Negative aspects of close relationships as a predictor of increased body mass index and waist circumference: the Whitehall II study.

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Negative Aspects of Close Relationships as a Predictor of Increased Body Mass Index and Waist Circumference: The Whitehall II Study

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Objectives. We investigated whether exposure to negative aspects of close relationships was associated with subsequent increase in body mass index (BMI) and waist circumference.

Methods. Data came from a prospective cohort study (Whitehall II) of 9425 civil servants aged 35 to 55 years at baseline (phase 1: 1985–1988). We assessed negative aspects of close relationships with the Close Persons Questionnaire (range 0–12) at phases 1 and 2 (1989–1990). We measured BMI and waist circumference at phases 3 (1991–1994) and 5 (1997–1999). Covariates at phase 1 included gender, age, marital status, ethnicity, BMI, employment grade, smoking, physical activity, fruit and vegetable consumption, and common mental disorder.

Results. After adjustment for sociodemographic characteristics and health behaviors, participants with higher exposure to negative aspects of close relationships had a higher likelihood of a 10% or greater increase in BMI and waist circumference (odds ratios per 1-unit increase 1.08 [95% confidence interval (CI) = 1.02, 1.14; $P = .007$] and 1.09 [CI = 1.04, 1.14; $P \leq .001$], respectively) as well as a transition from the overweight ($25 \leq$ BMI < 30) to the obese (BMI ≥ 30) category.

Conclusions. Adverse social relationships may contribute to weight gain. (*Am J Public Health.* 2011;101:1474–1480. doi:10.2105/AJPH.2010.300115)

Obesity is a major public health concern because it is associated with numerous ill health conditions such as type 2 diabetes, coronary heart disease, hypertension, stroke, and certain forms of cancer.[1] Obesity rates have rapidly increased to epidemic proportions. In England, for example, 24% of men and 25% of women are obese (body mass index [BMI, defined as weight in kg divided by height in m^2] ≥ 30).[2] The interplay among multiple factors—genetic factors, factors stemming from obesogenic environments, and individual, and cultural factors—is seen to be behind the obesity epidemic.[3] However, increasing evidence suggests that social relationships may also play a role in determining weight gain.

Stress associated with poor-quality relationships may contribute to weight gain via various mechanisms. Negative aspects of close relationships may induce negative feelings,[4] which can increase physiological arousal either through activation of the hypothalamic–pituitary–adrenal axis or through the fight-or-flight response and the secretion of adrenal medullary hormones.[5] Eating high-fat and high-carbohydrate caloric content "comfort food" may reduce biological stress system activity and the concomitant negative emotions.[6] Some evidence also suggests an association between chronic life stress and a greater preference for energy- and nutrient-dense foods, namely those that are high in fat and sugar.[7] In addition, there may be further effects via other unhealthy coping mechanisms such as physical inactivity.

Childhood adversities related to close relationships, such as physical abuse, verbal abuse, humiliation, neglect, strict upbringing, physical punishment, conflict, or tension, have been associated with an increased risk of obesity in adulthood.[8] However, limited and somewhat inconsistent evidence exists on the impact of negative aspects of close relationships in adulthood. One study revealed that heavier women had lower quality romantic relationships.[9] Poor marital quality has also been associated with a higher risk of metabolic syndrome[10] and obesity[11] in women. Strain in relations with family but not with one's spouse or partner was associated with weight gain in women with high initial BMI.[12] In addition, some studies have revealed an association between reports of insufficient social support and increased risk of obesity,[13,14] but other studies suggest no such association.[15]

With a few exceptions,[10–12] the evidence is cross-sectional or derived from short follow-ups. Such data leave open the possibility of reverse causality (i.e., obesity negatively influencing close relationships). Because the development of obesity has a relatively long induction period, it is plausible that prolonged exposure to problems in social relationships affects weight more than do short-term problems. Moreover, it might be more informative to look at weight gain rather than obesity status at 1 time point. We are not aware of previous studies examining the association between negative aspects of close relationships and weight gain. In addition, most of the earlier studies did not assess waist circumference, a measure of central obesity. Waist circumference is probably a better indicator of health risk than is BMI alone, especially when used in combination with BMI.[16]

In this study using data from the Whitehall II cohort of British civil servants, we investigated the extent to which exposure to negative aspects of close relationships was associated with subsequent weight gain, as indicated by increase in BMI and waist circumference over a long follow-up period.

