



Factors associated with weight changes in successful quitters participating in a smoking cessation program

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HIGHLIGHTS

- Smokers gain an average of 5 kg post 1 year of quitting cigarettes.
- Smokers with heavier dependence to cigarettes gain more weight.
- Heavier smokers should address weight management during smoking cessation.

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ABSTRACT

Objective: To identify possible predictors of post-cessation weight gain in smoking abstainers.

Patients and methods: A sample of 607 successful abstainers seen at the Centre for Tobacco-Dependent in Prague, Czech Republic, between 2005 and 2010, was included in this analysis. This sample was followed up for 1 year and included 47.9% women (N = 291) with the mean age of 48 years (18–85).

Findings: Post-cessation weight gain occurred in 88.6% of the 607 abstainers. The mean weight gain after one year post-quit was 5.1 kg (95% confidence interval 4.7–5.5 kg). Baseline characteristics associated with increased weight gain included a higher baseline smoking rate ($p < 0.001$), more severe cigarette dependence ($p = 0.003$), less physical activity ($p = 0.008$), and a report of increased appetite on the baseline assessment of withdrawal symptoms ($p < 0.001$).

Conclusions: Smokers who are more dependent and have minimal physical activity are at increased risk for post-cessation weight gain. For these smokers, incorporating interventions targeting the weight issue into tobacco dependence treatment is recommended. Further research should be done to identify reasons for this important quitting complication.

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1. Introduction

Although post-smoking cessation weight gain is well documented (Caan et al., 1996; Froom, Melamed, & Benbassat, 1998; John et al., 2005; Perkins, 1993) and occurs in about 84% of quitters (Aubin, Farley,

Lycett, Lahmek, & Aveyard, 2012; Cairella et al., 2007; Klein, Corwin, & Ceballos, 2004), the exact mechanisms underlying this important health issue are not clearly understood. Several factors contribute to this increase in body fat, including insulin resistance (Chiolero, Faeh, Paccaud, & Cornuz, 2008); however, some of the increase may be related to changes in the reinforcing properties of foods due to their association with the nicotine in cigarettes (Grimm, Ratliff, North, Barnes, & Collins, 2012).

The average weight gain is 3 to 6 kg at one year post-quit (Aubin et al., 2012; Chatkin & Chatkin, 2007), develops most rapidly initially, and then the rate of gain slows (Aubin et al., 2012; O'Hara et al., 1998) with the tendency to stabilize over time (Reas, Nygard, & Sorensen, 2009), not increasing. Former smokers revert to a mean BMI roughly equivalent to that of never-smokers when they achieve long-term

Abbreviations: CO, carbon monoxide; FTCD, Fagerström Test of Cigarette Dependence; MNWS, Minnesota Withdrawal Scale; NRT, nicotine replacement therapy.

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abstinence. This difference in BMI persists even after adjustment for energy and alcohol consumption, suggesting that the effects of smoking on BMI are not caused only by changes in dietary or alcohol consumption (Munafo, Tilling, & Ben-Shlomo, 2009).

Several factors associated with weight gain, including the absence of nicotine or other tobacco smoke substances, can increase energy intake (Chiolerio, Jacot-Sadowski, Faeh, Paccaud, & Cornuz, 2007). Evidence also suggests that hunger increases urges to smoke (Cheskin, Hess, Henningfield, & Gorelick, 2005; Leeman, O'Malley, White, & McKee, 2010). Self-administration of palatable foods, especially sweets, increases after nicotine deprivation (Hughes, Gust, Skoog, Keenan, & Fenwick, 1991).

Although nicotine is the only one addictive substance in tobacco (Le Houezec, 2003), the effects of nicotine and its metabolites are based on metabolic, central, and gastrointestinal influence. Nicotine does not acutely reduce hunger and eating and does not have an anorectic action (Henningfield, London, & Pogun, 2009). On the other hand, nicotine reduces food consumption and increases metabolic rate (Henningfield et al., 2009).

