Weight concerns as a predictor of smoking cessation according to nicotine dependence: A population-based study

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Abstract

Background: Nicotine-dependent smokers find it difficult to quit smoking. Additionally, smoking-specific weight concerns may affect smoking cessation although the evidence is controversial. We investigated whether smoking-specific weight concerns predict the probability of cessation and, if so, whether the effect varies according to the level of nicotine dependence. **Methods:** The study was conducted with a population-based sample of 355 adult daily smokers who participated in the baseline examination in 2007 and in the 2014 follow-up. Baseline nicotine dependence was classified as low or high (Fagerström Test for Nicotine Dependence; 0–3 vs. 4–10 points). Within these groups, we examined whether baseline weight concerns predict smoking status (daily,

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occasional, ex-smoker) at follow-up by using multinomial logistic regression with adjustment for multiple covariates. **Results:** Among low-dependent participants at baseline, 28.5% had quit smoking, while among highly dependent participants 26.1% had quit smoking. The interaction between weight concerns and nicotine dependence on follow-up smoking status was significant. Among participants with low nicotine dependence per the fully adjusted model, greater weight concerns predicted a lower likelihood of both smoking cessation (relative risk ratio 0.93 [95% CI 0.87–1.00]) and smoking reduction to occasional occurrence (0.89 [95% CI 0.81–0.98]). Weight concerns were not associated with follow-up smoking status among participants with high nicotine dependence. **Conclusions:** Weight concerns are associated with a smaller likelihood of quitting among smokers with low nicotine dependence. Weight concerns should be addressed in smoking cessation interventions, especially with smokers who have low nicotine dependence.

Smoking causes a heavy health burden worldwide (Carter et al., 2015). Assuming that its prevalence remains the same, in future, smoking will kill approximately 1 in 6 adults (Carter et al., 2015). Globally, approximately 1 in 3 men and 1 in 15 women are daily smokers, 6 in 10 smokers want to quit (Helldán, Helakorpi, Virtanen, & Uutela, 2013), and 4 in 10 daily smokers attempt to quit annually (Borland, Partos, Yong, Cummings, & Hyland, 2012). In a given year, unaided abstinence rates for 6 to 12 months are from 3% to 5% (Hughes, Keely, & Naud, 2004), while smoking cessation interventions including behavioural support and pharmacotherapy increase abstinence rates (Zwar, Mendelsohn, & Richmond, 2014). For an average smoker, successful cessation usually requires multiple attempts (Chaiton et al., 2016; Curry & McBride, 1994).

The identification of several smoking-cessation predictors has led to the development of effective cessation interventions. However, one obstacle to successful cessation is smoking-specific weight concerns (French & Jeffery, 1995; Jeffery, Hennrikus, Lando, Murray, & Liu, 2000; Meyers et al., 1997; Ockene et al., 2000). French and Jeffery defined the dimensions of smoking-specific weight concerns as "a) weight gain concerns/fears of weight gain,

b) dieting behaviors, c) dispositional weight concerns/dieting behaviors, and d) perceptions of overweight" (French & Jeffery, 1995, p. 234). Although many smokers have smoking-specific weight concerns (Rosenthal et al., 2013; Spring et al., 2009), daily smokers have more concerns than occasional or ex-smokers (Luostarinen et al., 2013). Moreover, smoking-specific weight concerns are more common and greater in women than in men (Clark et al., 2006; Jeffery et al., 2000; Luostarinen et al., 2013; Meyers et al., 1997; Pankova et al., 2016; Pomerleau & Snedecor, 2008). However, although women have more smoking-specific weight concerns, they do not gain more weight during smoking cessation (Tian, Venn, Otahal, & Gall, 2015). In addition, there is no strong evidence supporting the idea that smoking-specific weight concerns predict smoking cessation more strongly in women than in men (Germeroth & Levine, 2018).

Smoking-specific weight concerns reduce abstinence rates in some (French & Jeffery, 1995; Jeffery et al., 2000; Meyers et al., 1997; Ockene et al., 2000), but not in all studies (Borrelli & Mermelstein, 1998; French & Jeffery, 1995; Landrau-Cribbs, Cabriales, & Cooper, 2015; Sepinwall & Borrelli, 2004; Zhou et al., 2009) or do so for women only (Jeffery et al.,