METHODS

The target population of the Whitehall II Study was all office staff based in London, United Kingdom, in 20 civil service departments in 1985. The baseline cohort included 6895 men and 3413 women (age range 35–55 years; response rate 73%). Full details on study design and measures are reported elsewhere.[17] Briefly, negative aspects of close relationships were assessed at phase 1 (1985–1988) and phase 2 (1989–1990). We measured change in BMI and waist circumference between phase 3 (1991–1994) and phase 5 (1997–1999). Baseline covariates in our analysis are drawn from phase 1. Phases 1, 3 (n=8815; 86% of phase 1 respondents), and 5 (n=7870; 76% of phase 1 respondents) included a clinical examination and a questionnaire, whereas phase 2 (n=8132; 79% of phase 1 respondents) included only a questionnaire. Phase 4 data did not include relevant variables, and therefore we did not use them in the study. The median length of the follow-up from phase 1 to phase 5 was 11.2 years.

Negative Aspects of Close Relationships

We assessed negative aspects of close relationships at phases 1 and 2 with a 4-item scale from the Close Persons Questionnaire.[18] The questions refer to adverse exchanges and conflict within a relationship nominated by the respondents as their closest. The items are as follows: "How much in the last 12 months did this person give you worries, problems, and stress?"; "How much in the last 12 months would you have liked to have confided more in this person?"; "How much in the last 12 months did talking to this person make things worse?"; "How much in the last 12 months would you have liked more practical help with major things from this person?" We evaluated each of the 4 items on a Likert scale from 1 to 4, with higher scores indicating more negative aspects. We summed the Likert-scaled responses for the items. The Cronbach α was 0.63.[18] At phase 1, 7384 participants completed the Close Persons Questionnaire. We asked only 74% of respondents to complete it because this measure was introduced after the start of the baseline survey. At phase 2, 7727 participants completed the questionnaire. Correlation coefficients of scores at phases 1 and 2 suggest a moderate degree of consistency ($r=0.48$; $P<.001$). Although the questionnaire assesses social relationships relative to a maximum of 4 close relationships, our analyses, similar to previous studies in the Whitehall II data, focused on the first close relationship only, for which the reliability was the highest.[18]

The reliability and validity of the Close Persons Questionnaire was examined in a previous study.[18] A retest reliability study over a 4-week interval showed moderately high agreement for negative aspects of close relationships ($r=0.72$). To evaluate validity, the questionnaire was sent to the person closest to each of the last 60 interviewees who nominated a close relationship. Response from the person designated as the close relationship showed correlation with that reported by the participant ($r=0.65$ for female spouse and $r=0.40$ for male spouse).

Outcome Variables

Screenings at phases 3 and 5 included the measurement of height, weight, and waist circumference. BMI was calculated according to weight (kg) and height (m) assessed using standard protocols at the medical examination. Waist circumference was measured using a fiberglass tape measure at 600 g tension as the smallest circumference at or below the costal margin.[19] Test–retest reliability of the waist circumference measurement during 1 month, in 490 participants, was 0.96 at the phase 3 clinical examination.

Covariates

We included several factors that have been associated with obesity or weight gain[20–22] in the analysis as covariates. We assessed all covariates at phase 1. Age, gender, ethnicity (White vs non-White), marital status, and BMI were measured. We derived employment grade from a questionnaire asking details about job title and job characteristics. As in earlier studies in the Whitehall II cohort, the hierarchy of employment grades consisted of 3 levels (administrative, professional or executive, and clerical) according to salary, work role, and occupational seniority.

