Alcohol drinking in one's thirties and forties is associated with body mass index in men, but not in women: a longitudinal analysis of the 1970 British Cohort Study

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Abstract

Background: More longitudinal research with repeated measurements is required to understand independent associations of alcohol drinking with body mass index (BMI).

Objective: The objective was to investigate associations between alcohol drinking and BMI in four waves of the 1970 British Cohort Study.

Design: Alcohol drinking (exposure), BMI (outcome), smoking habit, occupation, longstanding illness, and leisure time physical activity (potential confounders) were assessed at ages 30, 34, 42, and 46. Multilevel models were fitted, and all variables were time varying.

Results: There were 15,708 observations in 5,931 men and 14,077 observations in 5,656 women. According to the regression coefficients, BMI was expected to increase by 0.14 (95% confidence interval: 0.13, 0.15) kg/m^2 per year in men. Alcohol drinking was associated with BMI in men. For example, BMI was expected to increase by 0.36 (0.11, 0.60) kg/m^2 per year in men who drank once a week and by 0.40 (0.14, 0.15) kg/m^2 per year in men who drank most days. In ten years, BMI was expected to increase by 5.4 kg/m^2 in men who drank and by 2.9 kg/m^2 in men who drank and were physically active. BMI was expected to increase by 0.18 (0.17, 0.19) kg/m^2 per year in women. Alcohol drinking was not associated with BMI in women. Rather, BMI was expected to increase by 0.25 (0.07, 0.43) kg/m^2 per year in women who were former smokers. In ten years, BMI was expected to increase by 4.3 kg/m^2 in women who were former smokers and by 0.8 kg/m^2 in women who were former smokers and who were physically active. Similar results were observed after adjustment for problematic drinking.

Conclusions: The use of multilevel models with time varying variables helps to clarify independent associations. The present study suggests that alcohol drinking is associated with BMI in men, but not in women.

Keywords: Alcohol Drinking; Body Mass Index; Overweight; Obesity; Weight Gain; Adult; Men; Women.

Introduction

Body mass index (BMI) is associated with morbidity and mortality (1, 2). In the latest UK Government policy paper on tackling obesity, it was announced that the government wanted to make companies add calorie labels to alcoholic drinks so that consumers might make healthier choices (3). However, it is not clear that alcohol drinking is associated with obesity (4, 5). Tackling obesity is a complex process (6) and more longitudinal research is required to understand independent associations of alcohol drinking with obesity (4, 5). Most longitudinal studies are relatively crude insomuch as alcohol drinking was only assessed at baseline (7-11). Alcohol drinking (12) and BMI (13) may vary with time. Potential confounders may also vary with time, including smoking habit (14), socioeconomic status (15), longstanding illness (16), and leisure time physical activity (17). Therefore, a longitudinal analysis with repeated measurements would provide a better understanding of the independent associations of alcohol drinking with obesity (12). The 1970 British Cohort study is a longitudinal study with repeated measurements of alcohol drinking, BMI, smoking habit, socioeconomic status, longstanding illness, and leisure time physical activity (18, 19). The objective of the present study is to investigate independent associations of alcohol drinking with BMI in four waves of the 1970 British Cohort Study.

Subjects and Methods

Participants

The 1970 British Cohort Study consists of people born in England, Scotland and Wales during a single week in 1970 and is described in detail elsewhere (18, 19). The present analysis included data from the age 30 survey (1999-2000), age 34 survey (2004-2005), age 42 survey (2012-2013), and age 46 survey (2016-2018) (19). Participants were interviewed face to face at the age 30 and age 34 surveys. Participants were interviewed face to face and were asked to complete a questionnaire at the age 42 and age 46 surveys. The interviewer transcripts and the self-completion questionnaires used in the 1970 British Cohort Study are available online (19). Local research ethics committees approved each survey and participants provided informed consent [for example, the most recent survey, the age 46 survey, was approved by NRES Committee South East Coast – Brighton & Sussex (Ref 15/LO/1446)].

Exposure

Alcohol drinking was assessed face to face at the age 30, age 34, and age 46 surveys using computer aided personal interviewing. Alcohol drinking was assessed by means of a self-completion questionnaire at the age 42 survey. At the age 30 and age 34 surveys, participants were asked: How often do you have an alcoholic drink of any kind? The answers included: on most days; two to three days a week; once a week; two to three times a month; less often or only on special occasions; and, never

nowadays or never had an alcoholic drink. At the age 42 and age 46 surveys, participants were asked: How often do you have a drink containing alcohol? The answers included: never; monthly or less; two to four times a month; two to three times a week; and, four or more times a week. Five alcohol drinking categories were assumed in the present study: nondrinker, less than once a week, once a week, two to three days a week, most days (Supplemental Table 1). Self-reported alcohol use is correlated with biochemical measures of drinking, albeit heavy drinking (20, 21).