2000). Some of this disparity in findings may result from the use of different smoking-specific weight-concern measures (Germeroth & Levine, 2018). Both general (Jeffery et al., 2000; Pisinger & Jorgensen, 2007; Rosenthal et al., 2013) and smoking-specific (Borrelli & Mermelstein, 1998; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Meyers et al., 1997) weight concerns have been investigated. However, since this article focuses on smoking-specific weight concerns, they are referred to only as "weight concerns" in the following text. A multiple-item scale may be the most accurate for measuring weight concerns because single-item assessments may have limited reliability, and many multiple-item weight concern scales seem to have proper face validity (Germeroth & Levine, 2018). One such scale, the Weight Control Smoking Scale (WCSS), has been validated and tested for reliability (Pomerleau & Snedecor, 2008). While weight concerns are only a suggested barrier to smoking cessation, a high level of nicotine dependence (ND) is a well-established obstacle (Sohn, Hartley, Froelicher, & Benowitz, 2003; Vangeli, Stapleton, Smit, Borland, & West, 2011; World Health Organization, 2016). Most smokers exhibit some signs of dependence (Fagerstrom, 2000), and a higher ND level predicts lower smoking cessation rates (Ockene et al., 2000; Vangeli et al., 2011). The positive association between nicotine dependence and weight concerns has been reported frequently (Aubin, Berlin, Smadja, & West, 2009; Pomerleau, Zucker, & Stewart, 2001; Strong et al., 2014). Furthermore, Jeffery et al. (2000) hypothesised that smokers with higher ND have more realistic worries about the adverse consequences of smoking cessation, and that weight concerns are merely an index of such worries. The authors further conjectured that the addiction itself may be strengthened by weight concerns (i.e., the presence of weight concerns maintains the smoking behaviour and thus leads to higher ND, which in turn hinders smoking cessation).

The six-item Fagerström Test for Nicotine Dependence (FTND) is the most common tool for determining ND in clinical settings (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) and is widely used in research (Sohn et al., 2003; Vangeli et al., 2011). Jeffery et al. (2000) suggested that some studies on weight concerns have failed to predict smoking status because the analyses were not controlled for ND or because the interplay between weight concerns and ND was not considered. This hypothesis, and the literature on weight concerns, ND, and smoking cessation, indicate that the interaction between weight concerns and ND on later smoking status needs to be investigated.

A recent review suggested the need to carefully test for and report on the covariates of weight concerns (Germeroth & Levine, 2018). Self-efficacy and motivation to quit are classic components involved in the smoking cessation process models (West & Hardy, 2006). In the COM-B system model, self-efficacy (capability [C] in the model) and motivation (M) appear with opportunity (O) (Michie, van Stralen, & West, 2011). In that model, self-efficacy, motivation, and opportunity equally and directly affect the behaviour change (B), and the influence is bidirectional, (i.e., behaviour change also affects self-efficacy, motivation, and opportunity). When examining weight concerns as a predictor of smoking cessation, it is important to take into account the classic predictors of health-behaviour change: self-efficacy and motivation to quit (Michie et al., 2011). However, the results of self-efficacy and motivation as predictors of smoking cessation have been inconsistent. Low self-efficacy (Gwaltney, Metrik, Kahler, & Shiffman, 2009; Ockene et al., 2000; Vangeli et al., 2011) and motivation to quit (Boardman, Catley, Mayo, & Ahluwalia, 2005; Curry, Grothaus, & McBride, 1997) reduce cessation rates, although not all studies have confirmed these associations (Baldwin et al., 2006; Gwaltney et al., 2009; Vangeli et al., 2011).

Taken together, several studies have reported weight concerns as a smoking cessation predictor, but there is a scarcity of research

addressing the effects of ND on this association. Our aim was to examine whether weight concerns predict changes in smoking status based on ND levels. We investigated this association in a longitudinal study of adults over a seven-year follow-up period.

Methods

Study population

The DIetary, Lifestyle and Genetic determinants of Obesity and Metabolic syndrome (DILGOM) is a sub-sample of the national FIN-RISK 2007 study (Vartiainen et al., 2010), which drew a random sample of 9905 men and women aged 25–74 years. At the baseline, 6258 participated in a more detailed health examination that included several questionnaires, clinical measurements, and blood samples. Of the 6258 participants, 5024 (80%) participated in the DILGOM baseline study. Of those, 4581 were invited to participate in the DILGOM follow-up in 2014; 3737 replied (82% response rate). All 1922 ever-smokers were identified from DILGOM 2007 based on their responses to the question "Have you smoked at least 100 cigarettes during your lifetime?" Those who answered "yes" completed an additional questionnaire about smoking, with 1746 (90%) responding. Among those ever-smokers, 618 were self-reported daily smokers, of whom 402 participated in the 2014 follow-up (65% participation rate).

Our analyses included 355 daily smokers (180 men, 175 women) who participated in baseline and follow-up studies and had no missing information on predictor, outcome or prospective confounding factors. In addition, cotinine levels at baseline and carbon monoxide (CO) levels at follow-up were available for a portion of the 355 participants. Blood cotinine levels at baseline were available from 344 participants and thus allowed the examination of correlations between weight concerns, FTND, and cotinine levels. In addition, CO measures were taken from a sub-sample of participants

and were available from 128 participants at follow-up. The reliability of self-reported smoking status in 2014 for the 128 participants with CO measurements and no missing information for applied variables was tested (see Table 3 below). Baseline variables were compared between participants and non-participants at follow-up (Table 4, below). The DILGOM 2007 and DILGOM 2014 studies were approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa, and all participants gave their written informed consent.