Health behaviors included self-reported smoking status (never smoker, ex-smoker, current smoker), daily fruit and vegetable consumption (yes vs no), weekly moderate physical activity hours, and weekly vigorous physical activity hours. Physical activity was assessed with a standardized instrument. Participants were asked the average number of hours per week spent in "moderately energetic" (e.g., dancing, cycling, leisurely swimming) and "vigorous" (e.g., running, hard swimming, playing squash) physical activity.[23]

The General Health Questionnaire-30 is a self-administered, well-established screening instrument designed for community settings.[24] It assesses common mental disorders such as depression and anxiety. As in previous studies, those with a total score of 5 or greater were defined as cases, and those scoring 0 to 4 as noncases.[25] The threshold scores are set to correspond to a case definition equivalent to that of the average patient referred to a psychiatrist.[26] In the Whitehall II Study, General Health Questionnaire "caseness" was validated against a clinical interview schedule; the sensitivity (73%) and specificity (78%) measures indicate that the definition of caseness is acceptable.[27]

Statistical Analysis

The complete case analyses of our study included 3703 (analyses on BMI increase) and 3224 (analyses on waist circumference increase) participants with no missing data on any of the study variables. The median length of the follow-up from phase 1 to phase 5 was 11.2 years; 273 individuals died during this period.

To explore potential selection bias resulting from missing data, we ran a subsidiary analysis in which we used multiple multivariate imputation[28] using negative aspects of close relationships at phases 1 and 2; BMI at phases 1, 3, and 5; waist circumference at phases 3 and 5; and all covariates at phase 1 (age, gender, ethnicity, marital status, employment grade, BMI, smoking, fruit and vegetable consumption, moderate and vigorous physical activity, and common mental disorder) to impute values for missing values for measures on the 9425 participants with at least 1 measurement of negative aspects of close relationships. We used switching regression in Stata version 11.0 (StataCorp LP, College Station, TX) as described by Royston[28] and carried out 10 cycles of regression switching and generated 10 imputation data sets. The multiple multivariate imputation approach creates numerous copies of the data (10 copies in this case) in which the missing values are imputed with an appropriate level of randomness by using chained

equations. The estimates are obtained by averaging across the results from each of these 10 data sets using Rubin's rules.[28] The procedure takes into account the uncertainty in the imputation as well as the uncertainty resulting from random variation, as undertaken in all multivariable analyses.

We used binary logistic regression to examine whether exposure to negative aspects of close relationships was associated with a 10% or greater increase in BMI and waist circumference in complete cases and in the imputed data set. The 10% change has been used in Whitehall II studies to assess meaningful change over time[29]; this categorization for BMI and waist circumference also provides sufficiently large groups for well-powered analyses. However, to ensure that our findings are robust and not attributable to a specific cutoff point, we ran sensitivity analyses. We repeated the analyses using 7.5% or greater and 15% or greater increases in BMI as outcomes in the complete case sample.

We ran separate analyses for negative aspects of close relationships at phases 1 and 2 as well as for the phase 1–phase 2 mean score. We used multinomial logistic regression to determine whether exposure to negative aspects of close relationships predicted transitions between BMI categories between phases 3 and 5. We used the models to assess the likelihood of

1. recommended healthy weight ($18.5 \leq BMI < 25$) at phases 3 and 5 (referent);
2. from recommended healthy weight at phase 3 to overweight ($25 \leq BMI < 30$) or obese ($BMI \geq 30$) at phase 5;
3. from overweight at phase 3 to recommended healthy weight at phase 5 or from obese at phase 3 to overweight or recommended healthy weight at phase 5;
4. overweight at both phases or obese at both phases; and
5. from overweight at phase 3 to obese at phase 5. Underweight participants, that is, those with a BMI of less than 18.5 at phase 3 or phase 5 were excluded from this analysis (n = 43 among complete cases).

