Helakorpi, Patja, Prättälä, & Uutela, 2007; Helakorpi, Uutela, Prättälä, & Puska, 1999), indicating a relative increase of intermittent smoking among smokers. In countries where smoking is widely restricted, smokers who cannot quit may modify their smoking patterns. This intermittent smoking phenomenon in countries with a mature tobacco epidemic also challenges the hardening hypothesis of the remaining smoking population (Hughes & Brandon, 2003; Warner & Burns, 2003). Thus, it is crucial that we learn more about characteristics of intermittent smoking.

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Few studies have reported on characteristics of intermittent smokers. Intermittent smoking is more frequent among women, younger persons, college students, and ethnic minorities (Okuyemi et al., 2002). Among women, education and smoking patterns in relatives were associated with very low levels of smoking versus regular smoking (Hajek, West, & Wilson, 1995). Particularly among young men, college education and never-daily smoking were strongly associated (Husten, McCarty, Giovino, Chrismon, & Zhu, 1998). However, a Swedish study reported no socioeconomic differences between intermittent and daily smokers (Lindstrom & Ostergren, 2001). Further, a Finnish study reported that intermittent male smokers had an otherwise healthier lifestyle than other smokers (Luoto, Uutela, & Puska, 2000).

Also, evidence on health consequences of intermittent smoking is limited. Intermittent and light smokers are often excluded from studies on the health hazards of smoking (Okuyemi et al., 2002). This may be related to the dose-response relationship of the health effects of smoking for many diseases, particularly for lung cancer (Gandini et al., 2008). Evidence so far suggests that, compared with never-smokers, even low-level smokers experience greater risks of coronary heart disease (Luoto et al., 2000; Okuyemi et al., 2002; Rosengren, Wilhelmsen, & Wedel, 1992; Willett et al., 1987).

Given that probably no safe smoking amount exists, low-level smoking patterns and their health consequences need more attention. Recommendations for further research include defining intermittent smoking, describing the characteristics of intermittent smokers, and assessing the health consequences of nondaily cigarette exposure (National Cancer Institute, 2007). Our primary aim was to examine characteristics of intermittent smoking among a Finnish adult twin population. Our secondary aim was to explore health consequences, with the incidence of lung cancer as an example.

Methods

Subjects

The Finnish Twin Cohort established in 1974 includes same-sex twin pairs born before 1958 and with both members alive in 1967; data were compiled from the Central Population Registry (Kaprio & Koskenvuo, 2002). Two questionnaire studies were carried out in 1975 and 1981 among all twins alive in the cohort, with response rates of 89% and 84%, respectively. We analyzed data from subjects ($N=21,340$, 47% men) with responses to both surveys in this longitudinal study and with their lung cancer incidence reported during the period 1982–2004, based on the Finnish Cancer Registry. The mean age in 1981 was 40.2 years ($SD=13.4$, range=24–101). Twin zygosity was determined by a validated questionnaire method of high accuracy (Sarna, Kaprio, Sistonen, & Koskenvuo, 1978).

Definition of intermittent smoking

Several terms, such as “occasional smokers” (Hennrikus, Jeffery, & Lando, 1996), “intermittent smokers” (Husten et al., 1998), “very light smokers” (Hajek et al., 1995), and “chippers” (Shiffman, 1989), describe nondaily cigarette smokers. American surveys have defined intermittent smokers as those who had never smoked daily in their lifetime despite smoking 100 or more cigarettes (Okuyemi et al., 2002). The Finnish National

Health Behavior Survey defined the intermittent (occasional) smoker as a person who has ever smoked at least 100 times, ever smoked daily, but at the time of the survey smoked last “2 days to 1 month ago” (Luoto et al., 2000). The present study defined intermittent cigarette smokers as those who had smoked at least 5–10 packs of cigarettes over their lifetime (100–200 cigarettes) but had never been or were not smoking daily or almost daily at the time of the survey. Subjects were asked, “Have you ever smoked more than 5–10 packs of cigarettes in your lifetime?” Those responding positively were asked, “Do you smoke or have you smoked cigarettes regularly, say daily, or almost daily during your lifetime?” The one subject responding no was classified as an intermittent cigarette smoker in that survey. Here we did not control for use of tobacco products other than cigarettes.