Measures

Smoking status. In 2007, smoking status was formed according to the current recommendations (West, 2017), and was defined based on answers to the following questions: (1) "Have you ever smoked?" (2) "Have you smoked at least 100 cigarettes during your lifetime?" (3) "Do you smoke currently?" and (4) "Have you ever smoked regularly (for at least a one-year period)?" Participants who answered "yes" to questions 1, 2, and 4 and "yes, on a daily basis" to question 3 were accepted for participation in the study as baseline current daily smokers. At the 2014 follow-up, baseline daily smokers were classified into three categories by smoking status as follows: (1) continuing daily smokers, (2) occasional smokers, and (3) ex-smokers. Ex-smokers comprised recent quitters and former smokers. Smoking classification was based on answers to the questions 1–4 above, and to the following additional question (5) "When was the last time you smoked?" The responses of the continuing daily smokers were similar to those submitted in 2007. Those who answered "yes" to questions 1, 2, and 4 and "yes, occasionally" to question 3, and "two days–one month ago" to question 5 were classified as occasional smokers. Finally, those who answered "yes" to questions 1, 2, and 4, "not at all" to question 3, and at least "one month ago" to question 5 were classified as ex-smokers. Those participants in the follow-up survey who

had a missing smoking status in 2014 were treated as non-participants.

Weight concerns. We applied a modified version of the Weight Concern Scale developed by Borrelli and Mermelstein (1998) to measure concerns about smoking-specific weight and weight gain. In brief, we modified this scale to be more suitable for a population-based sample by changing its final item. This modification is explained in detail in our previous article (Tuovinen et al., 2015). Weight concerns were measured using six items, including a Likert-type scale that ranged from 1 (not at all or very little) to 5 (very much). After subtracting 1 from each response, the items were scaled from 0 to 4, and a sum score ranging from 0 to 24 was created. This scale showed very high internal consistency (Cronbach's $\alpha = 0.90$).

Nicotine dependence. The six-item FTND was used to measure ND. Its sum score ranges from 0 to 10, with a higher score indicating a higher ND (Heatherton et al., 1991). Participants were divided into two groups based on FTND scores, analogically to Fagerstrom, Russ, Yu, Yunis, and Foulds's article (2012) in which the FTND score 0–3 stands for mild, 4–6 denotes moderate, and 7–10 indicates severe nicotine dependence. Thus, those with an FTND score of 0–3 formed the low ND group, and those with a score of 4–10 formed the high ND group (Fagerstrom & Furberg, 2008; Fagerstrom et al., 2012). In addition, the final regression models were controlled for FTND as a continuous variable to take into account the variation of FTND scores within the low and high ND groups.

Other variables. Based on the earlier literature and preliminary analyses (i.e., of unadjusted age and sex associations), we applied the following baseline variables as potential confounders: sex, age, self-efficacy and motivation to quit, physical activity, and education. Self-efficacy was measured based on responses to the question "If you were to try to quit smoking,

how much confidence would you have that you could quit for good?" Motivation was measured based on responses to the question "How willing are you to quit smoking for good?" Response options were based on an 11-point scale from "no confidence/willingness at all" to "very great confidence/willingness". Self-efficacy and motivation to quit were applied as a continuous variables. Physical activity was determined by self-reported leisure time, commuting, and occupational physical activities which were combined to create a physical activity index and applied as a continuous variable with the higher number standing for a higher level of physical activity (Borodulin et al., 2016). Education was self-reported as years of full-time study and divided as the following birth cohort-specific tertiles: low, intermediate, and high. A research nurse measured CO from expired air and took a blood sample to measure cotinine levels. The cut-off point for active smoking based on CO was set at 8 ppm as recommended by the Society for Research on Nicotine and Tobacco Subcommittee on Biochemical Verification (SRNT Subcommittee on Biochemical Verification, 2002).

Statistical analyses

The statistical analysis tool was StataSe (Version 13.1), (StataCorp, 2013) with significance set at $p < .05$, except for the interaction testing, for which statistical significance was set at $p < .10$. For a descriptive comparison of the study participants' characteristics, analyses of variance (one-way ANOVA) were conducted for the baseline FTND and for 2014 smoking status (i.e., daily, occasional, ex-smoker) for all variables with the exception of education. For education, differences were tested using Pearson's chi-square test. Baseline weight concerns and ND interaction on follow-up smoking status was evaluated using the Wald test. We conducted multinomial logistic regression to examine whether baseline weight concerns predicted smoking status based on ND level in a seven-year follow-up of two groups. We computed

relative risk ratios (RRRs) with 95% confidence intervals (CIs) for occasional and ex-smoking, with continuing daily smokers as the reference group. We used a stepwise procedure: the first model was controlled for sex and age, and the final model was further adjusted for self-efficacy and motivation to quit, physical activity index, education, and FTND. Correlations between weight concerns, FTND, and cotinine levels of the participants with cotinine data were evaluated using Pearson's correlation coefficient. We applied Cohen's kappa to observe the reliability of self-reported follow-up smoking status among a sub-sample of participants with CO measurements. Student's t-test was used to compare the means of the 2014 baseline variables of the participants and non-participants.

Results

Baseline characteristics

The 355 participants (180 men, 175 women) comprised 87 men and 92 women with low ND (FTND 0–3) and 93 men and 83 women with high ND (4–10) (Table 1). Overall quit rates were 29% in the low-ND group and 26% in the high-ND group. The proportion of occasional smokers was much higher for the low-ND group than for the high-ND group (15% vs. 2%). Baseline weight concerns were highest for those participants who had a high baseline ND and had become occasional smokers by the time of the follow-up (mean 11.0, SD 8.8).