TABLE 1—Characteristics of the Baseline Cohort, Study Participants With Complete Data, and the Imputed Sample: The Whitehall II Study, London, UK, 1985–1999

Baseline Characteristic	Baseline Cohort (Maximum n = 10 308)		Complete Cases (n = 3703)[a]		Imputed Sample (n = 9425)[b]	
	No.	% or Mean (SD)	No.	% or Mean (SD)	Mean No.	% or Mean (SD)
Gender						
Women	3413	33.1	1043	28.2	3039	32.2
Men	6895	66.9	2660	71.2	6386	67.8
Age, y	10 308	44.4 (6.9)	3703	44.3 (5.9)	9425	44.4 (6.0)
Ethnicity						
White	9181	89.1	3403	91.9	8510	90.3
Non-White	1127	10.9	300	8.1	915	9.7
Marital status						
Married or cohabiting	7608	74.1	2879	77.7	7086	75.2
Other	2662	25.9	824	22.3	2339	24.8
Occupational position						
Highest grade	3028	29.4	1162	31.4	2821	29.9
Intermediate grade	4943	50.0	1950	52.7	4582	48.6
Lowest grade	2337	22.6	591	15.9	2022	21.5
Smoking status						
Never	5062	49.5	1929	52.1	4650	48.6
Ex-smoker	3274	32.0	1247	33.7	3046	32.6
Current	1883	18.4	527	14.2	1657	17.7
Moderate physical activity, hr/wk	9929	2.9 (3.5)	3703	3.0 (3.5)	9425	2.9 (3.5)
Vigorous physical activity, hr/wk	9919	1.0 (1.9)	3703	1.0 (1.8)	9425	1.0 (1.9)
Fruit and vegetable consumption						
Daily	5998	58.4	2107	56.9	5480	58.1
Not daily	2744	41.6	1596	43.1	3945	41.9
Common mental disorder						
No	7445	73.1	2711	73.2	6827	73.0
Yes	2744	26.9	992	26.8	2521	27.0
Negative aspects of close relationships	7384	2.8 (2.4)	3703	2.8 (2.3)	9425	2.8 (2.4)
Negative aspects of close relationships (repeated)	7727	2.8 (2.3)	3231	2.9 (2.3)	9425	2.9 (2.4)

[a]Participants with no missing data on exposure, outcome, or covariate variables.
[b]Multiple imputed sample of participants with at least 1 measurement of negative aspects of close relationships at phase 1 or 2.

In these analyses, we conducted adjustment for covariates in 2 steps to distinguish the different types of confounders and to assess potential pathways. First, we adjusted the association of adverse close relationships and weight gain for age, gender, ethnicity, and marital status. Second, we added employment grade, BMI at baseline, health behaviors (smoking, moderate and vigorous physical activity, and fruit and vegetable consumption), and common mental disorder to the model. We considered all *P* values (2-tailed)<.05 to be statistically significant.

There were no consistent differences in our results between men and women, so we pooled and gender-adjusted the data. We performed analyses using SAS version 9.2 (SAS Institute, Cary, NC) and Stata version 11.0 (StataCorp LP, College Station, TX).

RESULTS

Table 1 shows the characteristics of the total Whitehall II baseline cohort, the participants with complete data on all study variables, and the imputed sample. Any differences in baseline characteristics were small, although differences were greater between complete cases and the baseline cohort than between the imputed sample and the baseline cohort.

