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The Effect of Weight Loss on Health, Productivity and Medical Expenditures among Overweight Employees

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Abstract

Objective—To test whether overweight or obese employees who achieve clinically significant weight loss of 5% or greater have reduced medical expenditures, absenteeism, presenteeism, and/or improved Health-Related Quality Of Life (HRQOL).

Methods—The sample analyzed combines data from full-time overweight or obese employees who took part in one of the WAY to Health weight loss studies: one that took place in 17 community colleges (935 employees) and another in 12 universities (933), all in North Carolina. The estimations are performed using non-linear difference-in-difference models where groups are identified by whether the employee achieved a 5% or greater weight loss (treated) or not (control) and the treatment variable indicates pre- and post-weight loss intervention. The outcomes analyzed are the average quarterly (90 days) amount of medical claims paid by the health insurer, number of days missed at work during the past month, Stanford Presenteeism Scale SPS-6 and the EQ-5D-3L measure of HRQOL.

Results—We find statistical evidence supporting that 5% or greater weight loss prevents deterioration in EQ-5D-3L scores by 0.026 points (p-value: 0.03) and reduces both absenteeism by 0.258 days per month (p-value: 0.093) and the likelihood of showing low presenteeism (Stanford SPS-6 score between 7 and 9) by 2.9 percentage points (p-value: 0.083). No reduction in medical expenditures was observed.

Conclusions—Clinically significant weight loss among overweight or obese employees prevents short term deterioration in HRQOL and there is some evidence that employee productivity is increased. We find no evidence of a quick return on investment from reduced medical expenditures, although this may occur over longer periods.

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Obesity; medical expenditures; absenteeism; presenteeism; weight loss

INTRODUCTION

Obesity rates in the United States have reached epidemic proportions, even among full time employees. Currently, over 28.5% of full time employees are obese (i.e. have a Body Mass Index or BMI greater than 30) and another 38% are overweight (i.e. have a BMI between 25 and 30) (1). There are many health and economic costs associated with overweight and obesity in the workplace. This includes reduced Health Related Quality Of Life (HRQOL) among employees and higher incidence of chronic diseases (2–4), which translates into higher medical expenses (5), health insurance rates (6, 7), rates of absenteeism and presenteeism (8–10), and ultimately, reduced firm profitability.

This suggests that health and, depending on the cost of the intervention, firm profitability could be improved by successful efforts to reduce the prevalence of overweight and obesity in the workplace. Whereas some of these efforts have been successful at achieving weight loss or other health gains among employees (11, 12), there is limited evidence that these programs are cost saving (13). This may result because the few studies that addressed cost implications were based on studies with only modest weight loss (13). To address this concern, Finkelstein and colleagues compared changes in medical expenditures and absenteeism among overweight full time employees at North Carolina Community Colleges who took part into a weight loss study (referred to as CDC-WAY throughout) stratified by degree of weight loss (14). The hypothesis tested was that those who lost 5% or more weight —a weight loss level that has been shown to yield clinical health benefits (15) —regardless of which arm of the study they were in, would have lower medical expenses and less absenteeism upon study conclusion (and after 18 months for medical expenditures) than those who gained weight or lost less than 5% of baseline weight. The authors were unable to reject the null hypothesis of no difference in outcomes (medical expenses and absenteeism) between the two groups at follow-up. However, the samples analyzed were small (667 individuals for absenteeism and 279 for medical expenditures) and less than 20% of the participants showed 5% or greater weight loss. Consequently, the study findings were associated with large confidence intervals, which reduced the chances of finding statistically significant differences between groups.

To address this concern, this analysis revisits and extends the original study by using, in addition to data from CDC-WAY, identical data from a similar weight loss study, NHLBI-WAY, targeting faculty and staff in other North Carolina colleges and universities. In addition, NHLBI-WAY data also allows us to test whether those with greater than 5% weight loss showed greater improvements in HRQOL, which is a likely mediator of improvements in medical expenditure and absenteeism, and to extend the analysis by measuring the impact that weight loss has on presenteeism. The latter allows for a more comprehensive assessment of the effect that weight loss has on employee productivity. This analysis also employs nonlinear statistical models in an effort to improve the efficiency of the estimates. Altogether, the larger sample size, improved methodology, and expansion to include HRQOL and presenteeism will provide a more rigorous test of whether or not programs that are successful at inducing clinically significant weight losses among employees can also yield short-term financial benefits to the employers who offer them. If we find short-term benefits, financing the cost of these programs could provide justification for employers to increase the availability of weight loss programs for employees.

