Hostility and Trajectories of Body Mass Index Over 19 Years: The Whitehall II Study.

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Abstract

The authors examined the associations of hostility measured in adulthood with subsequent BMI assessed at four time points over a 19-year period in a United-Kingdom cohort study. A total of 6,484 participants (4,494 men and 1,990 women) aged 35–55 years at baseline (1985–1988) completed the Cook-Medley-hostility-scale for hostility. BMI (kg/m^2) was assessed at medical examination at phases 1 (1985–1988), 3 (1991–1993), 5 (1997–1999) and 7(2002–2004). Mixed models analyses of repeated-measures showed clear evidence of increasing BMI over the follow-up in both sexes. In women, higher levels of hostility were associated with higher BMI at baseline and this effect remained constant over the follow-up period. In men, hostility levels were also strongly associated with BMI at baseline but results of the interaction term between time and hostility also suggest that this association increased over time, with the highest quartile of hostility gaining an excess of 0.016 kg/m^2 (p=0.023) annually over the follow-up period compared to the lowest quartile. The authors conclude that the difference in BMI as function of the hostility levels in men is not stable over time.

MESH Keywords Adult ; Body Mass Index ; Cohort Studies ; Female ; Great Britain ; Hostility ; Humans ; Male ; Middle Aged ; Social Class

INTRODUCTION

Numerous epidemiological investigations have found hostility, a measure of general cynicism and interpersonal mistrust, to be associated with an increased risk of hypertension 1–4, subclinical atherosclerosis 5, myocardial infarction 6, 7, coronary heart disease (CHD) 8–10, and all-cause mortality 6, 8, 11, 12. However, the mechanisms through which hostility affects health remain unclear. Several studies have identified hostility as related to higher alcohol consumption, less physical activity, smoking, and to greater body mass index (BMI) and caloric intake 3, 6, 13–16, supporting health behaviours as a possible pathway linking hostility to health 15.

Although the possibility that hostility influences health outcomes via health-related behaviours has gained recognition, statistical adjustments for these variables show only marginal 11, 17 to moderate 6 effects on the hostility-health association. Lack of attenuation of associations on adjustment for hypothesised mediating factors may indicate at least two issues. First, it is possible that health behaviours are not important mediators or that their effect is masked by other mediators of the association between hostility and health 14. Second, measurement imprecision may dilute the effect of health behaviours on the association between hostility and health. Measurement imprecision is possible because health-related behaviours are typically assessed at one point in time only, usually at baseline 4, 11, 14; the assumption being made is that the effect of hostility on health behaviours remains constant over time. However, this assumption is rarely tested even though there is some evidence to suggest that health behaviours vary over the adult life course 18–21.

The main objective of this study is to examine the association between hostility and body mass index (BMI) trajectories over the adult life course after controlling for potential confounding factors. We conducted a prospective investigation using data from a large cohort of British civil servants to examine the temporal association of hostility measured in adulthood with BMI assessed at four time points over a 19-year period. We focused on BMI because high BMI is an important risk factor for several chronic and organic diseases 22–24 and has been found to be associated with hostility 3, 16. Moreover, BMI may reflect the effects of other health-related behaviours such as physical activity 22, dietary patterns 25, 26, and alcohol consumption 27. In contrast to many previous studies with self-reported measures of health behaviours, in the present study BMI was assessed objectively during clinical examinations.

MATERIAL & METHODS

Data are drawn from the Whitehall II study, established in 1985 as a longitudinal study to examine the socioeconomic gradient in health and disease among 10,308 civil servants (6,895 men and 3,413 women)(30). All civil servants aged 35–55 years in 20 London based departments were invited to participate by letter, and 73% agreed. Baseline screening (Phase 1) took place during 1985–1988, and involved a medical examination and a self-administered questionnaire. Subsequent phases of data collection have alternated between postal questionnaire alone [Phases 2 (1989–1990), 4 (1995–1996), 6 (2001) and 8 (2006)] and postal questionnaire accompanied by a medical examination [Phases 3 (1991–1993), 5 (1997–1999) and 7 (2002–2004)]. The University College London ethics committee approved the study.