Tables 2 and 3 display the odds ratios (ORs) of a 10% or greater increase in BMI and waist circumference by exposure to negative aspects of close relationships (score range 0–12). In complete cases, a higher exposure to negative aspects of close relationships at phase 1 was associated with an increase in BMI (per 1-unit increase in the negative aspects score OR=1.06 [95% confidence interval (CI)=1.02, 1.10; *P*=.007]), and a higher exposure to negative aspects of close relationships at phase 1 was also associated with an increase in waist circumference (OR=1.06 [95% CI=1.02, 1.10; *P*=.002]). However, we saw the strongest association with both of these outcomes for the phase 1–phase 2 mean score of negative aspects of close relationships (OR=1.08 [95% CI=1.02, 1.14; *P*=.007] and OR=1.08 [95% CI=1.03, 1.13; *P*=.001], respectively). Additional adjustment for baseline covariates affected these estimates very little. In the imputed sample, we found a similar pattern of results, except that the effect size was slightly smaller (e.g., the OR for mean score and waist circumference was 1.04 [95% CI=1.00, 1.07; *P*=.03]).

We repeated the analyses using 7.5% or greater and 15% or greater increases in BMI as outcomes in the complete case sample. The results were very similar to those with a 10% or greater increase. For the phase 1 negative aspects of close relationships, OR=1.04 (95% CI=1.00, 1.07; *P*=.03) for a 7.5% or greater increase, and OR=1.08 (95% CI=1.00, 1.16; *P*=.04) for a 15% or greater increase (data not shown).

Table 4 summarizes the results from multinomial logistic regression analyses on the associations between negative aspects of close relationships and changes in BMI. Participants with high negative aspects of close relationships were more likely to experience a transition from overweight to obese BMI category than stay in the recommended healthy weight category throughout the study period compared with those who did not report negative aspects of close relationships (OR=1.05; 95% CI=1.00, 1.10 in the imputed sample). By contrast, a higher exposure to negative aspects of close relationships was not associated with transition from recommended weight to overweight or obesity; nor was the lack of negative close relationships associated with weight reduction among obese and overweight participants.

TABLE 2—Associations of Negative Aspects of Close Relationships at Phases 1 and 2 With ≥10% Increase in Body Mass Index (BMI) Between Phases 3 and 5 in Complete Cases and Imputed Sample: The Whitehall II Study, London, UK, 1985–1999

Exposure to Negative Aspects of Close Relationships (Range 0–12)	No. (Cases)	Model 1[a] OR (95% CI) for ≥10% Increase in BMI	Model 1[a] *P*	Model 2[b] OR (95% CI) for ≥10% increase in BMI	Model 2[b] *P*
Complete cases					
Phase 1 score	3703 (436)	1.06 (1.02, 1.10)	.007	1.06 (1.02, 1.11)	.008
Phase 2 score	3231 (372)	1.04 (0.99, 1.09)	.1	1.04 (0.99, 1.09)	.11
Mean score	3231 (372)	1.08 (1.02, 1.14)	.007	1.08 (1.02, 1.14)	.007
Imputed sample					
Phase 1 score	9425 (1376)	1.03 (1.00, 1.07)	.04	1.03 (1.00, 1.07)	.06
Phase 2 score	9425 (1376)	1.02 (0.99, 1.06)	.22	1.02 (0.98, 1.06)	.27
Mean score	9425 (1376)	1.04 (1.00, 1.08)	.07	1.04 (0.99, 1.08)	.09

Note. CI = confidence interval; OR = odds ratio. BMI was calculated by dividing weight in kilograms by height in meters squared.
[a]Adjusted for gender, age, marital status, and ethnicity.
[b]Additionally adjusted for baseline BMI, employment grade, smoking status, moderate physical activity, vigorous physical activity, daily fruit and vegetable consumption, and common mental disorder.

DISCUSSION

This prospective study suggests that negative interactions in close relationships may, albeit modestly, contribute to increases in BMI and waist circumference. Sociodemographic characteristics, health behaviors, and common mental disorders did not account for these effects. Analyses in repeat data indicated that a long-term exposure to negative aspects (indicated by mean score across 2 study phases) had a slightly stronger effect on weight gain than did a single measurement of the exposure.