Metabolic impact of nicotine includes a thermogenic effect via increased lipid oxidation (Yoshida, Yoshioka, Hiraoka, & Kondo, 1990) and sympathetic stimulation (Hofstetter, Schutz, Jequier, & Wahren, 1986) and thus stimulates the basal metabolism (Dallosso & James, 1984) with an energy expenditure increase of 5%–10% (Hofstetter et al., 1986). It has been described that smoking of one cigarette increases the energy expenditure by 3% in 30 min (Dallosso & James, 1984). This effect on basal metabolism seems to be lower in obese smokers (Audrain, Klesges, & Klesges, 1995), as the change in the resting energy expenditure of obese smokers was described to be on average 300 kJ (71 calories) lower than in non-obese ones (Audrain et al., 1995). In contrast, people who gain the most weight are more likely to succeed in quitting smoking (Hall, Tunstall, Vila, & Duffy, 1992).

All forms of nicotine are linked to dopamine and serotonin release which in turn leads to a decrease in appetite (Chatkin & Chatkin, 2007). Nicotine contributes to appetite decrease by binding to the $\beta 4$ subunit of nicotinic acetylcholine receptors in hypothalamus nicotine which stimulates the MC-4 subunit of pro-opiomelanocortin neurons, resulting in decreased food intake (Mineur et al., 2011). This knowledge has contributed to a better understanding of nicotine's central influence leading to appetite suppression in smokers. Several studies have reported delayed gastric emptying of solids in smokers (Gritz et al., 1988; Miller, Palmer, Smith, Ferrington, & Merrick, 1989). Recent data show that gastric motility is accelerated after stopping smoking, and this acceleration may be involved in the temporary appetite increase and weight gain (Kadota et al., 2010).

There is evidence from a twin study that weight gain on cessation is mediated genetically (Aveyard, Lycett, & Farley, 2012). The role of gender differences however remains unclear in the current literature. While some studies have found greater weight gain in women when they stop smoking (Swan & Carmelli, 1995), others have not (Dale et al., 1998). Thus, there is contradictory data on whether women gain more weight. Even if weight gain is similar, this represents a greater percentage of weight gain in women (Froom et al., 1998).

An increase in appetite is an independent withdrawal symptom (Hughes & Hatsukami, 1986), and smokers with an increased appetite have been found to gain more weight when they stop smoking (John, Meyer, Rumpf, Hapke, & Schumann, 2006). In addition, as physical activity leads to energy expenditure and is one of the most important mechanisms to reduce weight, we assume that the baseline level of physical activity may be a possible predictor of post-cessation weight gain.

According to current knowledge, all first-line medications for smoking cessation seem to prevent weight gain while being used with differing degrees of effect (Farley, Hajek, Lycett, & Aveyard, 2012). Whereas no differences have been observed in the long term (Kawada, 2004), these findings are supported also by the *Cochrane Database of*

Systematic Reviews paper published in 2012 (Farley et al., 2012). On the other hand, prolonged use of transdermal nicotine therapy may help to reduce weight gain in the short term. Extended treatment increased nicotine patch adherence which, in turn, reduced weight gain (Schnoll, Wileyto, & Lerman, 2012). Several options were tested regarding weight gain prevention. Some of these may be effective in the short term, e.g. the use of nicotine replacement therapy (NRT) or bupropion (Allen, Hatsukami, Brintnell, & Bade, 2005; Hurt et al., 1997; Levine et al., 2010) or inclusion of a behavioral weight control component within a tobacco treatment program (Spring et al., 2009). The only one strategy which seems to be effective in the long-term is physical activity (Farley et al., 2012).

Our aim is to identify possible predictors of post-cessation weight gain utilizing a sample of 607 biochemically confirmed smoking abstainers being treated, and followed up for 1 year, in the Czech Republic, which makes this sample unique as no other similar Czech data are available.