Outcome

Body mass index (kg/m^2) was derived from self-reported height and weight at the age 30, age 34, and age 42 surveys. Body mass index was derived from nurses' measurements of height and weight at the age 46 survey. The correlation between BMI based on self-reported data and BMI based on nurses' measurements at age 46 was 0.88 ($p<0.001$, n=7,124). Body mass index values greater than 75 were deemed to be dubious and were not included in the present analysis. Changes in BMI from one wave to the next greater than five times the standard deviation were also deemed dubious and were not included.

Confounding variables

Analyses were adjusted for variables that may be related to both the exposure and the outcome, including smoking habit (22, 23), socioeconomic status (24, 25), longstanding illness (16, 26), and leisure time physical activity (5, 23). Participants were asked about their smoking habit at every wave and three categories were

derived: never smoked, former smoker, and current smoker. Socioeconomic status was derived from occupations. Participants were asked about their occupation at every wave and three categories were derived: managerial or professional, skilled or semi-skilled, and unskilled. Participants were asked about longstanding illness at every wave and two categories were derived: no and yes. At the age 30 and age 34 surveys, participants were asked about longstanding illness, disability or infirmity defined as anything that has troubled them over a period of time, or that is likely to affect them over a period of time. At the age 42 and age 46 surveys, participants were asked: Do you have any physical or mental health conditions or illnesses lasting or expected to last 12 months or more? Leisure time physical activity habit was assessed during interviews at every wave. The participant was shown a card stating: Take part in competitive sport of any kind; Go to 'keep fit' or aerobics classes; Go running or jogging; Go swimming; Go cycling; Go for walks; Take part in water sports; Take part in outdoor sports; Go dancing; Take part in any other sport or leisure activity which involves physical exercise. The participant was then asked: Do you regularly take part in any of the activities on this card (by regularly, I mean at least once a month, for most of the year)? If the participant said yes, they were then asked how often: every day; four to five days a week; two to three days a week; once a week; two to three times a month; less often. Those who reported leisure time physical activity at least once a week were deemed to be physically active in the present study because taking part in one or two bouts of exercise per week is associated with considerable health benefits (27, 28).

Problematic drinking

Analyses were further adjusted for problematic drinking. At ages 30 and 34, the cutting down, being annoyed by criticism, feeling guilty, and eye-openers (CAGE) questionnaire was used to assess problematic drinking (29). Problematic drinking was defined as two or more affirmative replies to four questions (29): Have you ever felt that you ought to cut down on your drinking? Have people annoyed you by criticizing your drinking? Have you ever felt bad or guilty about your drinking? Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover? The CAGE questionnaire is regarded as a valid screening tool in general practice (29). At ages 42 and 46, cohort members were asked the five questions that make up the Alcohol Use Disorders Identification Test for Primary Care (AUDIT-PC): how often do you have a drink containing alcohol? (never scores 0; monthly or less scores 1; two to four times a month scores 2; two to three times a week scores 3; four or more times a week scores 4); how many drinks containing alcohol do you have on a typical day when you are drinking? (one to two scores 0; three to four scores 1; five to six scores 2; seven to nine scores 3; ten or more scores 4); how often in the last year have you found that you were not able to stop drinking once you started? (never scores 0; less than monthly scores 1; monthly scores 2; weekly scores 3; daily or almost daily scores 4); how often during the last year have you failed to do what was normally expected from you because of your drinking? (never scores 0; less than monthly scores 1; monthly scores 2; weekly scores 3; daily or almost daily scores 4); has a relative or friend, doctor or other health worker been concerned about your drinking and suggested that you cut down? (no scores 0; yes, but not in the last year scores 2; yes, during the last year scores 4). Total AUDIT-PC

scores of 0-4 were considered unproblematic drinking and total scores of five or more were considered problematic drinking. The ten-question alcohol use disorders identification test and shorter versions are regarded as valid screening tools for the detection of alcohol use disorder in the general population when compared with the criterion measure, the Diagnostic and Statistical Manual of Mental Disorders (30-32).