Measures

Hostility was assessed using the Cook-Medley scale 28 at phase 1 (1985–1988). Internal consistency, test–retest reliability, and construct validity of this scale have been demonstrated 29. Participants completed an abridged 38-item version (alpha cronbach's = 0.83) of the original 50-item instrument. Item savings were necessary, because of the length of the original questionnaire; the Minnesota Multiphasic Personality Inventory 30 numbers of the omitted items are: 19, 183, 237, 253, 386, 394, 410, 455, 458, 485, 504, and 558. High scores on the scale denote greater hostility but no natural or clinically based thresholds exist for defining "high" levels of hostility 28. Therefore, in order to investigate thresholds effects, we categorized hostility into four groups based on the nearest approximate of the quartile as in previous studies 31, 32: lowest (0–6), middle lowest (7–10), middle highest (11–15) and highest (> 16). The lowest quartile was the reference category.

Body Mass Index, calculated by dividing weight in kilograms by height in meters squared, was assessed at medical examination at phases 1 (1985–1988), 3 (1991–1993), 5 (1997–1999) and 7 (2002–2004). At phase 1, participants were asked to report their height and weight at age 25, allowing us to calculate their BMI at age 25. In the longitudinal analyses continuous measures of BMI were used but these were categorised into 4 groups (<20, 20–24.9, 25–29.9, or ≥ 30 kg/m^2), as in previous studies 33, 34, for the descriptive analysis.

Sociodemographic measures taken from the phase 1 questionnaire included sex (male vs. female) ethnicity (White vs. other) and marital status (Married/cohabiting vs. other). Age was categorized into four 5-year age groups (34–40, 41–45, 46–50, and 51–55) as there was no evidence of a linear relationship between age and BMI. Socioeconomic status (SES) assessed by British civil service grades of employment was categorized into three groups in order of decreasing salary and work role: administrative (high), professional/executive (middle), and clerical/support (low), a standard classification in the Whitehall II study.

Statistical analyses

Differences in sample characteristics between men and women were assessed using a chi-square test. Mean (standard error) BMI at each phase was calculated separately in men and women and shown graphically. We first examined the association between the covariates (age, SES, ethnicity, marital status and BMI at age 25) and BMI trajectories. In these analyses of change in BMI over four waves of data collection, spread over 19 years, we used mixed models analysis of repeated-measures in order to take into account the within-subject correlation between the measures of BMI. The dependent variables were the four repeated measures of BMI over a 19-year period, and the independent variables were: time (exact time in years between phases included as a continuous variable), the covariates, and interactions between time and these covariates.

Mixed models analysis of repeated-measures was also fitted to explore the temporal association between hostility levels and subject specific measures of BMI (variability in mean BMI) over 19 years of follow-up. In these analyses, we first used time, hostility levels and the interaction term between time and hostility levels as the independent variables (model 1). There were three coefficients of interest: one, the coefficient for time assessed the change in BMI with time; a p value <0.05 was taken to imply a significant change in BMI over the follow-up; two, the coefficient for hostility levels estimated the association between the four hostility levels and BMI at baseline (phase 1); three, the coefficient for the interaction term between time and hostility levels assessed whether the mean annual rate of change in BMI over the follow-up differed between hostility levels. A p value <0.05 for the interaction term indicates a significant difference in the mean annual rate of change in BMI over time between hostility levels. However, a p value > 0.05 suggests that the mean annual rate of change in BMI over time did not vary as a function of the hostility levels or that the association between hostility and BMI remained constant over time. These analyses were further adjusted (model 2) for covariates at baseline that had previously been shown to be associated with BMI trajectories over time. The procedure PROC MIXED in SAS was used to fit these models (version 9.1; SAS Institute, Cary, NC). As participants provided repeated BMI measurements, a covariance structure was specified for the error term in the mixed-effect model. An autoregressive order 1 model has been preferred due to correlation between BMI measurements. We used linear contrasts to test the effect of increasing hostility on BMI. The interaction term between time, hostility and sex was significant (p<0.05); this interaction is illustrated using line graphs of mean BMI trajectories over time for men and women by quartiles of hostility. All analyses were performed separately in men and women.