To refine the definition of intermittent smoking, we evaluated the consistency of smoking patterns at both surveys (1975 and 1981). Based on the two self-reports, the 21,340 respondents were categorized into four groups as follows: (a) never-smokers in 1975 and 1981 ($n=9,752$, 46%), (b) intermittent smokers (those who never proceeded to regular smoking but were intermittent smokers at least in one survey, including those who were consistently intermittent; $n=641$, 3%), (c) lifetime regular smokers (all who had proceeded to daily smoking in at least one survey, including those who were intermittent smokers at one survey but lifetime regular smokers at another; $n=10,646$, 50%), and (d) others, including possible misclassifications or misreports of smoking in one of the two surveys ($n=301$, 1%).

Characteristics of intermittent smokers

We compared the characteristics of intermittent smokers with those of never- and regular smokers. Age and sex were determined from registry information. We considered subjects who were single in both 1975 and 1981 as one category; those who had ever been married or in a marriage-like relationship were pooled together as the reference category. Education (years of schooling) was classified as those with senior high school (12 years of schooling) or higher education and those with lower education.

Concerning the use of tobacco other than cigarettes, we assessed pipe and cigar smoking. Ever having smoked a pipe or cigar was defined as someone who reported in 1975 or 1981 having ever smoked more than 50 cigars or 75 cigarillos or more than three to five packages of pipe tobacco. From those who reported ever having been a pipe or cigar smoker in 1975 or in 1981, we identified those who reported ever having been a regular or daily pipe smoker or cigar smoker.

We considered alcohol use, physical activity, and coffee and tea drinking as other health-related behaviors. Binge drinking was defined as having six or more drinks on one occasion at least monthly (Kaprio et al., 1987). Those who reported such drinking in either 1975 or 1981 were regarded as “binge drinkers.” We categorized physical activity as sedentary, intermediate, or active, based on frequency, duration, and intensity of leisure physical activity (Kujala, Kaprio, & Koskenvuo, 2002). Those reporting a low level of exercise in both 1975 and 1981 were regarded as “sedentary,” whereas those reporting a high level of exercise on both surveys were “conditioners.” Others were classified as “intermediate.” Daily coffee and tea drinking were assessed by the number of daily cups (nondaily or no use = 0) and used as continuous variables.

The mental health profile included measures of life satisfaction, stress, neuroticism, and extraversion. Life satisfaction was assessed by a four-item scale (range=4–20) that focused on feelings of (1) loneliness, (2) hardness of life, (3) happiness, and (4) anhedonia (Koivumaa-Honkanen, Kaprio, Honkanen, Viinamaki, & Koskenvuo, 2004). The mean of the 1975 and 1981 scores was used as a continuous variable in the analyses. Stress of daily activities (SDA) was defined by four self-reported items regarding being tense and nervous, having stress within daily activities, being mentally and physically exhausted at the end of day, and daily activities being extremely trying and stressful (Reeder, Schrama, & Dirken, 1973). Subjects' ratings (item fits them very well, well, poorly, or very poorly) were scored from 1 to 4. The SDA sum score ranged from 4 to 16; an increasing score indicated decreasing stress (Korkeila, Kaprio, Rissanen, Koskenvuo, & Sorensen, 1998). The mean of the 1975 and 1981 scores was used as a continuous variable in the analyses. Neuroticism and extroversion dimensions of personality (Eysenck & Eysenck, 1964) were assessed using a short form of the Eysenck Personality Inventory (Floderus, 1974). The 10-item neuroticism (range=0–10) and 9-item extroversion (range=0–9) scales were used (Lillberg, Verkasalo, Kaprio, Helenius, & Koskenvuo, 2002; Viken, Rose, Kaprio, & Koskenvuo, 1994). The mean of the 1975 and 1981 scores for extraversion and neuroticism were each used as a continuous variable in the analyses.

Data analyses

Data analyses for characteristics and health consequences of intermittent smoking were performed with Stata version 9.0. Since observations on twins within twin pairs may be correlated, robust estimators of variance and the cluster option in Stata were used when estimating standard errors (Williams, 2000). The statistical significance of differences between intermittent versus never-smokers and between intermittent versus regular smokers was tested by age- and sex-adjusted logistic regression. We computed odds ratios with 95% *CI*s for being an intermittent smoker (event) versus a never-smoker (nonevent) and for being an intermittent versus a regular smoker.

