

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

Nordic Studies on Alcohol and Drugs

2018, Vol. 35(5) 344–356

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DOI: 10.1177/1455072518800217

[journals.sagepub.com/home/nad](http://journals.sagepub.com/home/nad)



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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,

Submitted: 4 April 2018; accepted: 22 August 2018

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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.

### Keywords

nicotine dependence, smoking cessation, weight concerns

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  $\geq 8$  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)						<i>p</i> -value
	Daily smokers		Occasional smokers		Ex-smokers		
	FTND (baseline)						
	Low	High	Low	High	Low	High	
<i>n</i>	101	126	27	4	51	46	
Women (%)	50.0	49.2	59.3	50.0	49.0	41.3	
	Mean (SD)						
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 sub-groups 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 I	Final model
Low FTND ( <i>n</i> = 179)	RRR (CI)	RRR (CI)
	<i>p</i> -value	<i>p</i> -value
Daily smokers	1.00	1.00
Occasional smokers	0.89 (0.81; 0.97)	0.89 (0.81; 0.98)
	0.006	0.018
Ex-smokers	0.92 (0.86; 0.98)	0.93 (0.87; 1.00)
	0.010	0.035
Pseudo <i>R</i> <sup>2</sup>	0.05	0.12
High FTND ( <i>n</i> = 176)	RRR (CI)	RRR (CI)
	<i>p</i> -value	<i>p</i> -value
Daily smokers	1.00	1.00
Occasional smokers	1.06 (0.90; 1.24)	1.05 (0.89; 1.24)
	0.513	0.545
Ex-smokers	1.02 (0.97; 1.08)	1.01 (0.95; 1.07)
	0.453	0.714
Pseudo <i>R</i> <sup>2</sup>	0.02	0.11

Notes. Model I 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.  $\geq 8$ ),  $n = 109$ .

Carbon monoxide level (ppm)	Self-reported smoking status		
	n (%)		
	Daily smokers	Occasional smokers	Ex-smokers
$< 8$	12 (15)	13 (68)	30 (100)
$\geq 8$	67 (85)	6 (32)	0 (0)

Self-reported smoking status	Reliability of self-reported smoking status		
	Ex-smokers	Daily smokers	Total
Carbon monoxide ( $< 8$ )	30	12	42
Carbon monoxide ( $\geq 8$ )	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		
	Mean (SD)	n	Mean (SD)	N	p-value
N (total)	402	402	216	216	
Women (%)	47.8		37.5		
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.

### **Acknowledgements**

The first author thanks Antti Latvala for practical advice on the use of Stata. We also thank Kennet Harald and Kauko Heikkilä for data management.

### **Declaration of conflicting interests**

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: JK and TK consulted for Pfizer Finland on nicotine dependence from 2012 to 2015. THK has consulted for Pfizer (Global and Finland 2012–2014). E-LT, SES, HO, OR, KP, SM, and PJ have no conflicts of interest to declare.


### **Funding**

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Jalmari and Rauha Ahokas Foundation (E-LT), Juho Vainio Foundation (E-LT,

TK & PJ), Finnish Association of Occupational Health Physicians (E-LT), The Foundation of the Finnish Anti-Tuberculosis Association (E-LT), Juhani Aho Foundation for Medical Research (E-LT), The Research Foundation of the Pulmonary Diseases (E-LT), Hospital District of Southwest Finland (SES, grant # P3004), Yrjö Jahnsson Foundation (SES), Academy of Finland (JK, grants # 265240 and # 263278, SM and PJ grants # 136895 and # 263836).

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