Our results are in line with previous studies that have suggested a link between poor relationship quality or insufficient social support and obesity; however, these studies are limited because they did not specifically measure negative aspects of close relationships, did not assess cumulative exposure, and did not measure weight gain.[9,10,13,14] By contrast, in a previous longitudinal study strain in relations with a spouse or partner was not associated with weight gain.[12]

TABLE 3—Associations of Negative Aspects of Close Relationships at Phases 1 and 2 With ≥10% Increase in Waist Circumference Between Phases 3 and 5 in Complete Cases and Imputed Sample: The Whitehall II Study, London, UK, 1985–1999

Exposure to Negative Aspects of Close Relationships (Range 0–12)	No. (Cases)	Model 1[a] OR (95% CI) for ≥10% Increase in Waist Circumference	Model 1[a] *P*	Model 2[b] OR (95% CI) for ≥10% Increase in Waist Circumference	Model 2[b] *P*
Complete cases					
Phase 1 score	3224 (807)	1.06 (1.02, 1.10)	.002	1.06 (1.02, 1.10)	.001
Phase 2 score	2814 (698)	1.05 (1.01, 1.09)	.01	1.05 (1.01, 1.10)	.009
Mean score	2814 (698)	1.08 (1.03, 1.13)	.001	1.09 (1.04, 1.14)	≤.001
Imputed sample					
Phase 1 score	9425 (2629)	1.02 (0.99, 1.05)	.14	1.02 (0.99, 1.06)	.15
Phase 2 score	9425 (2629)	1.03 (1.00, 1.05)	.01	1.03 (1.01, 1.05)	.01
Mean score	9425 (2629)	1.04 (1.00, 1.07)	.02	1.04 (1.00, 1.07)	.03

Note. CI = confidence interval; OR = odds ratio.
[a]Adjusted for gender, age, marital status, and ethnicity.
[b]Additionally adjusted for baseline BMI, employment grade, smoking status, moderate physical activity, vigorous physical activity, daily fruit and vegetable consumption, and common mental disorder.

Potential explanations for the associations between negative aspects of close relationships and weight gain involve neuroendocrine effects of chronic stress via psychological processes as well as behavioral effects, or both.[18] More specifically, the presence of negative aspects of close relationships can induce psychological processes that are linked to negative appraisals and emotions or low mood. Dysfunctional social relationships may provoke negative feelings,[4] which can increase physiological arousal.[5] Marital strain has been shown to have deleterious effects on cardiovascular, endocrine, and immune functions.[30] Dallman et al.[6] proposed that people might eat high-fat and -carbohydrate caloric content "comfort food" in an attempt to reduce activity in the corticotrophin-releasing factor-driven central chronic stress response network with its attendant anxiety. Chronic life stress has been associated with a greater preference for energy-dense foods,[7] possibly leading to weight gain in those experiencing chronic stress.[31]

Furthermore, there may be effects via health behaviors and adherence to medical regimens. For example, the individual may use unhealthy eating and a physically inactive lifestyle as adverse coping mechanisms. Psychological and behavioral pathways can also influence each other.[32] However, in this study an adjustment for health behaviors had little effect on estimates, suggesting that the association between negative aspects of close relationships and weight change may be explained primarily by mechanisms other than those related to health behaviors.

The strengths of this study include the assessment of repeated exposure to negative aspects of close relationships and simultaneous inclusion of numerous covariates. Our study is derived from a large well-characterized cohort of British employees and a prospective study design with a median follow-up of 11.2 years. A further strength is that weight, height, and waist circumference were directly measured at both examinations (phases 3 and 5) and were not derived from questionnaires, thus minimizing the potential of recall bias and misclassification that occur when using self-reports.