2. Methods

2.1. Treatment program

This study included patients treated at the Center for Tobacco-Dependent in Prague, Czech Republic, between 2005 and 2010. This Center used evidence-based procedures including pharmacotherapy and psychobehavioral interventions according to Czech and international treatment recommendations and guidelines (Fiore et al., 2008; Králiková et al., 2005) described on our web page at <http://www.slz.cz/intervention-structure>. The treatment team consisted of nurses and medical doctors who were certified as Tobacco Treatment Specialists by the Mayo Clinic accredited program (accredited by the Council on Tobacco Treatment Training Programs) and its equivalent in the Czech Republic under the Society for Treatment of Tobacco Dependence (accredited by the Czech Medical Association). Because this treatment targeted the individual smoker, the treatment might differ in the type of medication used (varenicline; bupropion; NRT as patch, lozenge, inhaler and gum and/or their combination if needed) and the number of visits depending on the history, preferences, and compliance of patients, and according to patient comorbidities. The first-line medications included varenicline, bupropion, and nicotine. Whereas varenicline and bupropion were used in standard or reduced dosing (according to Fiore et al., 2008), NRT was recommended usually either as patch plus method (i.e. patch in combination with oral form of NRT – gum, inhaler, or lozenge) or in oral form only. Dosing of NRT was adjusted individually according to the presence of withdrawal symptoms during treatment. The type and dosage of medication selected were based on the therapist's recommendation (after a thorough assessment of the patient's history) and patient's choice. The initial visit, which included baseline assessments, was the same for all patients, regardless of the counselor assigned. The degree of tobacco dependence (Fagerström Test of Cigarette Dependence [FTCD] and Minnesota Withdrawal Scale [MNWS]) was evaluated, medical history was collected, and a basic physical exam was performed. Physical activity was assessed based on the following 4 categories: (1) Regular, at least 2–3 × weekly 46–60 min or 3 × weekly 20–30 min or more; (2) regular, weekly, but less frequent; (3) irregular, 1–2 × monthly; and (4) no physical activity.

At the second visit, physical dependence and psycho-social tobacco dependence were discussed during the 2-hour intervention. Habits and rituals associated with tobacco use, alternative or surrogate means of resolving the problem or means of avoiding such situations were analyzed and pharmacotherapy was introduced. At the end of the second visit, the patient and therapist decided the subsequent course of treatment including pharmacotherapy type and dose. They also planned the target quit date and the date of the first follow-up visit. The second visit also contained brief weight management recommendation, as described by Fiore et al. (2008).

Follow-up visits lasted 30 min on average. The first of these was planned within one or two weeks after the target quit day, then about once a month up to the third month of treatment. Regular in-person visits then occur at 6 and 12 months post-quit date, with a higher frequency if needed. At each visit, body weight, carbon monoxide (CO) in expired air, blood pressure, and heart rate were taken. The patient who failed to come for a planned appointment was contacted by phone. Using an intent-to-treat approach, any patient who did not attend a planned appointment was considered, from a statistical aspect, to be a smoker.

2.2. Study subjects

During the study period between 2005 and 2010, 1775 patients were treated in the Center for Tobacco-Dependent in Prague and passed the intensive initial smoking cessation intervention. Of these, 607 attended the 1-year follow-up visit, had expired CO < 6 ppm, and met criteria for continuous abstinence per Russell Standard Criteria (National Institute for Clinical Health and Excellence, 2008). These 607 successful abstainers formed the basis for this current report.