RESULTS

Only 75% of the 10,308 participants were asked to complete the hostility scale at phase 1 due to this measure being introduced after the start of the baseline survey. 6,484 participants responded to the hostility questions (84% of those asked). There were no differences between participants and those not included in terms of sex, SES, ethnicity, marital status and BMI at age 25 years. However, those who were not included in the present study were more likely to be men (69.3% vs 62.8%, $p<0.001$). Table 1 presents descriptive data from baseline (phase 1) in those included in the analyses

BMI changes over time

Figure 1 characterises the dynamics of BMI change over time in men and women. In both sexes mean BMI tended to increase over the 19 years of follow-up. In men (women), the mean BMI was 24.4 (24.3) at phase 1, 25.1(25.4) at phase 3, 26 (26.5) at phase 5 and 26.5 (27) at phase 7. Post-hoc paired t-test analyses (results not shown) revealed that the mean BMI differences between phase 1 and phase 3, phase 3 and phase 5, phase 5 and phase 7, and phase 1 and phase 7 were all significant ($p<0.001$) in both sexes.

Sociodemographic characteristics and BMI trajectories

Table 2 shows the results from the mixed models used to assess the associations between the covariates and BMI trajectories over time in men and women. The results indicate significant temporal effects ($p<0.001$); the coefficient for time implies that the mean annual rate of increase in BMI was 0.138 (0.260 in women) over the 19 year follow-up. BMI at baseline was lower in younger participants ($p<0.001$), but the interaction term between time and age showed a greater increase in mean BMI over time in the younger participants ($p<0.001$). Higher SES was associated with lower BMI at baseline in both sexes ($p \leq 0.025$), the interaction term with time suggested lower increases in mean BMI over time in the high compared to the low SES group in women alone ($p \leq 0.018$). 'White' participants had lower BMI at baseline in both sexes ($p \leq 0.04$) but the interaction term between time and ethnicity suggested a greater increase in mean BMI over time among 'white ' participants in both sexes ($p \leq 0.007$). Neither marital status nor the interaction term between time and marital status was associated with BMI. Finally, lower BMI at age 25 was associated with lower BMI at baseline ($p<0.001$) and the interaction term between time and BMI at 25 years suggested lower increases in mean BMI during the follow-up in participants who had lower BMI at age 25 years ($p \leq 0.022$).

Hostility as a predictor of BMI trajectories

Table 3 shows results from the mixed models undertaken to assess the associations between hostility levels and BMI trajectories over time in men and women. In model 1, men ($\beta = 0.731$, $p<0.001$) and women ($\beta = 1.326$, $p<0.001$), in the highest quartile of hostility had significantly higher BMI at the start of the follow-up. Furthermore, the interaction term between time and hostility in men suggests greater increase in BMI of among those in the highest quartile of hostility, with an excess of 0.016 in the mean annual increase of BMI ($p=0.023$) over the total duration of the follow-up compared to the lowest quartile. This effect remained in the fully adjusted analysis (model 2, $p= 0.043$). In women, there was no interaction between time and hostility, suggesting that the effect of hostility on BMI trajectory over 19 years remained constant over the total follow-up period.

DISCUSSION

In this study we sought to examine longitudinal associations of hostility measured in adulthood with BMI assessed at four points over a 19-year follow-up period. In general terms, there was clear evidence of increasing trend in mean BMI over time in both sexes. Higher levels of hostility were associated with higher mean BMI at the start of the follow-up period in both men and women. Furthermore, results from the analysis on the interaction with time showed that in men, the highest hostility levels were associated with increasing BMI during the 19-year follow-up period when compared to the lowest hostility levels. In women, the association between hostility and BMI remained constant over time. This implies that the effects of hostility on BMI in men and women track over time, with an increasing effect over time on BMI among the men with highest levels of hostility.