Weight concerns and smoking cessation

The interaction between weight concerns and ND on follow-up smoking status was significant (LR $\chi^2 = 6.37$ $p = .04$). When analysed based on ND, greater weight concerns predicted a less probable smoking cessation (RRR 0.92 [95% CI 0.86–0.98]) and reduction in smoking from daily to occasional (RRR 0.89 [95% CI 0.81–0.97]) in participants with low ND in the age- and sex-adjusted model (Table 2). This

result remained robust after adjustment for all confounders (RRR 0.93 [95% CI 0.87–1.00] and RRR 0.89 [95% CI 0.81–0.98], respectively). Self-efficacy was not a significant predictor whereas a higher motivation to quit predicted higher likelihood of smoking cessation for those with low ND. Weight concerns did not significantly predict smoking status in participants with high ND. Higher self-efficacy predicted less smoking cessation for those with high ND, while motivation was not a significant predictor.

Reliability of self-reported smoking status

Among those 128 participants with CO measurements at follow-up, none who reported being ex-smokers had CO levels ≥ 8 ppm, and Cohen's kappa was 0.75, $p < .001$, indicating high reliability (Table 3).

Correlations between cotinine, weight concerns, and FTND

Pearson's correlation between baseline cotinine level and FTND was $r = 0.47$ ($p < .001$), whereas no correlation between cotinine and weight concerns was found.

Comparison of baseline variables between participants and non-participants at follow-up

The mean values in the baseline variables between participants and non-participants in 2014 differed only in FTND levels: non-participants had a higher mean FTND than participants (mean 3.98, SD 2.5 vs. mean 3.56, SD 2.5) (Table 4).

Discussion

Our results regarding weight concerns as a predictor for quitting and reducing smoking based on nicotine dependence (ND) level suggest that ND modifies the association between weight concerns and later smoking status. As measured

Table 1. Baseline variables by follow-up smoking status and baseline FTND group: low nicotine dependence (0–3) or high (4–10), *n* = 355.

	Smoking status (follow-up)						
	Daily smokers		Occasional smokers		Ex-smokers		
	FTND (baseline)						
	Low	High	Low	High	Low	High	
n	101	126	27	4	51	46	
Women (%)	50.0	49.2	59.3	50.0	49.0	41.3	
	Mean (*SD*)						*p*-value
Age (years)	48.57 (10)	50.63 (10)	50.70 (14)	43.75 (11)	51.41 (13)	49.35 (12)	.498
Weight concerns (0–24)	9.63 (6.4)	9.24 (6.4)	6.22 (4.4)	11.00 (8.8)	7.12 (5.1)	9.67 (7.0)	.035
FTND (0–10)	1.77 (1.1)	5.69 (1.5)	1.33 (1.2)	6.00 (1.4)	1.24 (1.1)	5.67 (1.2)	< .001
Self-efficacy to quit (0–10)	5.86 (2.5)	4.71 (2.5)	6.62 (1.9)	2.25 (1.0)	6.24 (2.1)	5.22 (2.5)	< .001
Motivation to quit (0–10)	7.24 (2.2)	6.71 (2.7)	7.11 (2.2)	8.75 (1.0)	7.90 (2.0)	7.72 (2.6)	.025
Physical activity index (1–4)	2.95 (0.8)	2.98 (0.8)	3.41 (0.8)	3.25 (0.5)	2.90 (0.9)	2.74 (0.9)	.034
Education (%)							.057
Low	45.54	42.06	37.04	25.00	31.37	28.26	
Moderate	31.68	41.27	29.63	50.00	27.45	45.65	
High	22.77	16.67	33.33	25.00	41.18	26.09	

Notes. Differences in characteristics between the groups for all variables, with the exception of education, were determined using one-way ANOVA. For education, differences were tested using Pearson's chi-square test. FTND = Fagerström Test for Nicotine Dependence.

by our Weight Concerns Scale, each score increase of 1 point predicted a 7% lower cessation probability in smokers with low ND while weight concerns were not a significant predictor of smoking cessation for those with high ND. The effects are usually weaker in population-level studies compared to clinical-level studies; thus, this 7% decrease of probability per score represents a meaningful effect in a population. Similar results were observed with respect to transitioning from daily smoking to occasional smoking: 11% lower cessation probability per 1 score increase in the weight-concern sum score. Our finding that weight concerns predicted smoking cessation is in line with results of earlier studies (French & Jeffery, 1995; Jeffery et al., 2000; Meyers et al., 1997; Ockene et al., 2000). However, in previous studies smokers were not divided into subgroups based on their ND.

Our finding that weight concerns failed to predict later smoking status among highly ND smokers may be explained by the possibility that ND is such a strong obstacle to abstinence that it largely overwhelms the influence of weight concerns. Previous studies have reported a positive association between the level of weight concerns with ND level (Aubin et al., 2009; Pomerleau et al., 2001; Strong et al., 2014), a trend that is also evident in our sample. It appears to be that the higher the ND, the smaller the role of weight concerns. One reason for this finding could be that smokers who have higher ND have more realistic concerns about smoking cessation's unwanted consequences, such as weight gain and that weight

Table 2. Multinomial logistic regression of weight concerns as a predictor of follow-up smoking status according to nicotine dependence level. Relative risk ratios (RRRs) with 95% confidence intervals (CIs). Daily smokers in 2014 as reference group (RRR = 1), $n = 355$.