Statistics

All analyses were performed using Stata MP version 15.1 for Mac (StataCorp, Texas, USA). The *mixed* command was used to fit multilevel models to the longitudinal data. All the available data were used and all variables were time varying: the models included alcohol drinking (exposure), BMI (outcome), smoking habit, occupation, longstanding illness, and leisure time physical activity (potential confounders) at ages 30, 34, 42, and 46. Linear models that allowed for random slopes and intercepts best fitted the BMI scores. Such models reduced the residual variance by more than 30% compared with other linear and quadratic models. Body mass index was treated as a continuous variable and all other variables as categorical. The measure of time was years and the regression coefficient for each variable shows the expected change in BMI per year. The postestimation commands, *margins* and *marginsplot*, were used to create the figures showing associations between exposure and outcome between age 30 and age 46.

Results

Figure 1 shows participant flow. Data from more than three quarters of cohort members were used in the present study at age 30, age 34, and age 46, when alcohol drinking was assessed face to face. Data from two thirds of cohort members were used at age 42, when alcohol drinking was assessed by means of a self-completion questionnaire. Alcohol drinking frequency was not stated by 95 cohort members and the questionnaire was not received from 1,107 cohort members at age 42. All the available data were used in the multilevel models, whether from the minimum of one wave or from the maximum of four waves. **Table 1** shows male participants' characteristics. Less than five percent of men were nondrinkers in their thirties and less than ten percent were nondrinkers in their forties. The most common alcohol drinking frequency was 2-3 days a week. Body mass index increased with age. The proportion of men in managerial and professional occupations, the proportion of men with longstanding illness, and the proportion of men who were physically active also increased with age. The proportion of men who smoked decreased with age. Around 20% of men screened positive for problematic drinking in their thirties according to the CAGE questionnaire and around 30% screened positive in their forties according to the AUDIT-PC questionnaire. **Table 2** shows female participants' characteristics. Around six percent of women were nondrinkers in their thirties and around ten percent were nondrinkers in their forties. The most common alcohol drinking frequencies were less than once a week, once a week, and 2-3 days a week. Body mass index increased with age. The proportion in managerial and professional occupations and the proportion with longstanding illness increased from women in their thirties to women in their forties. The proportion of women who

were physically active was similar with age. The proportion of women who smoked decreased with age. Less than 15% of women screened positive for problematic drinking in their thirties according to the CAGE questionnaire and less than 20% screened positive in their forties according to the AUDIT-PC questionnaire. **Supplemental Table 2** shows alcohol drinking frequency in cohort members who were and were not included in the present analysis. Alcohol drinking frequency tended to be higher in those who were included in the present analysis than those who were not.

Table 3 shows longitudinal associations between alcohol drinking and BMI in men. The multilevel model included 15,708 observations nested in 5,931 men. Each category of alcohol drinking frequency was positively associated with BMI. The magnitude of the association between alcohol drinking frequency and BMI was similar for each category. For example, BMI was expected to increase by 0.36 (95% confidence interval: 0.11, 0.60) kg/m^2 per year in men who drank once a week and by 0.40 (0.14, 0.15) kg/m^2 per year in men who drank most days. Longstanding illness was also positively associated with BMI. Current smoking and leisure time physical activity were negatively associated with BMI. Similar results were observed after further adjustment for problematic drinking **(Supplemental Table 3).**

Table 4 shows longitudinal associations between alcohol drinking and BMI in women. The multilevel model included 14,077 observations nested in 5,656 women. There were no statistically significant associations between alcohol drinking and BMI. Rather, being a former smoker was positively associated with BMI and being a current smoker was negatively associated with BMI. Indeed, BMI was expected to

increase by 0.25 (0.007, 0.43) kg/m^2 per year in women who were former smokers. Skilled or semi-skilled occupation and longstanding illness were positively associated with BMI. Leisure time physical activity was negatively associated with BMI. Similar results were observed after further adjustment for problematic drinking **(Supplemental Table 4).**

Supplemental Figure 1 shows associations between smoking habit and BMI between age 30 and age 46. In men, BMI trajectories were parallel and significantly lower in current smokers than former smokers and those who never smoked. In women, BMI trajectories were parallel and significantly higher in former smokers and significantly lower in current smokers than those who never smoked. **Supplemental Figure 2** shows associations between leisure time physical activity and BMI between ages 30 and 46. In men and women, BMI trajectories were parallel and significantly lower in those who were active at least once a week than those who were not.