2.3. Study measures

- **Withdrawal:** Withdrawal symptoms were assessed at each visit using the MNWS (Hughes & Hatsukami, 1986). The MNWS symptoms assessed at visit 1 were used as baseline withdrawal measures.
- **Weight:** Body weight was measured at each visit using the personal digital scale [model: ETA no. 1775.90000], with light clothes and shoes off.
- **Physical activity:** Since the level of physical activity influences the energy expenditure, an evaluating scale with four different levels of physical activity was developed based on the World Health Organization General Practice Physical Activity Questionnaire (Puig Ribera et al., 2012; The General Practice Physical Activity Questionnaire (GPPAQ), 2009). Patients were screened at the initial prior-to-treatment baseline interview, based on the patient's own choice between groups: none (almost never), irregular (1–2 times per month), weekly (regularly every week but less often compared to the group regular), and regular (2–3 times per week in the length of 46–60 min or 3 times or more per week in the length of 20–30 min or more often).
- **% body fat:** The percentage of body fat was measured at baseline and one year post-quit by using the digital body fat meter [Omron BF 306].
- **Waist circumference:** Waist circumference was measured at baseline and one year post-quit by using a measuring tape, with light clothes on.
- **Hip circumference:** Hip circumference was measured at baseline and one year post-quit by using the same measuring tape as for waist circumference, with light clothes on.
- **Waist-to-hip ratio:** We have calculated the waist-to-hip ratio which is the ratio of measured waist circumference to measured hip circumference (Hainer, 2003).
- **Body mass index:** The body mass index was calculated using the ratio of body weight to the body surface (Hainer, 2003).
- **Tobacco dependence:** Tobacco dependence was defined by the FTCD, ≥ 5 points, screened at baseline (Fagerstrom, 2012).

2.4. Data analysis

A special program, ELZT (Evidence Léčby Závislosti na Tabáku-Register of Tobacco Dependence Treatment), was developed for the purpose of collecting and summarizing patient data.

Data were analyzed by the Institute of Biostatistics and Analyses at the Faculty of Medicine and the Faculty of Science Masaryk University, Brno. Baseline characteristics were summarized using mean \pm standard deviation for continuous variables and frequency percentages for categorical variables. Body measurement changes from baseline to one

year were calculated as absolute change and also as percentage change. In all cases, the mean change was reported along with 95% confidence interval (CI). Analysis of variance was used to assess characteristics potentially associated with change in weight from baseline to one year. The characteristics assessed included gender, age, FTCD, cigarettes per day, age at regular smoking initiation, amount of physical activity, and type of medication. Each characteristic was assessed individually. In addition, the baseline score for each of the individual withdrawal symptoms was dichotomized (present versus not present) and weight change was compared between groups for each symptom. In all cases $p < 0.05$ was considered statistically significant.

3. Results

Baseline characteristics of the 607 successful abstainers included in this report are summarized in Table 1 and changes in body measures from baseline to one year are summarized in Table 2. Of these 607, 69 (11.4%) lost weight between baseline and one year abstinence; 236 (38.9%) gained < 5 kg; 216 (35.6%) gained 5–10 kg; and 86 (14.2%) gained > 10 kg. The mean weight change from baseline to one year was +5.1 kg (95% CI, +4.7 kg to +5.5 kg). When expressed as a percentage change from baseline, the mean change was 6.8% (95% CI, 6.3% to 7.3%). Significant increases from baseline to one year were also found for other body measures (body mass index, % body fat, waist circumference, hip circumference, and waist-to-hip ratio).

Findings from analysis assessing characteristics potentially associated with weight gain are summarized in Table 3. Baseline characteristics associated with increased weight gain included a higher baseline smoking rate ($p < 0.001$), more severe cigarette dependence ($p = 0.003$), higher levels of expired air CO at baseline ($p = 0.001$) and less physical activity ($p = 0.008$). In addition, when expressed as a percentage change from baseline, women were found to gain significantly more weight than men ($p = 0.004$). The only baseline withdrawal symptom found to be associated with weight change was the item assessing “increased appetite, increased hunger, weight gain ($p < 0.001$).” Patients who reported experiencing this symptom at baseline (while smoking) were found to have increased weight gain at one year (Table 4).

We did not observe any differences in post-cessation weight gain one-year post-quit among those who did and did not use medication ($p = 0.870$). Similar findings were observed when the different types of medication (varenicline, bupropion, and NRT) were assessed individually (see Table 3). In addition, among those using a given medication, post-cessation weight gain was not found to be correlated with the duration of medication use ($p = 0.864$ for varenicline, $p = 0.844$ for bupropion and $p = 0.955$ for NRT). Since our data do not distinguish between different types of NRT we cannot evaluate the difference in post-cessation weight gain according to the type of NRT used.