	Model 1	Final model
Low FTND ($n = 179$)	RRR	RRR
	(CI)	(CI)
	p-value	p-value
Daily smokers	1.00	1.00
Occasional smokers	0.89	0.89
	(0.81; 0.97)	(0.81; 0.98)
	0.006	0.018
Ex-smokers	0.92	0.93
	(0.86; 0.98)	(0.87; 1.00)
	0.010	0.035
Pseudo R^2	0.05	0.12
High FTND ($n = 176$)	RRR	RRR
	(CI)	(CI)
	p-value	p-value
Daily smokers	1.00	1.00
Occasional smokers	1.06	1.05
	(0.90; 1.24)	(0.89; 1.24)
	0.513	0.545
Ex-smokers	1.02	1.01
	(0.97; 1.08)	(0.95; 1.07)
	0.453	0.714
Pseudo R^2	0.02	0.11

Notes. Model 1 adjusted for sex and age. Final model further adjusted for self-efficacy and motivation to quit, physical activity index, education, and nicotine dependence. FTND = Fagerström Test for Nicotine Dependence.

concerns are merely reflecting such worries (Jeffery et al., 2000). Another possible explanation is that the addiction itself may be strengthened as a consequence of greater weight concerns, hereby leading to stronger ND, which that hinders smoking cessation (Jeffery et al., 2000). Those who smoke more cigarettes tend to have a higher post-cessation weight gain (Sneve & Jorde, 2008). While high nicotine-dependent smokers have more weight concerns, the impact of weight concerns may be less significant in predicting cessation outcome.

This idea suggests that cessation interventions, especially those targeting weight concerns, should take into account the level of ND. This would be especially helpful for smokers with low ND. Even though in our data weight concerns do not predict smoking cessation for smokers with high ND, these smokers may still benefit from weight gain intervention as a part of smoking cessation intervention since those with high ND gain more weight on average during the cessation process (Sneve & Jorde, 2008). Not categorising participants according to ND level may be why in some studies weight concerns have failed to predict smoking cessation (Borrelli & Mermelstein, 1998; French & Jeffery, 1995; Landrau-Cribbs et al., 2015; Sepinwall & Borrelli, 2004; Zhou et al., 2009). Furthermore, weight concerns may prove to be an important predictor of smoking cessation only in some smoker sub-groups (Zhou et al., 2009).

The role of ND during smoking cessation is the strongest at the beginning of the process, when withdrawal symptoms emerge; during later phases, however, the role of ND decreases (Zhou et al., 2009). While one may assume that the role of weight concerns increases as actual weight gain occurs, such a phenomenon has not been clearly established (Borrelli & Mermelstein, 1998; Pinsker et al., 2017).

In our study, analyses were adjusted for the established predictors of smoking cessation (i.e., self-efficacy and motivation to quit). Higher self-efficacy predicted less smoking cessation for those with high ND, while self-efficacy was not a significant predictor for those with low ND. Higher motivation to quit, however, predicted a higher likelihood of smoking cessation for those with low ND. The result that self-efficacy and motivation to quit were not strong predictors of smoking cessation may be due to the fact that our data were derived from a population-based sample in which the participants were at different stages of change. In other words, when self-efficacy and motivation were measured, smoking cessation was not topical for all the participants. Many other studies reporting stronger associations have been cessation trials in which all participants were planning to quit smoking. In our data, the measured self-efficacy

Table 3. Self-reported smoking status by exhaled carbon monoxide level at follow-up, $n = 128$ and matrix of self-reported smoking status (ex-smokers vs. daily smokers) versus the carbon monoxide level (< 8 vs. ≥ 8), $n = 109$.

	Self-reported smoking status		
	n (%)		
Carbon monoxide level (ppm)	Daily smokers	Occasional smokers	Ex-smokers
< 8	12 (15)	13 (68)	30 (100)
≥ 8	67 (85)	6 (32)	0 (0)
	Reliability of self-reported smoking status		
Self-reported smoking status	Ex-smokers	Daily smokers	Total
Carbon monoxide (< 8)	30	12	42
Carbon monoxide (≥ 8)	0	67	67
Kappa = 0.75, p < .001			109

Notes. Main analyses included 355 participants; exhaled carbon monoxide available from 128 participants.

Table 4. Baseline variables among study participants and non-participants at follow-up in 2014.