To explore genetic influences on intermittent smoking, we used data from monozygotic (MZ) and dizygotic (DZ) twin pairs to calculate the cotwin probabilities of being intermittent smokers and the age- and sex-adjusted pairwise twin correlations. We ran three univariate genetic models for smoking pattern: a three-category phenotype (never, intermittent, and regular) as well as dichotomous phenotypes (never vs. intermittent, with regular smokers as missing data; and intermittent vs. regular, with never-smokers as missing data). Twin modeling is based on known biological similarities of family members, as MZ twins are genetically identical, whereas DZ twins share on average 50% of their segregating genes. Thus, a greater similarity for MZ twins compared with DZ twins provides support for genetic effects, under the assumption that MZ and DZ twins share equally their phenotype-relevant environmental experiences (Boomsma, Busjahn, & Peltonen, 2002; Neale & Maes, 2006). We used Mplus version 5 statistical software to estimate the proportion of phenotype variance accounted for by additive genetic (A) and shared environmental factors (C), as well as by factors unique for the cotwins (E) (Boomsma et al., 2002). The numbers of observations and twin pairs included in the univariate models were 6,301 MZ individual twins (2,647 complete pairs) and 13,472 DZ individual twins (5,356 complete pairs).

The 1,007 MZ and 2,760 DZ twins without a cotwin had missing information on their cotwins, or the cotwins belonged to the smoking status "Other."

Finally, we observed lung cancer incidence by smoking status from time of response to the 1981 questionnaire to the end of 2004, death, or migration from Finland, whichever came first. The cases of lung cancer were identified by record linkage with the Finnish Cancer Registry. Cox proportional hazard models adjusted for age and sex were used to estimate hazard ratios (*HR*s) and 95% *CI*s.

Results

Characteristics

Table 1 shows the characteristics of intermittent smokers compared with those of never-, regular, and other smokers, including the results of the logistic regressions in the two right-hand columns. First, considering intermittent versus never-smokers, the logistic regression analyses suggest that being an intermittent smoker was negatively associated with female sex but positively associated with higher education, use of other tobacco products, binge drinking, as well as scoring higher in neuroticism, extraversion, and stress. Second, considering intermittent versus regular smokers, being an intermittent smoker was significantly characterized by female sex, single marital status, higher education, not using tobacco other than cigarettes, not drinking much alcohol or coffee but drinking more tea, not being sedentary, as well as scoring lower in neuroticism and extraversion.

Heritability

Given that a twin was an intermittent smoker, the probability that a cotwin would be an intermittent smoker, compared with expectation, was fivefold (concordance/prevalence = 5.39) among the MZ twins and about twofold (1.90) among the DZ twins. The higher pairwise twin correlations among MZ pairs than DZ pairs (Table 2) suggest genetic effects for all phenotype definitions considered, but more strongly so for both smoking regularity phenotypes. Table 3 shows the estimates of the variance components from genetic models according to the best-fitting model. High heritability estimates were found for both phenotypes of smoking regularity based on AE (variance components of additive genetic and unique environmental effects) models, whereas for the phenotype including all three categories, the ACE (additive genetic, shared environmental and unique environmental) model provided the best fit, suggesting lower heritability and some effect of shared environment.

Lung cancer incidence

Based on 213 incident lung cancer cases, the *HR*s of lung cancer were not elevated (adjusted *HR* = 1.00, 95% *CI* = 0.13–7.52, one case) for the intermittent smokers but were highly elevated for all other smokers (Table 4).

Discussion

In the present longitudinal study among Finnish adult twins, we compared intermittent smokers with never- and lifetime

Table 1. Characteristics of intermittent smokers compared with never-smokers, lifetime regular smokers, and other smokers, with odds ratios (ORs) and 95% CIs for likelihood of being an intermittent smoker vs. a never-smoker and an intermittent smoker vs. a regular smoker