4. Discussion

We observed some baseline characteristics to be connected to the post-cessation weight gain. Some of these include personal characteristics (e.g. level of physical activity) while others include tobacco consumption characteristics (e.g. level of physical dependence defined by FTCD, number of cigarettes smoked prior to the treatment). This study shows that smokers who are more dependent experience larger post-cessation weight gain. These findings suggest that patients who are at higher risk for weight gain would profit from a weight management program as a part of the smoking cessation program.

Our study has confirmed past findings that the higher the tobacco dependence (defined by FTCD), the larger the weight gain (Chiolero et al., 2007). In addition the higher amount of cigarettes smoked per day (and in turn, higher CO) at baseline predicts the post-cessation weight gain. Incorporating weight management programs or physical activity programs into tobacco dependence treatment for those more

Table 1
Baseline characteristics.

Personal characteristics	Mean (\pm SD) ^a	N (%) ^b	Median (25th;75th) ^a
Gender (N = 607)			
Female		316 (52.1)	
Male		291 (47.9)	
Age at baseline visit (years) (N = 607)	48.2 (\pm 14.3)		50.0 (35.0;59.0)
\leq 39		202 (33.3)	
40–49		100 (16.5)	
50–59		154 (25.4)	
\geq 60		151 (24.9)	
BDI score (N = 397) ^c	9.2 (\pm 8.0)		7.0 (3.0;24.0)
Minimal depression		5 (1.3)	
Mild depression		331 (83.4)	
Moderate depression		13 (3.3)	
Severe depression		48 (12.1)	
FTCD (N = 606)	5.5 (\pm 2.4)		6.0 (4.0;7.0)
0–5		285 (47.0)	
\geq 6		321 (53.0)	
Cigarettes per day (N = 602)	24 (\pm 10.5)		20 (20;40)
\leq 19		124 (20.6)	
20–29		296 (49.2)	
30–39		105 (17.4)	
\geq 40		77 (12.8)	
CO level, ppm (N = 603)	16.1 (\pm 9.9)		16.0 (9.0;22.0)
\leq 7		125 (20.7)	
7–14		157 (26.0)	
14–21		148 (24.5)	
21–28		104 (17.2)	
$>$ 28		69 (11.4)	
Regular smoking initiation age (N = 606)	19 (\pm 5.1)		18.0 (16;26)
\leq 18		338 (55.8)	
\geq 19		268 (44.2)	
Physical activity (N = 606)			
Regularly (more times weekly)		122 (20.1)	
Weekly		108 (17.8)	
Irregularly		116 (19.1)	
Never		260 (42.9)	
Pharmacotherapy used (N = 605) ^d			
Bupropion		54 (8.9)	
Treatment length (months)	5.1 (\pm 4.2)		3.9 (1.2;12.5)
Varenicline		336 (55.5)	
Treatment length (months)	5.0 (\pm 3.5)		4.3 (2.5;12.9)
NRT		268 (44.3)	
Treatment length (months)	4.8 (\pm 5.3)		3.1 (1.4;14.3)
Without therapy		41 (6.8)	

Note. BDI = Beck Depression Inventory; CO = carbon monoxide; FTCD = Fagerström Test of Cigarette Dependence; NRT = nicotine replacement therapy.

^a Continuous variables are described by mean (\pm SD) and median with 25–75 percentiles.

^b Discrete variables are described by number and percentage.

^c BDI is only available for patients entered in 2007 and thereafter. It was not administered to patients early in the program (2005–2006).

^d Each patient could have more than one pharmacotherapy.

dependent can prevent extensive weight gain, as this population has higher risk of it.

Previously published data have suggested that post-cessation weight gain differs according to gender. Female quitters are considered to be at higher risk for weight gain (Croghan et al., 2009; Swan & Carmelli, 1995), although some studies show contrary results (Dale et al., 1998). Our data show a larger percentage of weight gain in female smokers, however absolute weight gain in kilograms does not differ between gender. Conflicting conclusions in previous studies may be explained by differences in methods used for weight gain evaluation.

