BRIEF REPORT

Smoking Cessation and Subsequent Weight Change

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ABSTRACT

Introduction: People who quit smoking tend to gain more weight over time than those who continue to smoke. Previous research using clinical samples of smokers suggests that quitters typically experience a weight gain of approximately 5 kg in the year following smoking cessation, but these studies may overestimate the extent of weight gain in the general population. The existing population-based research in this area has some methodological limitations.**Methods:** We assessed a cohort of individuals born in Dunedin, New Zealand, between 1972–1973 at regular intervals from age 15 to 38. We used multiple linear regression analysis to investigate the association between smoking cessation at ages 21 years to 38 years and subsequent change in body mass index (BMI) and weight, controlling for baseline BMI, socioeconomic status, physical activity, alcohol use, and parity (women).**Results:** Smoking status and outcome data were available at baseline and at follow-up for 914 study members. People who smoked at age 21 and who had quit by age 38 had a BMI on average 1.5 kg/m² greater than those who continued to smoke at age 38. This equated to a weight gain of approximately 5.7 kg in men and 5.1 kg in women above that of continuing smokers. However, the weight gain between age 21 and 38 among quitters was not significantly different to that of never-smokers.**Conclusions:** The amount of long-term weight gained after quitting smoking is likely to be lower than previous estimates based on research with clinical samples. On average, quitters do not experience greater weight gain than never-smokers.

INTRODUCTION

It is well established that smoking is associated with body weight. Smokers tend to weigh less than never-smokers, and former smokers weigh more than current smokers (Flegal, Troiano, Pamuk, Kuczmarski, & Campbell, 1995; Travier et al., 2009). Concern about weight gain following smoking cessation may deter smokers from attempting to quit (Pomerleau, Zucker, & Stewart, 2001) and actual weight gain could increase the likelihood of relapse (Pisinger & Jorgensen, 2007). A recent meta-analysis suggested that quitting led to a gain of around 5 kg in the year following cessation (Aubin, Farley, Lycett, Lahmek, & Aveyard, 2012). Some longitudinal research suggests that quitters gain 6.5–9 kg within 8 years after cessation (Lycett, Munafò, Johnstone, Murphy, & Aveyard, 2011; O'Hara et al., 1998). However, data in these studies were drawn from clinical trials, and since smokers presenting for cessation treatment differ from those in the general population (Fernández & Chapman, 2012), the generalizability of these findings is limited.

In the general population of smokers, the rate of weight gain directly after cessation may attenuate in the long term (Flegal

et al., 1995; Reas, Nygård, & Sørensen, 2009; Williamson et al., 1991). Population-based studies indicate that quitters gain about 2–3 kg more than those who continue to smoke over a period of 2–5 years (Kamaura, Fujii, Mizushima, & Tochikubo, 2011; Travier et al., 2012; U.S. Department of Health and Human Services, 1990), and 2.5–5 kg more than smokers over 10 years (Flegal et al., 1995; Reas et al., 2009; Williamson et al., 1991). Body mass indices (BMIs) of quitters have been found to be around 1.4–1.6 kg/m² higher than smokers at least 14 years after cessation (Munafò, Tilling, & Ben-Shlomo, 2009; Owen-Smith & Hannaford, 1999). Only a small number of studies have examined weight change among quitters in relation to never-smokers, with conflicting results. Some indicate that quitters do not gain significantly more weight than never-smokers in the long term (Reas et al., 2009; Travier et al., 2012), while others suggest that quitters gain significantly more weight than never-smokers (Basterra-Gortari et al., 2010; Flegal et al., 1995).

The existing longitudinal research has a number of important weaknesses, including the inability to control adequately for baseline BMI (Owen-Smith & Hannaford, 1999; Reas et al.,

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2009), and reliance on self-reported or retrospective reports of weight (Basterra-Gortari et al., 2010; Flegal et al., 1995; Owen-Smith & Hannaford, 1999; Reas et al., 2009; Travier et al., 2012) or smoking status (Flegal et al., 1995; Williamson et al., 1991). Some findings may have limited generalizability to the general population of smokers since cohorts were drawn from health service users (Owen-Smith & Hannaford, 1999; Travier et al., 2012) or university graduates (Basterra-Gortari et al., 2010), hence the need for further research (Fernández & Chapman, 2012).