However, several limitations need to be considered when interpreting the findings. First, our measure of negative aspects of close relationships was self-reported and may thus be influenced by personality traits or specific characteristics of respondents.[18] For example, levels of social support are lower than normal in hostile individuals as the result of less-effective coping strategies in psychosocial stress situations, increasing the likelihood of breakdown of intimate relationships and unhealthy lifestyle.[33,34] However, the

TABLE 4—Multinomial Logistic Regression Models: The Whitehall II Study, London, UK, 1985–1999

Exposure to Negative Aspects of Close Relationships	Recommended Healthy Weight at Phase 3 to Overweight or Obese at Phase 5	Overweight at Phase 3 to Recommended Healthy Weight at Phase 5 or Obese at Phase 3 to Overweight or Recommended Healthy Weight at Phase 5	Overweight at Both Phases or Obese at Both Phases	Overweight at Phase 3 to Obese at Phase 5
Complete cases				
Mean score, OR (95% CI)	1.02 (0.97, 1.08)	0.96 (0.86, 1.07)	1.00 (0.96, 1.04)	1.06 (0.98, 1.14)
P (No.)	.4 (431)	.46 (106)	.95 (1218)	.13 (205)
Imputed sample				
Mean score, OR (95% CI)	1.02 (0.99, 1.06)	1.00 (0.94, 1.07)	1.01 (0.99, 1.04)	1.05 (1.00, 1.10)
P (No.)	.22 (1349)	.96 (389)	.32 (3659)	.04 (573)

Note. CI = confidence interval; OR = odds ratio. Body mass index (BMI) calculated by dividing weight in kilograms by height in meters squared. Recommended healthy weight (18.5 ≤ BMI < 25) at both phases (n = 1233 in complete cases and n = 3333 in imputed sample) was used as a reference category. Overweight was defined as 25 ≤ BMI < 30; obese was defined as a BMI ≥ 30. Those considered underweight (BMI < 18.5 at phase 3 or phase 5) were excluded from the analysis (n = 43 in complete cases). Adjusted for gender, age, marital status, and ethnicity.

subjective experience is exactly what gives meaning and significance to social environmental characteristics, and these subjective experiences finally get under one's skin or cause adverse behavioral changes. Therefore, self-rated measures, such as those used here, are relevant indicators of social relationships, expressly because of their subjectivity.

Second, our complete case sample included less than half of the original cohort. Loss to follow-up is inevitable in all long-term prospective studies and may lead to biased estimates. We examined potential bias by performing subsidiary analyses with imputed data sets. These analyses suggested that incompleteness of data might have contributed to an overestimation rather than an underestimation of the association between negative aspects of close relationships and weight gain. This finding is important because sample attrition in prospective studies is often speculated to attenuate the effect estimates.

Third, although we adjusted for numerous possible confounders the possibility of residual confounding cannot be excluded in observational studies. For example, information was not available on childhood factors[35] or individual differences in genetic predisposition.[36] Finally, the participants were mostly White, middle-aged civil servants based in the southeast of England, limiting the generalizability of our findings. Thus, more diverse samples are needed to extend the validity of our findings.

Despite these limitations, our results suggest that exposure to negative aspects of close relationships is associated with an increased risk of weight gain. The study adds to the evidence that the development of obesity may be related to the social environment in which people live. Future research is needed to study the specific biological, behavioral, and psychological mechanisms linking social environmental factors to weight gain and whether interventions designed to improve social relationships could decrease obesity risk. ■

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Contributors

A. Kouvonen originated the idea for the study, performed analyses with M. Kivimäki, and led all aspects of the work including data analysis and writing. M. Stafford, R. De Vogli, and M. Kivimäki supervised all aspects of study implementation. M.J. Shipley provided advice in the choice of statistical methods, helped in the interpretation of the results, and critically reviewed drafts of the article. M. Stafford, R. De Vogli, M. Kivimäki, M.G. Marmot, T. Cox, J. Vahtera, A. Väänänen, T. Heponiemi, and A. Singh-Manoux helped conceptualize the ideas, interpret findings, and write and critically review drafts of the article.

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Note. The researchers are all independent of the funders.

Human Participant Protection

We obtained ethical approval for the Whitehall II Study from the University College London, Medical School Committee on the ethics of human research. We gained written informed consent from all participants.

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