A larger percentage of weight gain in female smokers was shown also in the ATTEMPT study (Aubin, Berlin, Smadja, & West, 2009), where weight gain of 5% or more was shown in 19% of women and 14% of men. Larger weight gain (measured by self-reported weight gain) was also observed in an earlier study (Williamson et al., 1991). On the other hand, some researchers reported larger weight gain in males compared to females (Dale et al., 1998).

Data from this study did not show any differences between type of pharmacotherapy and weight gain. Although some studies have shown that NRT may attenuate post-cessation weight gain (Allen et al., 2005;

Table 2
Body measurement characteristics.

Characteristics	N	Baseline mean (\pm SD)	1 yr post-quit mean (\pm SD)	Absolute difference (mean; 95% CI)	Relative difference (mean; 95% CI)
Weight	607	79.1 kg (\pm 16.8)	84.2 kg (\pm 17.2)	5.1 kg (4.7;5.5)	6.8% (6.3;7.3)
BMI	607	26.3 kg/m ² (\pm 4.5)	28.1 kg/m ² (\pm 4.8)	1.7 kg/m ² (1.6;1.9)	6.8% (6.3;7.3)
% body fat	270	29.1% (\pm 8.0)	31.9% (\pm 8.0)	2.8% (2.3;3.3)	12.1% (9.7;14.5)
WHR	433	88.1% (\pm 9.7)	90.2% (\pm 9.7)	2.1% (1.5;2.6)	2.6% (2.0;3.2)
Waist circumference	434	92.4 cm (\pm 14.1)	96.9 cm (\pm 14.0)	4.5 cm (3.9;5.1)	5.3% (4.6;6.0)
Hip circumference	433	104.5 cm (\pm 8.0)	107.2 cm (\pm 8.3)	2.7 cm (2.3;3.2)	2.7% (2.3;3.1)

Note. BMI = body mass index; WHR = waist-to-hip ratio.

Table 3
Predictors of weight change from baseline to 1 year.