We examine data from the Dunedin Multidisciplinary Health and Development Study, a longitudinal study of health and behavior in a New Zealand (NZ) birth cohort. We compare changes in weight following smoking cessation relative to continuing smokers and to never-smokers.

METHODS

Participants

Study participants belonged to a cohort born in Dunedin, NZ, between 1972 and 1973 (Hancox, Milne, & Poulton, 2004). The base sample for the study was 1,037 children (91% of eligible births; 52% male) who participated in the first follow-up assessment at age 3. Assessments were conducted at 2-year intervals until age 15, then at age 18, 21, 26, 32, and 38. The follow-up rates in this study (as percentage of surviving study members) were as follows: 96% at ages 15 and 18 years, 97% at age 21 years, 96% at age 26, 96% at age 32, and 95% at age 38. Study members represented the full range of socioeconomic status (SES) in the South Island of NZ. Approximately 90% of study members identify as NZ European; the sample is comparable with other population-based samples from Western societies (Poulton et al., 2006). Written informed consent was obtained for each assessment. The study was approved by the Otago Ethics Committee.

Measures

Smoking Status

Previous analysis of data from this cohort indicated the prevalence of daily smoking was 35% at age 21 years, with few smokers having quit before age 21 (McGee et al., 2013). Therefore, smoking at age 21 years was identified as the baseline for examining quitting. Study members were categorized as (a) continuous smokers (reported being a current smoker at both the age 21 and age 38 assessments); (b) quitters (reported being current smoker at age 21 and an ex-smoker at age 38), or (c) never-smokers (reported having never smoked for as long as a year and having smoked less than 20 packs of cigarettes in a lifetime at both age 21 and age 38 assessments). We defined current smoking as smoking daily for at least 1 month in the previous year (Hancox et al., 2004).

Weight and height have been measured at each assessment using calibrated scales (Landhuis, Poulton, Welch, & Hancox, 2008). BMI (kg/m^2) and weight (kg) at age 38 were the outcome measures. BMI and weight at age 18 were baseline measures.

SES of study members' families according to the highest parental occupation on a 6-point scale, based on the educational level and income associated with that occupation in

the NZ census (Elley & Irving, 1972) as previously reported (Hancox et al., 2004).

Physical activity at baseline (age 18) was assessed by a modified version of the Minnesota Leisure Time Physical Activity Questionnaire (Reeder, Stanton, Langley, & Chalmers, 1991). At age 38, physical activity during the 7 days prior to the assessment was assessed through participant interview, and the total hours spent on all physical activities was used as follow-up measure.

Alcohol consumption was assessed at baseline (age 21) and at 38 years via self-report of annual frequency of consuming five or more drinks on a single occasion.

Parity between age 21 and 38 was included as a dichotomous variable in the analyses for female study members (van Roode, Dickson, Sharples, & Paul, 2012).

Statistical Analyses

Multiple linear regression was used to test associations between smoking status and changes in BMI (kg/m^2) and weight (kg), controlling for the covariates above. We examined differences in outcomes between quitters and continuous smokers, and between quitters and never-smokers. All analyses were first performed for the cohort as a whole and then separately by sex. The assumptions for the application of multiple linear regression were checked, and log-transformation of BMI values and exclusion of outliers were performed to improve the fit of the model.

RESULTS

Smoking status and outcome data were available at baseline and follow-up for $N = 914$ study members ($N = 456$ women; $N = 458$ men). Approximately 22% ($N = 203$) were continuous smokers; 14% ($N = 130$) were quitters, and around 60% ($N = 546$) were never-smokers. A proportion of smokers at age 38 began smoking after the age 21 assessment ($N = 35$); these were excluded due to their small number.

The mean BMI of continuous smokers increased by $3.1 \text{ kg}/\text{m}^2$ between baseline and follow-up, while that of quitters increased $3.6 \text{ kg}/\text{m}^2$ and never-smokers $3.4 \text{ kg}/\text{m}^2$, as shown in Figures 1 and 2.