The present findings are in line with some previous studies showing hostility to be associated with higher BMI 3, 13, 14, 16. However, to the best of our knowledge, this is the first large-scale study to examine the longitudinal relationship of hostility to BMI assessed repeatedly over an extended follow-up period. As BMI has been shown to change considerably over time 18, it is crucial to examine the dynamics of the association between hostility and BMI over time. The longitudinal modelling approach using time effects allowed us to control for weight gain over time, as well as to provide precise estimates of the effects. In contrast to some prior studies 3, 6, BMI in the present study was derived from height and weight assessed at a medical examination, thus minimizing measurement error or information bias and excluding the possibility of common-method bias. We were also able to control for self-reported BMI at 25 years, allowing us to examine the BMI trajectory over the adult life course.

As in other studies, BMI in the present study increased over time 18. The result showing the highest hostility level to be associated with increasing mean BMI during the follow-up in men is consistent with our hypothesis that CHD behavioural risk factors associated with hostility do not remain constant throughout an individual's life. The fact that high hostility was associated with higher BMI over the total follow-up period and also, in men, with an excess annual increase of BMI during the follow-up, lends support to the hypothesis that hostility, as an individual personality characteristic may influence the development and the maintenance of behaviour-related risk factors 6 , evident in measures such as BMI.

There are several possible explanations of the link between hostility and BMI. First, the general cynicism and mistrust which characterise hostile individuals may discourage them from following health promoting messages 35. Cynicism may decrease the perceived importance of health-enhancing behaviours such as diet and physical activity 14, 15 which have been found to be associated with greater BMI and obesity 22, 26. Second, lower SES is associated with higher hostility 12, 35 and with greater BMI 36, and may be driving the association between hostility and BMI. However, in our analysis this association remained robust to adjustment for SES, either on its own or simultaneously with the other covariates. We assessed SES using employment grade, the main measure of SES in the Whitehall II study. People in different grades differ with respect to salary, social status and level of responsibility. Further research using repeated measures of SES will be required to examine whether changes in socioeconomic circumstances mediate the association between hostility and development of BMI. An alternative explanation for this association is related to the psychosocial vulnerability model of hostility 14, 37. According to this model, hostile individuals, given their oppositional attitudes and behaviours, are more likely to have increased interpersonal conflicts, lower social support, more stressful life events and higher likelihood of depression 14, 37. The interrelations between these variables may influence BMI. For example, depression could result from a lack of social support or stressful life events, and then affect diet or physical activity levels that could, in turn, lead to higher BMI 38. Here again further research using repeated measures of depression is needed to examine this possibility.

In women, we observed increases in mean BMI during the follow-up period but the association between hostility and BMI remained constant over the follow-up period. In other words, the interaction term between time and hostility did not suggest that the association between hostility and BMI observed at baseline increased or decreased over time even though it tracks over time. These sex-specific results suggest that the influence of hostility on BMI may be gender patterned; perhaps due to sex specific biologic phenomena. CHD affects men more than women 39 and it is not surprising that hostility, a risk factor for CHD 11, 14, is associated with increasing effect over time on BMI in men alone. The menopause could be a confounder as it has been found that at this time or several years before women experience weight gain or difficulty maintaining their usual weight 40.

In interpreting the present results, it is important to note two limitations. First, our cohort of civil servants did not include blue collar workers and unemployed people and is thus not representative of the general population, which may limit the generalisability of our findings. Second, we were able to control for BMI at 25 years, but was derived from self-reported height and weight. However, in our results BMI at 25 years was found to be strongly associated with objectively measured BMI at phase 1, pleading for the validity of this measure.

In sum, this study shows mean BMI to increase over the 19 year follow-up period in both men and women. We also found prospective evidence for the effect of hostility on BMI over the 19-year follow-up period. Finally, higher hostility was associated with significantly greater increases in BMI over time in men, suggesting that differences in BMI as function of hostility is not stable over time. These results have implications for studies, on the association between hostility and CHD for example, in which the association between hostility and health outcomes is adjusted for health behaviours like BMI at baseline in order to assess the 'independent' effect of hostility on health. Our findings suggest that controlling for baseline BMI might not be sufficient to address the mediation effect, particularly in men. Epidemiological studies with repeated measures of covariates are widespread now. Going beyond baseline covariates might allow proper modelling of the mechanisms underlying the association between hostility and important health outcomes, such as CHD.