Discussion

The objective of the present study was to investigate associations between alcohol drinking and BMI in the longitudinal study, the 1970 British Cohort Study. Alcohol drinking, BMI and potential confounding variables were assessed during four waves of the longitudinal study: age 30, age 34, age 42, and age 46. All variables were time varying and the main findings were that alcohol drinking was associated with BMI in men, but not in women. Similar results were observed after further adjustment for problematic drinking. The magnitude of the association between alcohol drinking frequency and BMI in men was similar for each category, from less than once a week to most days. Tackling obesity is a complex process (6) and the present study suggests that longstanding illness is positively associated with BMI and that cigarette smoking and leisure time physical activity are negatively associated with BMI in men and women.

Longitudinal studies with repeated measurements are needed to provide a better understanding of the independent associations of alcohol drinking with obesity (12). However, alcohol drinking was only assessed at baseline in most longitudinal studies (7-11). Observations are correlated in longitudinal studies with repeated measurements, and multilevel (or “mixed”) models should be used to analyse such correlated data (12, 33). To the best of our knowledge, there is only one other study in which the association of alcohol drinking with obesity was assessed while accounting for within-person correlations (23). Mozaffarian and colleagues assessed alcohol drinking on more than one occasion in 22,557 men followed for 20 years, 50,422 women followed for 20 years, and 47,898 women followed for 12 years in the

United States (23). Changes in weight were evaluated at 4-year intervals and analyses were adjusted for potential confounders (23). Within each 4-year period, the reported association between alcohol and weight was 0.19 (0.10, 0.27) kg per drink per day (23). Like the present study, current smoking and leisure time physical activity were inversely associated with weight gain (23). Unlike the present study in the United Kingdom, alcohol drinking was associated with weight gain in men and women (23).

According to the regression coefficients in the present study, BMI was expected to increase by 0.14 kg/m^2 per year in men and by a further 0.4 kg/m^2 per year in men who drank less than once a week, once a week, 2-3 days a week, or most days; there was no dose-response relationship between alcohol drinking frequency and BMI in men. In ten years, BMI was expected to increase by around 5.4 kg/m^2 in men who drank [(0.14*10) + (0.4*10) = 5.4]. The increase in BMI was expected to be less in men who were physically active in their leisure time. In ten years, BMI was expected to increase by around 2.9 kg/m^2 in men who drank and were physically active [(0.14*10) + (0.4*10) + (-0.25*10) = 2.9]. Body mass index was expected to increase by around 0.18 kg/m^2 per year in women and by a further 0.25 kg/m^2 per year in women who were former smokers. In ten years, BMI was expected to increase by around 4.3 kg/m^2 in women who were former smokers [(0.18*10) + (0.25*10) = 4.3]. The increase in BMI was expected to be less in women who were physically active in their leisure time. In ten years, BMI was expected to increase by around 0.8 kg/m^2 in women who were former smokers and who were physically active [(0.18*10) + (0.25*10) + (-0.35*10) = 0.8]. These findings may have implications for policy makers. Alcohol drinking is important to the social fabric of

many human societies (34) and it is unrealistic to expect adults to abstain in liberal societies (35). It is possible to increase community levels of physical activity with bold policies and large interventions (36, 37) and there should be more emphasis on physical activity in the UK government's strategy to tackle obesity (3). In particular, physical activity policies and interventions should be targeted at men who drink and at women who wish to give up smoking because most smokers gain weight after quitting (38).

This study has some possible limitations. Self-reported variables are subject to biases. The apparent lack of a dose-response relationship between alcohol drinking frequency and BMI may be due to recall bias. It is also possible that alcohol-based calories replace food-based calories in moderate drinkers without increasing total energy intake, although more research is required to test this notion (8, 39). The main analysis was not adjusted for alcohol drinking volume per se, but the secondary analysis was adjusted for problematic drinking and the CAGE and AUDIT-PC questionnaires include questions about excess drinking. The analyses were not adjusted for alcohol drink type, but alcohol drink type probably has little impact on BMI (4). In men, for example, BMI is around 0.2 kg/m^2 higher in those who drink beer and around 0.3 kg/m^2 lower in those who drink white wine compared with those who never drink each type of alcoholic drink (4). In women, BMI is around 0.1 kg/m^2 higher in those who drink beer and around 0.6 kg/m^2 lower in those who drink white wine compared with those who never drink each type of alcoholic drink (4). Diet was not assessed using consistent methods in the 1970 British Cohort Study; however, it is not clear that diet is associated with both alcohol drinking and BMI (8, 23, 40, 41). There were some questions about diet in the age 30 wave of the 1970 British Cohort

Study and correlations of fruit and vegetable consumption with alcohol drinking and BMI are shown in **Supplemental Table 5**. The correlations were weak and the associations were counterintuitive. For example, there were positive correlations between vegetable consumption and alcohol drinking and negative correlations between vegetable consumption and BMI.