METHODS

Study design

The first source of data, CDC-WAY, was a study conducted among overweight and obese employees at 17 community colleges in North Carolina. The study was designed to test the effectiveness of three 12 month long weight loss interventions: a low cost environmental change intervention, a web-based weight loss program and a web-based weight loss program plus financial incentives. Details of the recruitment strategy of the 935 participants and their demographics are described elsewhere (16).

The second study, NHLBI-WAY, was designed to rigorously test the independent and combined effects of a self-directed web-based weight loss intervention. Participants in the incentive arm were eligible for up to $150 in CDC-WAY and up to $160 at the 12 month weigh-in in NHLBI-WAY, where payments were based on percentage of baseline weight lost. NHLBI-WAY was conducted over 18 months among employees from 12 different North Carolina universities, historically black colleges, and community colleges. Recruitment methods of 933 participants and eligibility criteria were nearly identical to that used in the prior study. Therefore the two samples are expected to be highly comparable. In each study, those who consented to participate were asked to sign a second consent allowing access to their health insurance claims data from the North Carolina State Health Plan for Teachers and Employees. Survey data and measured height and weight were collected between August 2005 and November 2006 for CDC-WAY and from September 2008 through June 2010 for NHLBI-WAY. The participants of both studies had height and weight measured by a trained research team member and completed questionnaires at baseline and at several measurement points, including a 12 month assessment which, for consistency, is the primary endpoint used in this analysis. The questionnaires captured basic demographic data, diet and exercise patterns, and notably the EQ-5D-3L (17) measure of health related quality of life (NHLBI Only), a one-item question on absenteeism, and the Stanford Presenteeism Scale SPS-6 (18).

Claims data were extended to include additional 1.5 and 1 years post-12 month weigh-in for CDC-WAY and NHLBI-WAY respectively, and data from the year preceding the start of both studies. To address privacy concerns during IRB review, individuals with any evidence of claims related to mental health, substance abuse, HIV/AIDS, other communicable diseases, or genetic testing were not included in the final claims data set. All other claims for covered services for all consenting participants were made available to the research team. Both studies were approved by the institutional review boards at the University of North Carolina at Chapel Hill, the Research Triangle Institute (CDC-WAY only), and at each participating institution.

Dependent variables

The EQ-5D-3L algorithm converts each participant's responses to the 5 EQ-5D 3-level questions into a HRQOL score that ranges between 0 (death) and 1 (perfect health). Note that EQ-5D-3L scores were available for NHLBI-WAY participants only and that negative scores (for health states deemed worse than death) are not observed in our sample of working employees. Absenteeism was measured in both studies as the self-reported number of days missed from work due to illness or injury over the 30 days preceding the measurement points. The SPS-6 scores range from 6 for those who do not suffer from presenteeism, in the sense that they can concentrate on and perform their work despite being overweight, to 30 for those whose work is most adversely affected by their weight. For tractability, we created a 4-category scale of presenteeism by aggregating the SPS-6 scores as follow: 6 for no presenteeism (55% of the sample), 7 to 9 for low presenteeism (19%), 10 to 15 for moderate presenteeism (16%), and 16 to 30 for high presenteeism (11%). Quarterly amounts of medical expenditures paid by the health insurer (net of claim reversals) were computed during the intervention, 12 months before, and 18 months beyond the 12 month measurement point for both studies. In the primary analysis of this study, inpatient expenses were not included in the totals due to their limited number and large variance. All expenditures were converted to Quarter 1 2010 prices by means of the medical component of the consumer price index (19).

Statistical Analysis

Following Finkelstein *et al.*, the analyses rely on a difference-in-difference (20) identification strategy where changes in the dependent variables from baseline to follow-up (the first difference) are compared between those who did or did not show evidence of 5% or greater weight loss (the second difference). Individuals with missing weight loss at follow-up but whose medical claims or survey data were available were included in the analyses and assumed to have less than 5% weight loss using an intention-to-treat analytic strategy. Because the primary research question is independent of study arm, this allowed for pooling individuals from different study arms across the two studies. We merely need to know whether each participant was successful at achieving 5% or greater weight loss; how the weight loss was achieved is immaterial for assessing its impact on these outcomes.