Characteristic	Number of subjects	Never-smokers	Intermittent smokers	Regular smokers	Other smokers	Intermittent vs. never OR (95% CI) ^a	Intermittent vs. regular OR (95% CI) ^a
Sociodemographics							
Age (years, in 1981)							
Mean (SD)	21,340	42.6 (14.4)	37.9 (12.3)	38.1 (12.1)	41.0 (15.2)	0.98 (0.97–0.99)***	1.00 (0.99–1.01) ^{ns}
Sex (percent)							
Men	10,141	30.1	57.1	63.2	37.2	1.00 (ref)	1.00 (ref)
Women	11,199	69.9	42.9	36.8	62.8	0.35 (0.30–0.42)***	1.30 (1.1–1.5)**
Marital status (percent)							
Single 1975 and 1981	4,484	22.5	28.4	19.2	19.9	1.11 (0.91–1.35) ^{ns}	1.71 (1.42–2.7)***
Others	16,856	77.5	71.2	80.8	80.1	1.00 (ref)	1.00 (ref)
Education (percent)							
Lower than senior high school	17,735	83.7	76.3	88.0	89.0	1.00 (ref)	1.00 (ref)
Senior high school or higher	2,959	16.3	23.7	12.0	11.0	1.29 (1.04–1.60)*	2.29 (1.86–2.83)***
Missing data	646						
Use of other tobacco products							
Ever smoked pipe or cigars (1975 or 1981)							
No	17,388	99.5	90.6	64.3	88.0	1.00 (ref)	1.00 (ref)
Yes	3,944	0.5	9.4	35.7	12.0	15.4 (10.0–23.5)***	0.16 (0.12–0.22)***
Missing data	8						
Ever regularly smoked pipe (1975 or 1981)							
No	19,690	99.9	98.9	84.9	94.0	1.00 (ref)	1.00 (ref)
Yes	1,638	0.1	1.1	15.1	6.0	7.74 (2.76–21.7)***	0.62 (0.03–0.13)***
Missing data	12						
Ever regularly smoked cigars (1975 or 1981)							
No	20,431	99.9	98.3	91.9	97.3	1.00 (ref)	1.00 (ref)
Yes	891	0.1	1.7	8.1	2.7	10.8 (4.54–25.9)***	0.21 (0.11–0.38)***
Missing data	18						
Other lifestyle							
Alcohol use							
Binge drinker (1975 or 1981)	6,785	11.2	33.8	51.8	22.5	2.61 (2.13–3.19)***	0.45 (0.38–0.55)***
Others	14,081	88.8	66.2	48.2	77.5	1.00 (ref)	1.00 (ref)
Missing data	474						
Physical activity							
Sedentary (1975 and 1981)	1,170	5.1	4.1	6.0	4.0	1.03 (0.63–1.71) ^{ns}	0.32 (0.20–0.53)***
Intermediate	19,054	89.4	87.2	89.5	91.7	1.12 (0.82–1.52) ^{ns}	0.46 (0.34–0.62)***
Conditioner (1975 and 1981)	1,085	5.4	8.7	4.6	4.3	1.00 (ref)	1.00 (ref)
Missing data	31						
Coffee drinking (cups per day)							
Mean of 1975 and 1981 (SD)	21,285	4.5 (2.3)	4.4 (2.3)	5.3 (2.8)	4.8 (2.6)	1.00 (0.97–1.04) ^{ns}	0.86 (0.83–0.89)***
Tea drinking (cups per day)							
Mean of 1975 and 1981 (SD)	17,908	1.0 (1.3)	1.0 (1.2)	0.8 (1.2)	0.9 (1.1)	0.95 (0.89–1.02) ^{ns}	1.10 (1.03–1.16)**
Mental profile							
Life satisfaction ^b							
Mean of 1975 and 1981 (SD)	21,336	8.5 (2.3)	8.5 (2.3)	8.7 (2.4)	8.6 (2.4)	1.02 (0.98–1.06) ^{ns}	0.97 (0.93, 1.00) ^{ns}
Stress of daily activities ^c							
Mean of 1975 and 1981 (SD)	20,666	13.0 (2.4)	12.7 (2.2)	12.7 (2.4)	12.8 (2.6)	0.95 (0.92–0.99)**	1.01 (0.97–1.04) ^{ns}
Neuroticism							
Mean of 1975 and 1981 (SD)	21,166	4.8 (2.1)	4.9 (2.0)	5.2 (2.1)	5.1 (2.2)	1.07 (1.03–1.12)**	0.93 (0.89–0.97)***
Extraversion							
Mean of 1975 and 1981 (SD)	21,194	4.8 (2.3)	5.1 (2.3)	5.3 (2.3)	5.3 (2.1)	1.05 (1.01–1.09)**	0.96 (0.92–0.99)*

Note. ref, reference category.

^aLogistic regressions: age adjusted for sex; sex adjusted for age; all other characteristics adjusted for sex and age simultaneously.

^bHigher score indicating increasing dissatisfaction.

^cHigher score indicating lower stress level.

* $p < .05$; ** $p < .01$; *** $p < .001$; ns ($p \geq .05$).