	Participants		Non-participants		
N (total)	402 402		216 216		
Women (%)	47.8		37.5		
	Mean (SD)	n	Mean (SD)	N	p-value
Age (years)	50.38 (11.4)	402	49.64 (13.9)	216	.480
Weight concerns (0–24)	8.78 (6.2)	393	9.72 (6.4)	199	.086
FTND (0–10)	3.56 (2.5)	398	3.98 (2.5)	212	.047
Self-efficacy to quit (0–10)	5.45 (2.5)	385	5.39 (2.5)	199	.758
Motivation to quit (0–10)	7.16 (2.5)	385	6.87 (2.6)	199	.190
Physical activity index (1–4)	2.98 (0.8)	389	2.89 (0.9)	197	.223
Education (%)		398		215	.100
Low	38.19		46.51		
Moderate	37.19		29.77		
High	24.62		23.72		

Notes. Differences in characteristics between the groups for all variables, with the exception of education, were determined using one-way ANOVA. For education, differences were tested using Pearson's chi-square test. FTND = Fagerström Test for Nicotine Dependence.

and motivation may have differed from what they were immediately prior to actual cessation attempts during the follow-up period. We did not conduct any measurements between the two surveys.

The main strength of this study was a relatively long follow-up period of seven years. During that time, the ex-smokers could stabilise their non-smoking behaviour, since smoking cessation is characterised by states of abstinence, relapsing, and quitting again (Killeen, 2011). Also, we studied this phenomenon within a population, while most of the previous studies have been conducted in more restricted samples. In addition, there was no significant difference in weight concern level between participants and non-participants.

This study also had some limitations. First, we applied a slightly modified version of the Borelli and Mermelstein Weight Concern Scale (Borrelli & Mermelstein, 1998), which makes it more difficult to compare our results with those of other studies using the original scale. The original scale had been applied mainly in treatment studies of smokers who were planning to quit. Because our study was conducted among all smokers, such modification was relevant. Despite this modification, our scale was highly internally consistent. Second, we lacked data at intermediate time-points between baseline and follow-up, during which time weight concerns, self-efficacy, and motivation to quit may have changed before the actual cessation. Third, we had biochemical information (CO and cotinine measurements) from some of the participants only. However, our biochemical information among sub-samples at the baseline (cotinine) and at follow-up (CO) strongly suggested that self-reports of smoking status were reliable. Fourth, although the participation rate at follow-up in 2014 was 65%, because of participants with missing information at smoking-status follow-up were excluded, only 57% of the baseline daily smokers were eventually included in our analysis; it is well known that smokers participate less than non-smokers in health surveys (Christensen, Ekholm, Gray, Glumer, & Juel, 2015). Our participants and non-participants showed no significant differences in their baseline variables with the exception of the FTND. Fifth, the difference in the abstinence rate is quite narrow (29% for low ND and 26% for high ND) between the two groups. Sixth, the groups of occasional smokers were quite small, although the results for those occasional smokers with low ND were statistically significant. The fifth and sixth limitations point out that our results are only suggestive. Finally, although the analyses were adjusted for several confounders, the possibility of residual confounding cannot be ruled out.

Our population-based results provide insight only into the interplay between weight concerns, ND, and smoking cessation, and further examination of this interplay in clinical settings would result in stronger evidence. We suggest that weight concerns should be addressed as a part of smoking-cessation interventions, especially to those smokers having low ND. This should be done because smoking-cessation intervention combined with weight-control treatment enhances tobacco abstinence and reduces post-cessation weight gain in the short term more effectively than smoking-cessation intervention alone (Spring et al., 2009). There is no consensus to date, however, as to whether the focus of cessation interventions should be on reducing weight concerns or reducing actual weight gain (Borrelli & Mermelstein, 1998; Spring et al., 2009; Tian et al., 2015).

In conclusion, among baseline daily smokers, ND may modify the longitudinal association of weight concerns with later smoking status. Weight concerns predicted later smoking status only for those with low ND but not for those with high ND. For future practical implications, weight concerns should be addressed in smoking cessation interventions, especially with smokers who have low ND, whereas those interventions targeted at smokers with high ND should emphasise effective ND treatment.

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Declaration of conflicting interests

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References

Aubin, H. J., Berlin, I., Smadja, E., & West, R. (2009). Factors associated with higher body mass index, weight concern, and weight gain in a multinational cohort study of smokers intending to quit. *International Journal of Environmental Research and Public Health*, 6(3), 943–957.

Baldwin, A. S., Rothman, A. J., Hertel, A. W., Linde, J. A., Jeffery, R. W., Finch, E. A., & Lando, H. A. (2006). Specifying the determinants of the initiation and maintenance of behavior change: An examination of self-efficacy, satisfaction, and smoking cessation. *Health Psychology*, 25(5), 626–634.

Boardman, T., Catley, D., Mayo, M. S., & Ahluwalia, J. S. (2005). Self-efficacy and motivation to quit during participation in a smoking cessation program. *International Journal of Behavioral Medicine*, 12(4), 266–272.

Borland, R., Partos, T. R., Yong, H. H., Cummings, K. M., & Hyland, A. (2012). How much unsuccessful quitting activity is going on among adult smokers? Data from the international tobacco control four country cohort survey. *Addiction (Abingdon, England)*, 107(3), 673–682.

Borodulin, K., Harald, K., Jousilahti, P., Laatikainen, T., Mannisto, S., & Vartiainen, E. (2016). Time trends in physical activity from 1982 to 2012 in Finland. *Scandinavian Journal of Medicine & Science in Sports*, 26(1), 93–100.