To estimate the effect of 5% or greater weight loss, in each model we regress the dependent variable on a binary variable indicating 5% or greater weight loss (vs. not), a binary variable indicating the follow-up (vs. baseline) period, and an interaction between these two variables. We also include the following control variables: age, baseline BMI, and binary variables indicating gender, ethnicity, faculty members, the study, intervention arms, and whether the participant has any of the following comorbidities: diabetes, chronic dizziness, bone or joint problems, chest pains or a past stroke/heart attack. For the medical expenditures analysis, an additional binary variable is used to identify the quarters in the 1.5 year post 12 month weigh-in and an interaction variable between this variable and the binary variable indicating 5% weight loss.

In order to both improve efficiency and avoid biases (21), we use nonlinear models for the above regressions. Note that with such models, the interaction term no longer represents the difference-in-difference estimate of the treatment effect (22), but this effect can be estimated by computing differences in changes in predicted outcomes for each treatment group from baseline to follow-up and using the bootstrap method to test for significance in the difference of the changes. In what follows, we describe the nonlinear models used to explain HRQOL, absenteeism, presenteeism and medical expenditures.

The EQ-5D-3L measure of HRQOL, which takes values between 0 and 1 in our sample, is characterized by a large number of individuals (48% of the sample) reporting a score of 1, perfect health. To account for this and to ensure the predictions fall into the 0 to 1 range, we apply the two-part model used by Oberhofer and Pfaffermayr in a similar context (23). The first part of the model consists of a logit model that predicts whether the individual reports perfect health. The second part is a fractional response model (24) only estimated for those with less than perfect health. The estimates are then combined as follows to estimate predicted scores for each person:

$$E(EQ5D|X) = Prob(EQD5 = 1|X) + (1 - Prob(EQD5 = 1|X)* E(EQ5D|EQ5D < 1,X),$$

where the probability of perfect health is estimated with the logit model and the conditional expectation for those with less than perfect health is estimated with a fractional logit model; X is a vector of control variables.

The absenteeism variable is characterized by a large number of zero outcomes (79% of the sample), which we deal with by applying a hurdle model that can be viewed as a two-part model in the context of count data (25). The first part is a logit model explaining whether the individual has missed any work and the second part is a truncated negative binomial model explaining the number of days missed for those who missed at least one day. The two parts are combined in a similar way as above to compute expected days missed for each individual in the sample. As for the presenteeism model, after verifying that the assumption of proportional odds holds (26), we have estimated it via a single ordered logit regression.

Quarterly total healthcare claims data are characterized by a large number of individuals with zero dollar claims (on average 23.5% of the sample each quarter) and, for those who do have claims, the distribution of expenditures is highly right-skewed with a small number of very expensive claims. To account for this, we again employ a two-part regression model. The first part is a logit model explaining the probability of participants having a positive claim. The second part estimates medical expenditures conditional on having positive expenditures using a GLM with logarithmic link and a Gamma distribution to account for the skewness of the expenditure distribution (27). Note that the link and distribution have been chosen using the Box-Cox (28) and Park (29, 30) tests. Results are then combined to compute expected expenditures for each individual in each period. In order to increase the efficiency of all estimations, we fit Generalized Estimating Equation (GEE) population-averaged panel data models that account for correlations at individual level (31). All estimations were performed using Stata 11 and inference performed by means of a nonparametric bootstrap with 1,000 repetitions.