Table 2. Age- and sex-adjusted pairwise twin correlations

Phenotype	Number of pairs		Pairwise twin correlations (95% CI)	
	MZ	DZ	MZ	DZ
Ever-smokers versus never-smokers	2,647	5,356	0.87 (0.84–0.89)	0.62 (0.59–0.65)
Intermittent smokers versus regular smokers (among ever-smokers)	1,128	2,145	0.56 (0.36–0.71)	0.38 (0.22–0.52)
Intermittent smokers versus never-smokers (regular smokers excluded)	1,194	2,008	0.62 (0.42–0.76)	0.33 (0.16–0.47)

Note. DZ, dizygotic; MZ, monozygotic.

regular smokers. Given that we used data on twins, we estimated possible genetic effects on intermittent smoking. Finally, the Finnish cancer registry data allowed us to investigate incident lung cancer. Compared with lifetime regular smokers, consistent intermittent smokers had more favorable characteristics, such as higher education, less use of other tobacco products, healthier lifestyles, and mental health profiles that were partly more positive. However, intermittent smokers compared mostly unfavorably with never-smokers with respect to other lifestyle factors, despite being better educated. Moreover, intermittent smoking seems to have substantial heritability. Further, consistent intermittent smokers did not show elevated lung cancer risk in comparison with never-smokers.

We had strict criteria for intermittent smoking because of the use of two measurements 6 years apart to define consistency of the smoking pattern. Thus, the prevalence of consistent intermittent smokers was only 3% in our sample. Inconsistent intermittent smokers, who reported intermittent smoking in one survey but lifetime regular smoking in the other survey (2.2% of all subjects), were not considered as intermittent smokers in our analyses because they had proceeded to daily smoking at least once during their lifetime. Other studies may have defined intermittent smoking with one measurement only, without consideration of the longitudinal consistency of the smoking pattern. Thus, the prevalences from such cross-sectional studies are higher than those reported here, but they do not reflect any stability of the smoking pattern. If we had relied on such a “snapshot” definition of intermittent smoking, the prevalence in our sample would have been 5%–6%. Intermittent smokers likely represent at least three groups of smokers. The first and second groups are transient intermittent smokers (i.e., either former daily smokers approaching cessation and not recalling ever being daily smokers or smokers in the process of proceeding to daily smoking). The latter transition is analogous to how most adolescents become regular smokers: It is well recognized

that tobacco dependence commonly develops rapidly after the onset of intermittent smoking (DiFranza et al., 2002). The third group includes consistent nondaily, occasional smokers (Okuyemi et al., 2002). Different definitions of intermittent smoking in different studies may limit comparisons of prevalence. Because the youngest subjects in the present study were 24 years old at the second survey, we are not dealing with an adolescent population typically in the process of smoking initiation. In the 1981 survey, more than 90% of smokers reported starting smoking before age 24 ($Mdn = 18$ years). Further, some of our intermittent smokers may have become regular smokers after the second survey.

Several factors characterized intermittent smoking. Being female, consistently single, and with higher education was associated with intermittent versus regular smoking. Intermittent smoking also has been observed more commonly among women and college students (Okuyemi et al., 2002), and a strong association has been reported between higher education and nondaily (Hassmiller, Warner, Mendez, Levy, & Romano, 2003; Husten et al., 1998) or low-level (Hajek et al., 1995) smoking. Use of other tobacco products, binge drinking, heavy coffee consumption, and being sedentary were more characteristic of regular than intermittent smokers. Intermittent smokers demonstrated healthier lifestyle indicators, compared with lifetime regular smokers, in an earlier Finnish study (Luoto et al., 2000). Concerning the mental health profile, those with more stress were more likely to be intermittent than never-smokers, whereas stress did not differ between intermittent and regular smokers. Intermittent smokers had neuroticism scores intermediate between never-smokers and regular smokers, whereas increasing extroversion decreased the likelihood of being an intermittent versus a regular smoker. Although the intermittent smokers compared more favorably with regular smokers, they compared less favorably with never-smokers in respect to several characteristics. Most important, intermittent cigarette smokers had

Table 3. Results of the best-fitting univariate genetic models; standardized variance components (95% CIs)

Phenotype	Standardized variance components (95% CI)			Fit compared with full ACE model			
	Additive genetic effects (a^2)	Shared environmental effects (c^2)	Unique environmental effects (e^2)	$\Delta\chi$	Δdf	p	ΔAIC
Three categories of smoking (never, intermittent, regular smokers)	0.47 (0.40–0.54)	0.39 (0.33–0.45)	0.14 (0.12–0.16)				
Intermittent smokers versus regular smokers (among ever-smokers)	0.67 (0.66–0.67)		0.33 (0.33–0.34)	1.420	1	0.23	–0.580
Intermittent smokers versus never-smokers (regular smokers excluded)	0.77 (0.75–0.78)		0.23 (0.22–0.24)	0.030	1	0.86	–1.970