Borrelli, B., & Mermelstein, R. (1998). The role of weight concern and self-efficacy in smoking cessation and weight gain among smokers in a clinic-based cessation program. *Addictive Behaviors*, 23(5), 609–622.

Carter, B. D., Abnet, C. C., Feskanich, D., Freedman, N. D., Hartge, P., Lewis, C. E., . . . Jacobs, E. J. (2015). Smoking and mortality: Beyond established causes. *The New England Journal of Medicine*, 372(7), 631–640.

Chaiton, M., Diemert, L., Cohen, J. E., Bondy, S. J., Selby, P., Philipneri, A., & Schwartz, R. (2016). Estimating the number of quit attempts it takes to quit smoking successfully in a longitudinal cohort of smokers. *BMJ Open*, 6(6), e011045–2016-011045.

Christensen, A. I., Ekholm, O., Gray, L., Glumer, C., & Juel, K. (2015). What is wrong with non-respondents? Alcohol-, drug- and smoking-related mortality and morbidity in a 12-year follow-up study of respondents and non-respondents in the Danish health and morbidity survey. *Addiction (Abingdon, England)*, 110(9), 1505–1512.

Clark, M. M., Hurt, R. D., Croghan, I. T., Patten, C. A., Novotny, P., Sloan, J. A., . . . Loprinzi, C. L. (2006). The prevalence of weight concerns in a smoking abstinence clinical trial. *Addictive Behaviors*, 31(7), 1144–1152.

Curry, S. J., Grothaus, L., & McBride, C. (1997). Reasons for quitting: Intrinsic and extrinsic motivation for smoking cessation in a population-based sample of smokers. *Addictive Behaviors*, 22(6), 727–739.

Curry, S. J., & McBride, C. M. (1994). Relapse prevention for smoking cessation: Review and evaluation of concepts and interventions. *Annual Review of Public Health*, 15, 345–366.

Fagerstrom, K. (2000). The epidemiology of nicotine dependence. In R. Lu, J. Mackay, S. Niu, & R. Peto (Eds.), *Tobacco: The growing epidemic* (pp. 218–218). London, UK: Springer.

Fagerstrom, K., & Furberg, H. (2008). A comparison of the Fagerstrom test for nicotine dependence and smoking prevalence across countries. *Addiction (Abingdon, England)*, 103(5), 841–845.

Fagerstrom, K., Russ, C., Yu, C. R., Yunis, C., & Foulds, J. (2012). The Fagerstrom test for nicotine dependence as a predictor of smoking

abstinence: A pooled analysis of varenicline clinical trial data. *Nicotine & Tobacco Research*, *14*(12), 1467–1473.

French, S. A., & Jeffery, R. W. (1995). Weight concerns and smoking: A literature review. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *17*(3), 234–244.

Germeroth, L. J., & Levine, M. D. (2018). Postcessation weight gain concern as a barrier to smoking cessation: Assessment considerations and future directions. *Addictive Behaviors*, *76*, 250–257.

Gwaltney, C. J., Metrik, J., Kahler, C. W., & Shiffman, S. (2009). Self-efficacy and smoking cessation: A meta-analysis. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors*, *23*(1), 56–66.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K. O. (1991). The Fagerstrom test for nicotine dependence: A revision of the Fagerstrom tolerance questionnaire. *British Journal of Addiction*, *86*(9), 1119–1127.

Helldán, A., Helakorpi, S., Virtanen, S., & Uutela, A. (2013). *Health behaviour and health among the Finnish adult population, spring 2013*. Helsinki, Finland: National Institute for Health and Welfare.

Hughes, J. R., Keely, J., & Naud, S. (2004). Shape of the relapse curve and long-term abstinence among untreated smokers. *Addiction (Abingdon, England)*, *99*(1), 29–38.

Jeffery, R. W., Hennrikus, D. J., Lando, H. A., Murray, D. M., & Liu, J. W. (2000). Reconciling conflicting findings regarding postcessation weight concerns and success in smoking cessation. *Health Psychology*, *19*(3), 242–246.

Killeen, P. R. (2011). Markov model of smoking cessation. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(Suppl 3), 15549–15556.

Landrau-Cribbs, E., Cabriales, J. A., & Cooper, T. V. (2015). General and smoking cessation weight concern in a Hispanic sample of light and intermittent smokers. *Addictive Behaviors*, *41*, 29–33.

Luostarinen, M., Tuovinen, E. L., Saarni, S. E., Kinnunen, T., Hukkinen, M., Haukkala, A., . . . Korhonen, T. (2013). Weight concerns among Finnish ever-smokers: A population-based study. *Nicotine & Tobacco Research*, *15*(10), 1696–1704.

Meyers, A. W., Klesges, R. C., Winders, S. E., Ward, K. D., Peterson, B. A., & Eck, L. H. (1997). Are weight concerns predictive of smoking cessation? A prospective analysis. *Journal of Consulting and Clinical Psychology*, *65*(3), 448–452.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science: IS*, *6*, 42-5908-6-42.

Ockene, J. K., Emmons, K. M., Mermelstein, R. J., Perkins, K. A., Bonollo, D. S., Voorhees, C. C., & Hollis, J. F. (2000). Relapse and maintenance issues for smoking cessation. *Health Psychology*, *19*(1 Suppl), 17–31.