RESULTS

Analysis samples

Table 1 presents the combined study samples for the analysis of HRQOL, absenteeism, presenteeism and health expenditures. The CDC-WAY study enrolled 935 eligible participants and NHLBI-WAY enrolled 933, amounting to a combined baseline sample of 1,868 participants. HRQOL and presenteeism come from NHLBI-WAY only. After 12 months, 631 (67% of baseline) participants provided information on HRQOL. There were no statistically significant differences in baseline characteristics between respondents and non-respondents. Among all HRQOL respondents, 105 (17%) lost over 5% of their baseline weight over the 12 month follow-up period. 1,137 participants (61% of enrollees at baseline) provided absenteeism data after 12 months. As for comparison of baseline characteristics between respondents and non-respondents (not reported in the table) we find that respondents were slightly younger on average (46.3 v 47.2, p=0.04) and a higher proportion was female (84.2% v 81.4%, p=0.03). Of this sample, 197 (17%) lost 5% or more of baseline weight. Finally, 1,409 participants (75% of enrollees at baseline) consented to allow access to their medical claims; of these, 365 (25%) were not provided due to the presence of at least one of the exclusionary diagnosis codes (listed in the table). A further 106 (11%) were not enrolled in the State Health Plan. This left an analysis sample of 938 for the medical claims analysis of which, 114 (12%) lost 5% or greater weight. Respondents were slightly older (47.3 v 45.4, p=0.001) and more were male (19.7% v 13.1%).

The top portion of Table 2 compares baseline demographics between those who did or did not lose 5% or greater weight for each analysis sample. There were no statistically significant differences in baseline characteristics for any of the four samples analyzed. The only exception is that the percentage of faculty members was slightly higher and age slightly lower among those who have successfully lost 5% or more weight in the absenteeism sample. The bottom portion of Table 2 compares differences in weight change and the outcome variables of interest. Those who lost 5% or greater weight averaged about 9% weight loss in each sample, or nearly 19 pounds. Those whose weight loss did not exceed this threshold gained about one pound on average over the one year period of study, revealing a roughly 20 pound difference in weight at 12 months. At baseline, those who went on to lose 5% or more weight had slightly better outcomes in all models. These differences are controlled for in the difference-in-difference analysis.

Table 3 presents predictions at baseline and follow-up and the difference-in-difference estimates for those who did or did not lose 5% or greater weight for each variable of interest with corresponding regressions results available in Appendix Table 1. Concerning HRQOL, those who lost 5% or more weight showed almost no change in EQ-5D-3L scores, whereas those who did not saw their score deteriorate. As a result, the difference-in-difference estimate is positive and statistically significant, with a positive difference in HRQOL score of 0.026 (p-value: 0.03) for those who lost 5% or more weight compared with those who did not. Absenteeism rates increased for both groups at follow-up. However, the difference-in-difference estimate provides marginal statistical evidence at the 10% level (p-value: 0.093) that weight loss resulted in a reduction in absenteeism of 0.26 days per month relative to those who did not lose 5% or more of baseline weight.

The table then outlines results from the presenteeism analyses. Results show a 6.3% greater probability of not having any presenteeism for those with 5% or greater weight loss and lower probabilities for greater levels of presenteeism. However, the only result that is marginally statistically significant (p-value: 0.083) is the reduction by 3 percentage points in the probability of showing low presenteeism.

The last three lines show predicted quarterly health expenditures for the pre-intervention, intervention and post-intervention periods. Comparing row 1 with row 2, we see that those who lost 5% or greater weight had significantly lower medical expenditures during the pre-intervention period. This suggests that those who went on to lose 5% or more weight had a different medical profile than those who did not. Regardless, after controlling for these differences, the difference-in-difference estimates for the intervention and post-intervention periods are not statistically significant, suggesting that weight loss did not positively influence medical expenditures over this period relative to those who did not lose the weight.

DISCUSSION

This study builds off of a prior analysis that showed no statistically significant improvements in absenteeism or medical expenses as a result of clinically relevant weight loss (14). This study also extends the prior analysis by including estimates for presenteeism and HRQOL. Whereas we come to similar conclusions with respect to medical expenditures, we find some evidence, at the 10% level of statistical significance (p-value: 0.093), that absenteeism rates improved relative to those who did not lose 5% or greater weight. We also find some evidence that weight loss moves individuals toward lower levels of presenteeism, although results are only marginally significant for low presenteeism levels (SPS-6 scores between 7 and 9). Together, these results suggest that employee productivity could be improved when a 5% or greater weight loss is achieved.

The results also reveal that 5% weight loss or greater prevented HRQOL deterioration. This highly statistically significant result (p=0.03) is consistent with cross-sectional studies showing an inverse relationship between weight and HRQOL (32–34). Conservatively, assuming that deterioration in HRQOL is only prevented during the intervention period (1 year), that like in our sample, 17% of the participants lose 5% or more weight, and excluding any potential savings in absenteeism or presenteeism, we can compute an upper bound for the cost of an intervention that generates these results. Using a threshold for cost-effectiveness of $50,000 per QALY, an intervention with per capita costs of $221 or less would be cost-effective ($50{,}000 \times 0.026 \times 0.17 = \$221$). This for instance exceeds the cost of the CDC-WAY web-based program and web-based plus financial incentives (forthcoming).