After adjusting for sex, baseline BMI, SES, physical activity at baseline and follow-up, and alcohol consumption at baseline and follow-up, quitters had a BMI on average $1.5 \text{ kg}/\text{m}^2$ higher than continuous smokers (95% CI = 0.4–2.5). When the analyses were performed separately by sex, the results were similar for men and women. The fully adjusted BMI increase among quitters equated to an average weight gain of 5.7 kg (95% CI = 1.5–9.8) for men and 5.1 kg (95% CI = 0.8–9.3) for women, greater than continuous smokers. Compared with the never-smokers, there was no statistically significant difference in BMI (or weight) at follow-up for the quitters (unstandardized beta = $0.02 \text{ kg}/\text{m}^2$, 95% CI = -0.90 to 0.94 , $p = .97$). This analysis was also performed separately by sex, with similar results for men and women. We reran the regression analyses with log-transformed BMI, excluding five outliers with BMIs greater than $35 \text{ kg}/\text{m}^2$ at age 18. This improved the distribution of the residuals versus the fitted values but made no difference to the results in terms of effect size or statistical significance.

Figure 1. Body mass index (BMI) among male study members, from ages 15 to 38 years, by smoking category.

Figure 2. Body mass index (BMI) among female study members, from ages 15 to 38 years, by smoking category.

DISCUSSION

In this cohort, continuous smokers experienced an average BMI gain of 3.1 kg/m^2 between ages 21 and 38, while quitters gained an average 3.6 kg/m^2 and never-smokers 3.4 kg/m^2 . After adjusting for a range of confounding factors, quitters experienced an increase in BMI of around 1.5 kg/m^2 over and above that of continuous smokers over the 17-year period. This increase was similar for male and female quitters, and represented a weight gain of around 5kg more than smokers' weight gain. Importantly, however, we found that these quitters did not gain additional weight compared with people who had never smoked.

Our findings suggest that persistent smokers gain less weight in early adulthood compared with quitters and never-smokers. However, the long-term weight gain associated with

quitting smoking appears to be lower than has been previously indicated by research with clinical samples (Aubin et al., 2012; Lycett et al., 2011; O'Hara et al., 1998). Our results are consistent with population-based studies, which report that quitters tend to gain around 3–5 kg or increase their BMI by around 1.5 kg/m^2 , more than continuing smokers over a long-term period (Flegal et al., 1995; Munafò et al., 2009; Owen-Smith & Hannaford, 1999; Reas et al., 2009; Williamson et al., 1991). Previous research has produced inconsistent findings with regard to whether quitters gain more weight over time than never-smokers. We found that the weight gain among quitters over the follow-up period did not differ significantly to that among never-smokers, a finding that is consistent with evidence from some European research (Reas et al., 2009; Travier et al., 2012).

An important strength of this research is the low rate of attrition throughout the study, with over 90% of the original cohort participating in each assessment between 18 and 38 years old. In contrast to earlier studies, we did not have to rely on retrospective reports of smoking, and weight and height were measured objectively rather than self-reported. Therefore, the likelihood that our results could be explained by a systematic bias arising from measurement error, or by selection bias, seems low. We were also able to control for a range of possible confounders, and in particular, controlling for baseline BMI/weight has addressed a criticism of previous research (Fernández & Chapman, 2012). As with any observational research, it remains plausible that unmeasured confounding may have affected the observed association. A limitation of this study is that we do not know the exact age at which quitters may have stopped smoking between baseline and follow-up years, and it is likely that at follow-up some of the cohort were very recent quitters and/or intermittent smokers. It is plausible this resulted in an underestimation of the weight gain associated with cessation. However, a supplementary analysis comparing study members who had stopped smoking at age 32 and 38 ($N = 60$) with those who were still smoking at 32 but had quit by age 38 ($N = 70$) found no significant differences in BMI gain between these subgroups. Furthermore, the consistency of our results with other population-based longitudinal research provides confidence in the size of the associations we have reported.

This research has important implications for smoking cessation practice. Smokers can be advised that initial weight gain following cessation is unlikely to continue at the same rate in the long term and that their average gain will not exceed that which would have occurred if they had not started smoking. The BMI increase of 1.5 kg/m^2 among quitters in our cohort would appear unlikely to offset the health benefits associated with quitting: A U.S. study found that even with a substantially lower average BMI, normal-weight smokers had significantly higher overall risk of mortality compared with overweight or obese former smokers (Siahpush et al., 2013).

People who quit smoking tend to gain a moderate amount of weight compared with continuing smokers, though do not appear to experience greater weight gain than never-smokers. The extent of weight gain following smoking cessation among smokers in the general population is likely to be lower than previous estimates based on research with clinical samples.

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DECLARATION OF INTERESTS

None declared.

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