In conclusion, this study suggests that alcohol drinking is associated with BMI in men, but not in women. Body mass index is expected to increase every year in men and to increase further in men who drink. However, BMI is expected to increase less in men who drink and are physically active in their leisure time. Body mass index is expected to increase every year in women and to increase further in women who were former smokers. However, BMI is expected to increase much less in women who are former smokers and are physically active in their leisure time.

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Table 1. Male participants' characteristics

Variable		Wave			
		Age 30 (n=4,730)	Age 34 (n=4,155)	Age 42 (n=3,334)	Age 46 (n=3,489)
Alcohol drinking frequency, No. (%)					
	Nondrinker	165 (3.49)	178 (4.28)	200 (6.00)	282 (8.08)
	Less than once a week	843 (17.82)	711 (17.11)	474 (14.22)	490 (14.04)
	Once a week	975 (20.61)	777 (18.70)	787 (23.61)	841 (24.10)
	2-3 days a week	1,898 (40.13)	1,557 (37.47)	1,146 (34.37)	1,199 (34.37)
	Most days	849 (17.95)	932 (22.43)	727 (21.81)	677 (19.40)
Body mass index (kg/m^2), mean±SD		25.61±3.99	26.58±4.28	27.43±4.45	28.02±4.76
Smoking, No. (%)					
	Never smoked	2,069 (43.74)	1,860 (44.77)	1,604 (48.11)	1,662 (47.64)
	Former smoker	885 (18.71)	964 (23.20)	953 (28.58)	1,134 (32.50)
	Current smoker	1,776 (37.55)	1,331 (32.03)	777 (23.31)	693 (19.86)

Occupation, No. (%)					
	Managerial or professional	2,003 (42.35)	1,951 (46.96)	1,778 (53.33)	1,888 (54.11)
	Skilled or semi-skilled	2,632 (55.64)	2,093 (50.37)	1,484 (44.51)	1,316 (37.72)
	Unskilled	95 (2.01)	111 (2.67)	72 (2.16)	285 (8.17)
Longstanding illness, No. (%)					
	No	3,752 (79.32)	3,086 (74.27)	2,563 (76.87)	2,446 (70.11)
	Yes	978 (20.68)	1,069 (25.73)	771 (23.13)	1,043 (29.89)
Leisure time physical activity, No. (%)					
	No	1,373 (29.03)	1,257 (30.25)	731 (21.93)	658 (18.86)
	Yes	3,357 (70.97)	2,898 (69.75)	2,603 (78.07)	2,831 (81.14)
Problematic drinking, No. (%)					
	No	3,814 (80.63)	3,231 (77.76)	2,209 (66.26)	2,408 (69.02)
	Yes	916 (19.37)	924 (22.24)	1,125 (33.74)	1,081 (30.98)

Table 2. Female participants' characteristics

Variable	Wave			
	Age 30 (n=4,127)	Age 34 (n=3,573)	Age 42 (n=3,157)	Age 46 (n=3,220)
Alcohol drinking frequency, No. (%)				
Nondrinker	251 (6.08)	213 (5.96)	271 (8.58)	348 (10.81)
Less than once a week	1,250 (30.29)	1,053 (29.47)	736 (23.31)	717 (22.27)
Once a week	996 (24.13)	746 (20.88)	818 (25.91)	766 (23.79)
2-3 days a week	1,224 (29.66)	1,088 (30.45)	938 (29.71)	1,010 (31.37)
Most days	406 (9.84)	473 (13.24)	394 (12.48)	379 (11.77)
Body mass index (kg/m^2), mean±SD	24.15±4.61	25.07±4.93	26.05±5.30	27.27±6.01
Smoking, No. (%)				
Never smoked	2,000 (48.46)	1,707 (47.77)	1,597 (50.59)	1,589 (49.35)
Former smoker	802 (19.43)	865 (24.21)	918 (29.08)	1,028 (31.93)
Current smoker	1,325 (32.11)	1,001 (28.02)	642 (20.34)	603 (18.73)