Ackowledgements:

Grants and/or financial support

AS-M is supported by a 'EURYI' award from the European Science Foundation and a 'Chaire d'excellence' award from the French Ministry of Research. MM is supported by an MRC Research Professorship. MK is supported by the Academy of Finland (grant 117604). The Whitehall II study is supported by grants from the Medical Research Council; British Heart Foundation; Health and Safety Executive; Department of Health; National Heart Lung and Blood Institute (HL36310), US, NIH: National Institute on Aging, US, NIH; Agency for Health Care Policy Research (HS06516); and the John D and Catherine T MacArthur Foundation Research Networks on Successful Midlife Development and Socio-economic Status and Health.

Footnotes:

Conflict of interest: None to declare

Abbreviations

BMI: Body Mass Index

CHD: coronary heart disease

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Figure 1

Means (SE) of BMI at phases 1 (1985–1988), 3 (1991–1993), 5 (1997–1999) and 7(2002–2004) in men (N=3323) and women (N=1356), Whitehall II cohort, United Kingdom

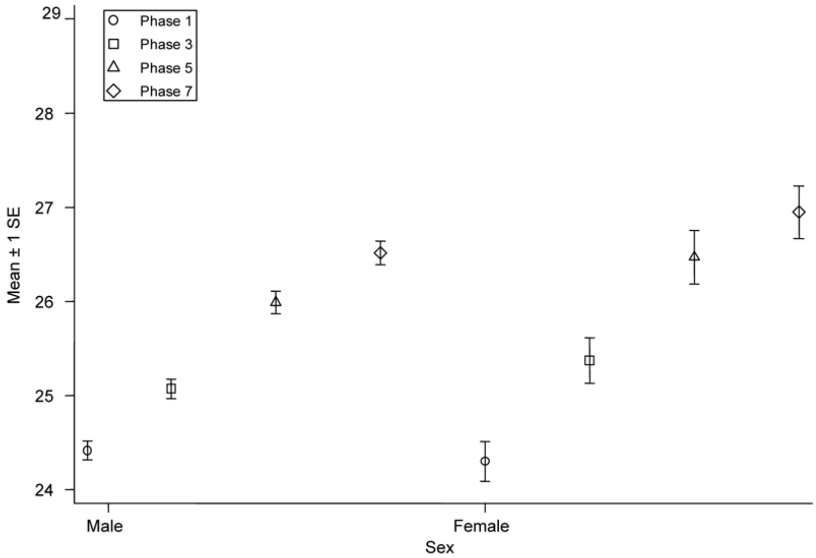
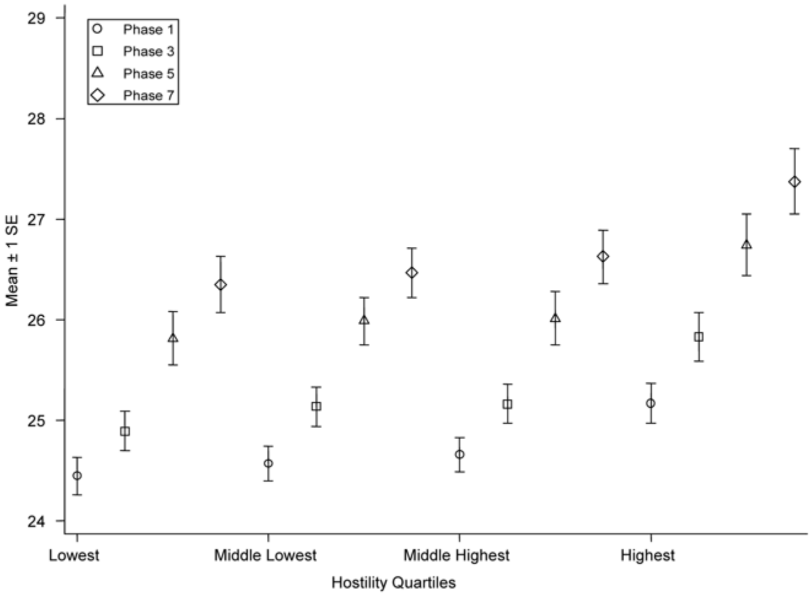