Table 4. Incidence of lung cancer by smoking (1982–2004): Results of the survival analysis among 21,340 respondents

1975–1981 smoking status	Number of subjects	Number of cases	Hazard ratio ^a	95% CI
Never-smokers	9,752	17	1.00	Reference
Intermittent smokers	641	1	1.00	0.13–7.52
Lifetime regular smokers	10,646	192	11.0	6.66–18.2
Other smokers	301	3	6.09	1.76–21.1

Note. ^aHazard ratio adjusted for age and sex.

used other tobacco products (pipe or cigar) more often than never cigarette smokers, although less so than regular cigarette smokers. In the comparison of intermittent and regular cigarette smokers, intermittent smokers did not seem to compensate with the use of other tobacco products.

Finally, a question could arise over the degree to which genetic influences, including nicotine metabolism genes such as CYP2A6 (Audrain-McGovern et al., 2007; Kubota et al., 2006), protect some individuals from becoming regular smokers. We used our twin data to explore quantitative genetic influences on intermittent smoking. Based on the univariate genetic models, intermittent smoking, compared with never- and regular smoking, has substantial heritability. Hajek et al. (1995) showed that similar regular or very light smoking patterns were reported by other family members. Such familial aggregation may arise from genetic or early social influences on family members. Except for this study, heritability estimates of intermittent smoking specifically have not been studied. Other smoking phenotypes, such as amount and persistence of smoking, have shown some 50% heritability (Li, Cheng, Ma, & Swan, 2003), and those genetic influences are largely independent of genetic influences on age at onset (Broms, Silventoinen, Madden, Heath, & Kaprio, 2006).

Lung cancer has an established cumulative dose–response relationship with smoking (Gandini et al., 2008). Thus, we were able to validate the intermittent smoking pattern, as the consistent intermittent smokers were not assumed to reach such a high lifetime accumulated dose of carcinogens, and their risk was the same as for never-smokers. The more than 10-fold risk of lung cancer among the regular smokers in our study is consistent with a recent meta-analysis (Gandini et al., 2008). We were unable to trace any specific studies on intermittent smoking and lung cancer risk. However, studies have examined the number of cigarettes smoked in relation to lung cancer risk (Okuyemi et al., 2002). Elevated lung cancer risk has been demonstrated at the daily level of one to nine cigarettes, and a dose–response pattern has been shown (Gandini et al., 2008). However, lung cancer risk also depends strongly on the duration of cigarette smoking (Peto, 1986). Further, light smokers may compensate for low-level smoking by inhaling more deeply to reach the level of nicotine needed, and this compensation may increase exposure to carcinogens (Okuyemi et al., 2002). Recent investigations suggest complicated interactions between amount, duration, and intensity of smoking (Lubin, Caporaso, Wichmann, Schaffrath-Rosario, & Alavanja, 2007). The present study focused on longitudinal consistency of intermittent smoking,

and we did not have data on total number of cigarettes smoked within a certain time period or on inhaling patterns. A limitation may be that the *HRs* were not adjusted for characteristics other than sex and age. However, smoking as the main risk factor for lung cancer is well established, and adjustment for factors (apart from age and sex) other than exposure to cigarette smoke is not as crucial as for other outcomes, such as cardiovascular diseases. Another limitation is that we did not use data on smoking status beyond the 1981 survey.

In further studies, the relatively small number of consistent intermittent smokers (3% of the sample) may pose limitations. For example, our point estimate for lung cancer risk for consistent intermittent smokers was based on one case and had wide *CI*s. Thus, the public health impact of this smoking pattern cannot be assessed based solely on this result; it also does not justify any health messages suggesting that a safe level of tobacco consumption exists.

In summary, consistent intermittent smokers form a relatively small fraction of lifetime smokers. Compared with lifetime regular cigarette smokers, consistent intermittent smokers have higher education, less use of other tobacco products, healthier lifestyles, and mental health profiles that are partly more favorable. Compared with never-smokers, intermittent smokers have unhealthier lifestyles and partly less favorable mental health profiles, despite being better educated. Intermittent smoking demonstrates relatively high heritability. The health consequences of intermittent smoking should be investigated further, including cardiovascular and nonmalignant pulmonary outcomes.

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Declaration of Interests

None declared.

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