Occupation, No. (%)					
	Managerial or professional	1,653 (40.05)	1,661 (46.49)	1,591 (50.40)	1,557 (48.35)
	Skilled or semi-skilled	2,387 (57.84)	1,855 (51.92)	1,511 (47.86)	1,488 (46.21)
	Unskilled	87 (2.11)	57 (1.60)	55 (1.74)	175 (5.43)
Longstanding illness, No. (%)					
	No	3,253 (78.82)	2,652 (74.22)	2,314 (73.30)	2,098 (65.16)
	Yes	874 (21.18)	921 (25.78)	843 (26.70)	1,122 (34.84)
Leisure time physical activity, No. (%)					
	No	1,221 (29.59)	952 (26.64)	944 (29.90)	839 (26.06)
	Yes	2,906 (70.41)	2,621 (73.36)	2,213 (70.10)	2,381 (73.94)
Problematic drinking, No. (%)					
	No	3,803 (92.15)	3,068 (85.87)	2,613 (82.77)	2,682 (83.29)
	Yes	324 (7.85)	505 (14.13)	544 (17.23)	538 (16.71)

Table 3. Longitudinal associations of alcohol drinking and other variables with body mass index in men

Variable		Coefficient (95% confidence interval)
Alcohol drinking		
	Nondrinker	Reference
	Less than once a week	0.39 (0.15, 0.64)
	Once a week	0.36 (0.11, 0.60)
	2-3 days a week	0.38 (0.13, 0.63)
	Most days	0.40 (0.14, 0.66)
Time, per year		0.14 (0.13, 0.15)
Smoking		
	Never smoked	Reference
	Former smoker	-0.06 (-0.21, 0.09)
	Current smoker	-0.61 (-0.77, -0.45)
Occupation		
	Managerial or professional	Reference
	Skilled or semi-skilled	-0.01 (-0.12, 0.09)
	Unskilled	0.13 (-0.10, 0.36)
Longstanding illness		
	No	Reference
	Yes	0.20 (0.10, 0.30)

Leisure time physical activity		
	No	Reference
	Yes	-0.25 (-0.34, -0.16)

Values are mutually adjusted regression coefficients, showing the expected change in BMI per year. In this table, for example, BMI is expected to increase by 0.4 (0.14, 0.66) kg/m^2 per year in men who drink alcohol most days. We used a linear model that allowed for random intercepts and random slopes. Variables were assessed at age 30, age 34, age 42 and age 46 and all variables in the model are time varying. Model includes 15,708 observations nested in 5,931 male cohort members. The average number of observations per cohort member was 2.6, where the minimum was 1 and the maximum was 4.

Table 4. Longitudinal associations of alcohol drinking and other variables with body mass index in women

Variable		Coefficient (95% confidence interval)
Alcohol drinking		
	Nondrinker	Reference
	Less than once a week	0.05 (-0.17, 0.27)
	Once a week	-0.13 (-0.36, 0.11)
	2-3 days a week	-0.17 (-0.41, 0.06)
	Most days	-0.26 (-0.53, 0.01)
Time, per year		0.18 (0.17, 0.19)
Smoking		
	Never smoked	Reference
	Former smoker	0.25 (0.07, 0.43)
	Current smoker	-0.26 (-0.46, -0.06)
Occupation		
	Managerial or professional	Reference
	Skilled or semi-skilled	0.16 (0.04, 0.27)
	Unskilled	0.26 (-0.06, 0.57)
Longstanding illness		
	No	Reference
	Yes	0.35 (0.23, 0.46)

Leisure time physical activity		
	No	Reference
	Yes	-0.35 (-0.45, -0.24)

Values are mutually adjusted regression coefficients, showing the expected change in BMI per year. In this table, for example, BMI is expected to decrease by 0.26 (0.46, 0.06) kg/m^2 per year in women who smoke. We used a linear model that allowed for random intercepts and random slopes. Variables were assessed at age 30, age 34, age 42 and age 46 and all variables in the model are time varying. Model includes 14,077 observations nested in 5,656 female cohort members. The average number of observations per cohort member was 2.5, where the minimum was 1 and the maximum was 4.

Figure 1. Participant flow. *Body mass index values greater than 75 kg/m^2 were deemed to be dubious and were not included in the present analysis. †Cohort members were not included in a given wave if they were missing data for the exposure, the outcome, and the confounding variables. ‡Changes in BMI from one wave to the next greater than five times the standard deviation were also deemed dubious and were not included.