Figure 2

Means (SE) of BMI at phases 1 (1985–1988), 3 (1991–1993), 5 (1997–1999) and 7(2002–2004) in men (N=2980–3676) and women (N=1099–1444) by hostility score quartiles, Whitehall II cohort, United Kingdom

Men



Women

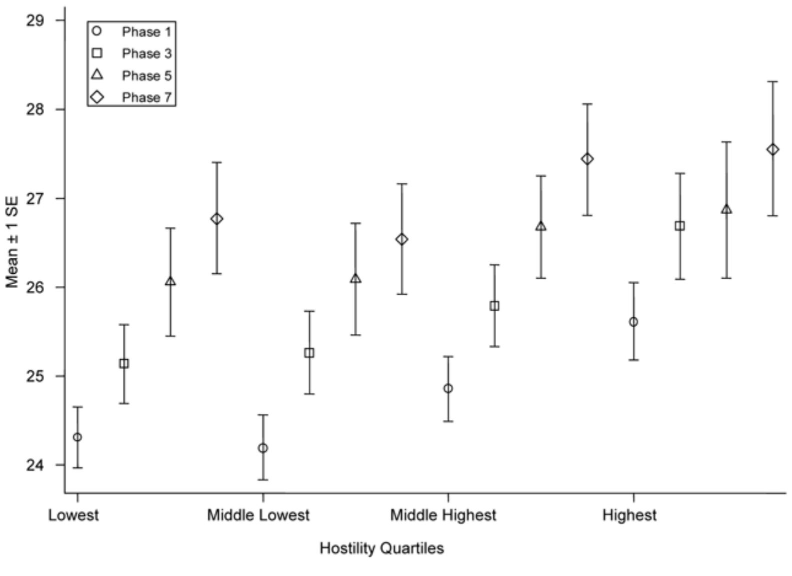


Table 1

Characteristics of participants in the Whitehall II cohort (United Kingdom) at phase 1 (1985–1988) by sex

	Men	Women	P value
	N (%)	**N (%)**	
Age in years			<0.001
35–40	1245 (27.7)	467 (23.5)	
41–45	1260 (28.0)	494 (23.8)	
46–50	905 (20.1)	446 (22.4)	
51–55	1084 (24.1)	1084 (29.3)	
SES			<0.001
High	1661 (37.0)	206 (10.4)	
Middle	2367 (52.7)	843 (42.4)	
Low	466 (10.4)	941 (47.3)	
Ethnicity			<0.001
White	4141 (92.2)	1710 (85.9)	
Other	349 (7.8)	280 (14.1)	
Marital status			<0.001
Married/cohabiting	3582 (80.0)	1169 (59.1)	
Other	895 (20.0)	808 (40.9)	
BMI at age 25 years			<0.001
<19.9	550 (12.6)	489 (25.3)	
20–24.9	3122 (71.3)	1199 (62.1)	
25–29.9	635 (14.5)	197 (10.2)	
>30	71 (1.6)	45 (2.3)	
Hostility levels			0.480
Highest quartile	1001 (22.3)	432 (21.7)	
Middle highest	1210 (26.9)	531 (26.7)	
Middle Lowest	1143 (25.4)	508 (25.5)	
Lowest quartile	1140 (25.4)	519 (26.1)	

Table 2

Mixed models analyses for associations between sociodemographic measures and BMI trajectories from phase 1(1985–1988) to phase 7(2002–2004), Whitehall II cohort, United Kingdom.

	Men (n=4358)			Women (n=1911)		
	Estimate (β)	**Standard error (SE)**	**p value**	**Estimate (β)**	**Standard error (SE)**	**p value**
Time	0.138	0.025	<0.001	0.260	0.038	<0.001
Age in years						
35–40	−0.551	0.122	<0.001	−1.663	0.249	<0.001
40–45	−0.454	0.120	<0.001	−1.217	0.242	<0.001
45–50	−0.032	0.130	0.806	−0.470	0.248	0.006
	ref			ref		