Pankova, A., Kralikova, E., Stepankova, L., Zvolska, K., Bortlicek, Z., Blaha, M., . . . Croghan, I. T. (2016). Weight concerns associated with delay in quit date but not treatment outcomes: A Czech Republic experience. *Nicotine & Tobacco Research*, *20*, 89–94.

Pinsker, E. A., Hennrikus, D. J., Erickson, D. J., Call, K. T., Forster, J. L., & Okuyemi, K. S. (2017). Cessation-related weight concern among homeless male and female smokers. *Preventive Medicine Reports*, *7*, 77–85.

Pisinger, C., & Jorgensen, T. (2007). Weight concerns and smoking in a general population: The Inter99 study. *Preventive Medicine*, *44*(4), 283–289.

Pomerleau, C. S., & Snedecor, S. M. (2008). Validity and reliability of the weight control smoking scale. *Eating Behaviors*, *9*(3), 376–380.

Pomerleau, C. S., Zucker, A. N., & Stewart, A. J. (2001). Characterizing concerns about postcessation weight gain: Results from a national survey of women smokers. *Nicotine & Tobacco Research*, *3*(1), 51–60.

Rosenthal, L., Carroll-Scott, A., Earnshaw, V. A., Sackey, N., O'Malley, S. S., Santilli, A., & Ickovics, J. R. (2013). Targeting cessation: Understanding barriers and motivations to quitting among urban adult daily tobacco smokers. *Addictive Behaviors*, *38*(3), 1639–1642.

Sepinwall, D., & Borrelli, B. (2004). Older, medically ill smokers are concerned about weight gain after quitting smoking. *Addictive Behaviors*, *29*(9), 1809–1819.

Sneve, M., & Jorde, R. (2008). Cross-sectional study on the relationship between body mass index and smoking, and longitudinal changes in body mass index in relation to change in smoking status: The Tromso Study. *Scandinavian Journal of Public Health*, *36*(4), 397–407.

Sohn, M., Hartley, C., Froelicher, E. S., & Benowitz, N. L. (2003). Tobacco use and dependence. *Seminars in Oncology Nursing*, *19*(4), 250–260.

Spring, B., Howe, D., Berendsen, M., McFadden, H. G., Hitchcock, K., Rademaker, A. W., & Hitsman, B. (2009). Behavioral intervention to promote smoking cessation and prevent weight gain: A systematic review and meta-analysis. *Addiction (Abingdon, England)*, *104*(9), 1472–1486.

SRNT Subcommittee on Biochemical Verification. (2002). Biochemical verification of tobacco use and cessation. *Nicotine & Tobacco Research*, *4*(2), 149–159.

StataCorp. (2013). *Stata Statistical Software: Release 13.1*. College Station, TX: StataCorp.

Strong, D. R., Uebelacker, L., Fokas, K., Saritelli, J., Matsko, S., Abrantes, A. M., & Schonbrun, Y. (2014). Utilization of evidence-based smoking cessation treatments by psychiatric inpatient smokers with depression. *Journal of Addiction Medicine*, *8*(2), 77–83.

Tian, J., Venn, A., Otahal, P., & Gall, S. (2015). The association between quitting smoking and weight gain: A systemic review and meta-analysis of prospective cohort studies. *Obesity Reviews*, *16*(10), 883–901.

Tuovinen, E. L., Saarni, S. E., Kinnunen, T. H., Haukkala, A., Jousilahti, P., Patja, K., . . . Korhonen, T. (2015). Associations of weight concerns with self-efficacy and motivation to quit smoking: A population-based study among Finnish daily smokers. *Nicotine & Tobacco Research*, *17*(9), 1134–1141.

Vangeli, E., Stapleton, J., Smit, E. S., Borland, R., & West, R. (2011). Predictors of attempts to stop smoking and their success in adult general population samples: A systematic review. *Addiction (Abingdon, England)*, *106*(12), 2110–2121.

Vartiainen, E., Laatikainen, T., Peltonen, M., Juolevi, A., Mannisto, S., Sundvall, J., . . . Puska, P. (2010). Thirty-five-year trends in cardiovascular risk factors in Finland. *International Journal of Epidemiology*, *39*(2), 504–518.

West, R. (2017). Tobacco smoking: Health impact, prevalence, correlates and interventions. *Psychology & Health*, *32*(8), 1018–1036.

West, R., & Hardy, A. (2006). *Theory of addiction* (1st ed.). Oxford, UK: Blackwell Publishing Ltd.

World Health Organization. (2016). WHO tobacco. Retrieved from http://www.who.int/mediacentre/factsheets/fs339/en/

Zhou, X., Nonnemaker, J., Sherrill, B., Gilsenan, A. W., Coste, F., & West, R. (2009). Attempts to quit smoking and relapse: Factors associated with success or failure from the ATTEMPT cohort study. *Addictive Behaviors*, *34*(4), 365–373.

Zwar, N. A., Mendelsohn, C. P., & Richmond, R. L. (2014). Supporting smoking cessation. *BMJ (Clinical Research Ed.)*, *348*, f7535.