Although there was no evidence of savings in medical expenditures, this result is not unexpected. While there is clear evidence from the Diabetes Prevention Program and other studies that weight loss among obese individuals improves diabetes outcomes and risks for numerous chronic conditions (35–39), it may be unreasonable to expect substantial improvements in medical expenditures in such a short period among a population of full time employees, as the adverse health consequences of excess weight are more severe among those in their 50's and beyond.

As for the limitations of our study, it is based on a select sample of majority female, overweight/obese employees at colleges and universities in North Carolina who agreed to participate in the research study. Moreover, in response to IRB concerns, 26% of the eligible sample for the claims analysis was removed due to the presence of mental health problems and other conditions (see Table 1). Excluding these individuals from the analysis may have caused an underestimation of the effect of weight loss on medical expenditures given the high correlation between BMI and poor mental health (40). Another point is that both our measures for HRQOL and productivity losses are self-reported and might yield biased results if weight loss were to alter the employee's perception of her own health and productivity. It should be noted that self-reported number of days missed at work is a common measure of absenteeism that has been shown to be reliable (41).

Despite these limitations, this study suggests that clinically significant weight loss among overweight employees prevents deterioration in HRQOL and provides some evidence that these improvements may lead to increases in employee productivity. However, over the period analyzed, medical expenditures did not appear to be affected. Future studies should attempt to gather objective data on these outcomes over an extended period, and include additional measures of employee output, such as job turnover, worker's compensation costs, and other measures of productivity, in efforts to provide greater evidence on the long term economic benefits to employers of sustained weight loss. Research should also continue to identify strategies that are effective in generating and sustaining this level of weight loss among overweight employees so that long-term health and economic benefits are fully realized.

REFERENCE LIST

1. Authors's calculations based on data from the Centers for Disease Control and Prevention. NHANES 2009–10. 2010. Available at: http://www.cdc.gov/nchs/nhanes/nhanes2009-2010/nhanes09_10.htm
2. Kushner RF, Foster GD. Obesity and quality of life. Nutrition (Burbank, Los Angeles County, Calif). 2000; 16:947–952.
3. Must A, Spadano J, Coakley EH, et al. The disease burden associated with overweight and obesity. JAMA: the journal of the American Medical Association. 1999; 282:1523.
4. Field AE, Coakley EH, Must A, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. Archives of Internal Medicine. 2001; 161:1581. [PubMed: 11434789]
5. Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: how much, and who's paying? HEALTH AFFAIRS-MILLWOOD VA THEN BETHESDA MA. 2003; 22:3–219.
6. Bhattacharya J, Sood N. Health insurance and the obesity externality. 2006:297–318.
7. Dor, A.; Ferguson, C.; Langwith, C., et al. A Heavy Burden the Individual Costs of Being Overweight and Obese in the United States. George Washington University, School of Public Health and Health Services, Department of Health Policy; 2010.

8. Goetzel RZ, Gibson TB, Short ME, et al. A multi-worksite analysis of the relationships among body mass index, medical utilization, and worker productivity. Journal of Occupational and Environmental Medicine. 2010; 52:S52. [PubMed: 20061888]

9. Flegal KM, Carroll MD, Ogden CL, et al. Prevalence and trends in obesity among US adults, 1999–2000. JAMA: the journal of the American Medical Association. 2002; 288:1723.