50–55						
Time * age in years						
35–40	0.079	0.007	<0.001	0.107	0.015	<0.001
40–45	0.055	0.007	<0.001	0.067	0.014	<0.001
45–50	0.013	0.007	0.075	0.065	0.015	<0.001
50–55	ref			ref		
SES						
High	−0.472	0.164	0.004	−0.693	0.308	0.025
Middle	−0.244	0.154	0.114	−0.327	0.195	0.093
Low	ref			ref		
Time * SES						
High	−0.010	0.010	0.365	−0.040	0.017	<0.018
Middle	−0.008	0.010	0.670	−0.031	0.012	0.010
Low	ref			ref		
Ethnicity						
White	−0.359	0.175	0.040	−2.11	0.268	<0.001
Other	ref			ref		
Time* Ethnicity						
White	0.030	0.011	0.005	0.044	0.017	0.007
Other	ref			ref		
Marital status						
Married/cohabiting	0.078	0.111	0.484	0.056	0.179	0.757
Other	ref			ref		
Time*marital status						
Married/cohabiting	0.007	0.006	0.268	−0.017	0.011	0.102
Other	ref			ref		
BMI at age 25 years						
<19.9	−8.824	0.361	<0.001	−12.048	0.600	<0.001
20–24.9	−6.011	0.344	<0.001	−9.078	0.581	<0.001
25–29.9	−2.420	0.358	<0.001	−4.652	0.633	<0.001
>30	ref			ref		
Time * BMI at age 25 years						
<19.9	−0.088	0.022	<0.001	−0.216	0.035	<0.001
20–24.9	−0.090	0.021	<0.001	−0.166	0.034	<0.001
25–29.9	−0.061	0.022	0.005	−0.136	0.038	0.000
>30	ref			ref		

Table 3

Mixed models analyses for associations between hostility levels and BMI trajectories from phase 1(1985–1988) to phase 7(2002–2004), Whitehall II cohort, United Kingdom.

	Men			Women		
	* Model 1 (n=4494)			Model 1 (n=1990)		
	Estimate (β)	**Standard error (SE)**	**p value**	**Estimate (β)**	**Standard error (SE)**	**p value**
Time	0.113	0.006	<0.001	0.151	0.010	<0.001
Hostility levels						
Highest quartile	0.731	0. 146	<0.001	1.326	0.306	<0.001
Middle highest	0.220	0.139	0.115	0.552	0.290	0.057
Middle Lowest	0.132	0.141	0.352	−0.100	0.293	0.732
Lowest quartile	ref			ref		
P value for linear contrast		<0.001			<0.001	
Time* hostility levels						
Highest quartile	0.016	0.007	0.023	0.006	0.014	0.709
Middle highest	0.012	0.006	0.052	0.016	0.014	0.238
Middle Lowest	0.005	0.007	0.424	0.008	0.014	0.547
Lowest quartile	ref			ref		
P value for linear contrast		0.011			0.562	
	** Model 2 (n=4374***)			Model 2 (n=1924***)		
	Estimate (β)	**Standard error (SE)**	**p value**	**Estimate (β)**	**Standard error (SE)**	**p value**
Time	0.174	0.391	<0.001	0.133	0.028	<0.001
Hostility levels						
Highest quartile	0.555	0.124	<0.001	0.333	0.255	0.191
Middle highest	0.212	0.116	0.068	0.240	0.232	0.302
Middle Lowest	0.139	0.117	0.233	−0.137	0.235	0.559
Lowest quartile	ref			ref		
P value for linear contrast		<0.001			0.055	
Time* hostility levels						
Highest quartile	0.014	0.007	0.043	0.010	0.016	0.525
Middle highest	0.010	0.006	0.125	0.011	0.013	0.478
Middle Lowest	0.006	0.006	0.309	0.009	0.013	0.491
Lowest quartile	ref			ref		
P value for linear contrast		0.041			0.696	

* Model 1: time, hostility levels, time*hostility

** Model 2: Model 1+ age, time*age, SES, time*SES (not in men), ethnicity, time*ethnicity, BMI at 25 years old, and time*BMI at 25 years old.

*** N values in model 2 should be similar to that of the table 2. They are slightly higher because marital status was not included as covariate (p>0.05 in table 2)