Predictors	Weight change (kg)		Weight change (% baseline)	
	Mean (\pm SD)	p ^a	Mean (\pm SD)	p ^a
Gender (N = 607)		0.715		0.004
Female (N = 291)	5.2 (\pm 5.1)		7.6 (\pm 7.1)	
Male (N = 316)	5.0 (\pm 5.1)		6.0 (\pm 6.1)	
Age at baseline visit (years) (N = 607)		0.386		0.764
\leq 39 (N = 202)	5.1 (\pm 5.0)		6.8 (\pm 6.6)	
40–49 (N = 100)	5.9 (\pm 5.4)		7.4 (\pm 6.7)	
50–59 (N = 154)	5.0 (\pm 5.0)		6.6 (\pm 6.4)	
\geq 60 (N = 151)	4.8 (\pm 5.0)		6.6 (\pm 6.8)	
BDI score (N = 397)		0.927		0.990
Minimal depression (N = 5)	4.2 (\pm 3.6)		5.8 (\pm 5.6)	
Mild depression (N = 331)	5.0 (\pm 5.3)		6.6 (\pm 6.8)	
Moderate depression (N = 13)	4.6 (\pm 4.1)		6.7 (\pm 5.6)	
Severe depression (N = 48)	4.9 (\pm 3.4)		6.9 (\pm 4.3)	
FTCD (N = 606)		0.003		0.002
0–5 (N = 285)	4.5 (\pm 4.1)		5.9 (\pm 5.5)	
\geq 6 (N = 321)	5.7 (\pm 5.7)		7.5 (\pm 7.4)	
CO level, ppm (N = 603)		0.001		0.001
\leq 7 (N = 125)	3.6 (\pm 4.5)		4.9 (\pm 5.7)	
7–14 (N = 157)	4.8 (\pm 5.0)		6.5 (\pm 6.4)	
14–21 (N = 148)	5.7 (\pm 4.8)		7.5 (\pm 6.3)	
21–28 (N = 104)	5.6 (\pm 5.8)		7.3 (\pm 7.2)	
$>$ 28 (N = 69)	6.5 (\pm 5.3)		8.7 (\pm 7.7)	
Cigarettes per day (N = 602)		$<$ 0.001		0.007
\leq 19 (N = 124)	3.6 (\pm 4.1)		5.1 (\pm 5.8)	
20–29 (N = 296)	5.1 (\pm 4.7)		6.9 (\pm 6.2)	
30–39 (N = 105)	5.8 (\pm 5.3)		7.6 (\pm 6.8)	
\geq 40 (N = 77)	6.5 (\pm 6.7)		7.9 (\pm 8.6)	
Regular smoking initiation age (N = 606)		0.890		0.943
\leq 18 (N = 338)	5.1 (\pm 5.1)		6.8 (\pm 6.8)	
\geq 19 (N = 268)	5.1 (\pm 5.0)		6.8 (\pm 6.5)	
Physical activity (N = 606)		0.008		0.019
Regularly (N = 122)	4.0 (\pm 4.4)		5.7 (\pm 6.4)	
Weekly (N = 108)	4.7 (\pm 4.0)		6.2 (\pm 5.4)	
Irregularly (N = 116)	6.2 (\pm 4.8)		8.3 (\pm 6.7)	
Never (N = 260)	5.3 (\pm 5.7)		6.9 (\pm 7.0)	
Bupropion (N = 605)		0.923		0.760
Yes (N = 54)	5.1 (\pm 5.2)		7.1 (\pm 7.2)	
No (N = 551)	5.1 (\pm 5.1)		6.8 (\pm 6.6)	
Varenicline (N = 605)		0.301		0.376
Yes (N = 336)	5.3 (\pm 5.0)		7.0 (\pm 6.5)	
No (N = 269)	4.9 (\pm 5.2)		6.5 (\pm 6.8)	
NRT (N = 605)		0.156		0.320
Yes (N = 268)	4.8 (\pm 5.1)		6.5 (\pm 6.8)	
No (N = 337)	5.4 (\pm 5.0)		7.0 (\pm 6.4)	

Note. BDI = Beck Depression Inventory; CO = carbon monoxide; FTCD = Fagerström Test of Cigarette Dependence; NRT = nicotine replacement therapy.

^a Differences between categories tested by using analysis of variance.

Farley et al., 2012; Pack et al., 2008; Schnoll et al., 2012), others have not observed any such differences at one year post-quit (Farley et al., 2012).

Physical activity is an important part of a healthy lifestyle. According to recent reviews, physical activity can prevent weight gain after quitting (Farley et al., 2012). In addition, the effect of physical activity continues one-year post-quit. Our data show that the higher the intensity of physical activity at baseline, the smaller the weight gain after quitting, thus confirming current knowledge. We should emphasize its incorporation into smoking cessation programs.

The severity of increased appetite is connected to the post-cessation weight gain (i.e. those with more severe intensity gain more). Our findings are thus consistent with the literature (John et al., 2006). This represents another important situation for action: those expressing more severe appetite increase should be offered a weight management program.

Although weight was recorded at each visit, several limitations related to time and place of measurement could have resulted in measurement inaccuracy. The day time of the measurement differed between patients throughout the data collection. This can cause the divergence. Although the staff was consistent in measuring weight (light clothes only – no

shoes, coats, hats or scarves), the potential for a bias in how patients were measured could have occurred. The weight machine as well as body fat meter were calibrated annually. While individuals were uniformly instructed on how to measure for waist and hip circumference, differences between staff members cannot be discounted. In addition, our study sample included only patients who came for the 12-month follow-up visit and reported continuous abstinence. Facing these facts, selection bias has to be taken into account as well.

As our data are clinical, medication is targeted to the individual. This is the major limitation when looking at the medication. We did not find any significant difference in weight gain after quitting smoking according to the kind of medication. Targeting the pharmacotherapy is therefore required.