10. Cawley J, Rizzo JA, Haas K. Occupation-specific absenteeism costs associated with obesity and morbid obesity. Journal of Occupational and Environmental Medicine. 2007; 49:1317. [PubMed: 18231079]

11. Benedict MA, Arterburn D. Worksite-Based Weight Loss Programs: A Systematic Review of Recent Literature. American Journal of Health Promotion. 2008; 22:408–416. [PubMed: 18677881]

12. Anderson LM, Quinn TA, Glanz K, et al. The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: a systematic review. American Journal of Preventive Medicine. 2009; 37:340–357. [PubMed: 19765507]

13. Pelletier KR. A review and analysis of the clinical and cost-effectiveness studies of comprehensive health promotion and disease management programs at the worksite: Update VI1I 2008–2010. Journal of Occupational and Environmental Medicine. 2011; 53:1310. [PubMed: 22015548]

14. Finkelstein EA, Linnan LA, Tate DF, et al. A longitudinal study on the relationship between weight loss, medical expenditures, and absenteeism among overweight employees in the WAY to Health study. Journal of occupational and environmental medicine/American College of Occupational and Environmental Medicine. 2009; 51:1367. [PubMed: 19952786]

15. Blackburn G. Effect of degree of weight loss on health benefits. Obesity research. 1995; 3:211s. [PubMed: 8581779]

16. Linnan L, Tate DF, Harrington CB, et al. Organizational- and employee-level recruitment into a worksite-based weight loss study. Clinical Trials. 2012

17. Williams A. EuroQol—a new facility for the measurement of health-related quality of life. Health policy (Amsterdam, Netherlands). 1990; 16:199–208.

18. Koopman C, Pelletier KR, Murray JF, et al. Stanford Presenteeism Scale: Health Status and Employee Productivity. Journal of Occupational and Environmental Medicine. 2002; 44:14–20. [PubMed: 11802460]

19. Bureau of Labor Statistics. [Accessed July 30 2012] Consumer Price Index - All Urban Consumers, Medical Component. 2011. Available at: http://data.bls.gov/pdq/SurveyOutputServlet;jsessionid=D62CDE279B82A937CBCC8EB6716CC9BD.tc_instance4

20. Madrian BC. Employment-Based Health Insurance and Job Mobility: Is there Evidence of Job-Lock? The Quarterly Journal of Economics. 1994; 109:27–54.

21. McCullagh, P.; Nelder, JA. Generalized linear models. Chapman & Hall/CRC; 1989.

22. Ai C, Norton EC. Interaction terms in logit and probit models. Economics Letters. 2003; 80:123–129.

23. Oberhofer H, Pfaffermayr M. Fractional response models-A replication exercise of Papke and Wooldridge (1996). Working Papers. 2009

24. Papke, LE.; Wooldridge, J. Econometric methods for fractional response variables with an application to 401 (k) plan participation rates. Cambridge, Mass., USA: National Bureau of Economic Research; 1993.

25. Pohlmeier W, Ulrich V. An econometric model of the two-part decisionmaking process in the demand for health care. Journal of Human Resources. 1995:339–361.

26. Fu VK. Estimating generalized ordered logit models. Stata Technical Bulletin. 1999; 8

27. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. Journal of Health Economics. 1999; 18:153–171. [PubMed: 10346351]

28. Box GEP, Cox DR. An Analysis of Transformations. Journal of the Royal Statistical Society Series B (Methodological). 1964; 26:211–252.

29. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? Journal of Health Economics. 2001; 20:461–494. [PubMed: 11469231]

30. Park RE. Estimation with Heteroscedastic Error Terms. Econometrica. 1966; 34:888.

31. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. Biometrika. 1986; 73:13–22.
32. Søltoft F, Hammer M, Kragh N. The association of body mass index and health-related quality of life in the general population: data from the 2003 Health Survey of England. Quality of Life Research. 2009; 18:1293–1299. [PubMed: 19813103]
33. Jia H, Lubetkin EI. The impact of obesity on health-related quality-of-life in the general adult US population. Journal of public health. 2005; 27:156. [PubMed: 15820993]
34. Hassan M, Joshi A, Madhavan S, et al. Obesity and health-related quality of life: a cross-sectional analysis of the US population. International journal of obesity. 2003; 27:1227–1232. [PubMed: 14513071]
35. Bosello O, Armellini F, Zamboni M, et al. The benefits of modest weight loss in type II diabetes. International journal of obesity Supplement. 1997; 21:S10–S13.
36. Goldstein DJ. Beneficial health effects of modest weight loss. International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity. 1992; 16:397.
37. Mertens IL, Van Gaal LF. Overweight, obesity, and blood pressure: the effects of modest weight reduction. Obesity. 2000; 8:270–278.
38. Pi-Sunyer FX. Short-term medical benefits and adverse effects of weight loss. Annals of Internal Medicine. 1993; 119:722. [PubMed: 8363205]
39. Van Gaal L, Wauters M, De Leeuw I. The beneficial effects of modest weight loss on cardiovascular risk factors. International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity. 1997; 21:S5.
40. McElroy SL, Kotwal R, Malhotra S, et al. Are mood disorders and obesity related? A review for the mental health professional. Journal of Clinical Psychiatry. 2004
41. Linton SJ, Halldén K, Hellsing AL. The reliability of self-reported sick absenteeism: a pilot study. Cognitive Behaviour Therapy. 1995; 24:145–150.