5. Conclusion

Smokers who are more dependent and have minimal physical activity are at increased risk for post-cessation weight gain. For these smokers, incorporating interventions targeting the weight issue into tobacco dependence treatment is recommended.

Table 4
Withdrawal symptoms as predictor of weight change ^a.

Predictors	Weight change (kg)		Weight change (% baseline)	
	Mean (±SD)	p ^b	Mean (±SD)	p ^b
Angry, irritable, frustrated		0.305		0.312
Absent (N = 506)	5.0 (±5.1)		6.7 (±6.7)	
Present (N = 99)	5.6 (±5.1)		7.4 (±6.5)	
Anxious, nervous		0.942		0.672
Absent (N = 527)	5.1 (±5.0)		6.8 (±6.4)	
Present (N = 78)	5.1 (±5.4)		7.1 (±7.8)	
Depressed mood, sad		0.864		0.989
Absent (N = 531)	5.1 (±5.0)		6.8 (±6.6)	
Present (N = 74)	5.0 (±5.3)		6.8 (±7.0)	
Desire or craving to smoke		0.709		0.884
Absent (N = 450)	5.2 (±4.8)		6.8 (±6.2)	
Present (N = 155)	5.0 (±5.7)		6.9 (±7.6)	
Difficulty concentrating		0.662		0.428
Absent (N = 529)	5.1 (±4.9)		6.7 (±6.3)	
Present (N = 76)	5.4 (±6.0)		7.4 (±8.5)	
Increased appetite, hungry, weight gain		<0.001		<0.001
Absent (N = 417)	4.5 (±5.0)		6.0 (±6.4)	
Present (N = 188)	6.5 (±4.9)		8.6 (±6.7)	
Restless		0.664		0.476
Absent (N = 563)	5.1 (±5.1)		6.7 (±6.6)	
Present (N = 42)	5.4 (±4.8)		7.5 (±6.3)	
Insomnia, sleep problems, awakening at night		0.700		0.277
Absent (N = 510)	5.1 (±5.0)		6.7 (±6.4)	
Present (N = 95)	5.3 (±5.6)		7.5 (±7.9)	
Impatient		0.692		0.991
Absent (N = 517)	5.2 (±5.0)		6.8 (±6.6)	
Present (N = 88)	4.9 (±5.2)		6.8 (±6.9)	
Constipation		0.561		0.836
Absent (N = 568)	5.1 (±5.1)		6.8 (±6.6)	
Present (N = 37)	4.6 (±5.1)		6.6 (±7.1)	
Dizziness		0.575		0.627
Absent (N = 583)	5.1 (±5.0)		6.8 (±6.6)	
Present (N = 22)	4.5 (±5.6)		6.1 (±7.2)	
Coughing		0.818		0.863
Absent (N = 569)	5.1 (±5.0)		6.8 (±6.6)	
Present (N = 36)	5.3 (±5.7)		7.0 (±7.0)	
Dreaming or nightmares		0.499		0.660
Absent (N = 576)	5.1 (±5.0)		6.8 (±6.5)	
Present (N = 29)	4.5 (±5.9)		6.3 (±9.0)	
Nausea		0.357		0.411
Absent (N = 591)	5.1 (±5.1)		6.8 (±6.6)	
Present (N = 14)	3.9 (±5.2)		5.4 (±6.5)	
Sore throat		0.493		0.695
Absent (N = 588)	5.1 (±5.1)		6.8 (±6.6)	
Present (N = 17)	5.9 (±5.1)		7.4 (±6.6)	

^a Withdrawal symptoms were not recorded in 2 patients.

^b Differences between categories tested by using analysis of variance.

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Contributors

Authors AK and EK designed the study and wrote the protocol. Authors AK, EK, LS, KZ, and ITC conducted literature searches and provided summaries of previous research studies. Authors MB, MS, ZB, and DRS conducted the statistical analysis. Authors AK, EK, and ITC wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

Conflict of interest

The authors have no conflicts of interest and/or financial disclosures to declare.

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