Appendix

Table 1

Parameter estimates of the two-part models for HRQOL, absenteeism, presenteeism and health expenditures

	HRQOL		Absenteeism		Presenteeism	Health Expenditures†	
	Logit	**F-logit**	**Logit**	**ZTNB**	**Ordered logit**	**Logit**	**Log-Gamma GLM**
5% weight loss	0.335	0.014	−0.382	0.019	−0.280	−0.330*	−0.240
	(0.221)	(0.415)	(0.216)	(0.282)	(0.200)	(0.161)	(0.173)
Intervention dummy	−0.422***	−0.056	0.119	0.940***	−0.406***	0.272***	0.181**
	(0.094)	(0.161)	(0.100)	(0.130)	(0.120)	(0.052)	(0.065)
Intervention × 5% weight loss	0.300	0.168	−0.079	−0.378	−0.318	0.125	0.255
	(0.231)	(0.468)	(0.272)	(0.369)	(0.306)	(0.142)	(0.193)
Age at baseline (mean-centered)	−0.017*	−0.001	−0.014*	0.011	−0.016**	0.036***	0.020***
	(0.007)	(0.012)	(0.006)	(0.006)	(0.006)	(0.005)	(0.004)
Male dummy	0.184	0.082	−0.450*	−0.420*	0.111	−0.541***	−0.122
	(0.196)	(0.342)	(0.177)	(0.206)	(0.152)	(0.114)	(0.097)
Faculty dummy	−0.364*	−0.012	−0.495***	0.127	0.445***	0.046	−0.066
	(0.177)	(0.286)	(0.145)	(0.159)	(0.135)	(0.114)	(0.089)
Employee unspecified job dummy	−0.595	−0.149	0.284	−0.108	0.027	0.069	0.107
	(0.444)	(0.615)	(0.336)	(0.337)	(0.331)	(0.176)	(0.131)

	HRQOL		Absenteeism		Presenteeism	Health Expenditures†	
	Logit	**F-logit**	**Logit**	**ZTNB**	**Ordered logit**	**Logit**	**Log-Gamma GLM**
Baseline BMI	−0.028*	−0.007	0.015	0.012	0.044***	0.008	0.019***
	(0.011)	(0.018)	(0.009)	(0.009)	(0.009)	(0.008)	(0.006)
Co-morbidities	−0.566**	−0.106	0.352*	−0.069	0.181	1.002***	0.363***
	(0.207)	(0.298)	(0.160)	(0.164)	(0.157)	(0.176)	(0.100)
Incentive Study	−0.021	−0.020	−0.064	0.203	0.062	0.115	−0.075
	(0.142)	(0.233)	(0.120)	(0.131)	(0.113)	(0.103)	(0.078)
Web-based study	−0.100	0.004	0.084	−0.412***	0.122	0.132	−0.058
	(0.141)	(0.232)	(0.117)	(0.124)	(0.111)	(0.097)	(0.076)
CDC dummy	N/A	N/A	−0.199	0.329*	N/A	−0.222*	0.051
			(0.122)	(0.131)		(0.106)	(0.082)
Post-intervention period	N/A	N/A	N/A	N/A	N/A	0.241***	0.093
						(0.048)	(0.060)
Post-intervention × 5% weight loss	N/A	N/A	N/A	N/A	N/A	0.131	0.109
						(0.130)	(0.179)
Constant	1.996***	1.761*	−0.988*	−0.964*	N/A	−1.013**	4.962***
	(0.542)	(0.891)	(0.423)	(0.448)		(0.375)	(0.296)
Cut-off 1	N/A	N/A	N/A	N/A	0.931*	N/A	N/A
					(0.425)		
Cut-off 2	N/A	N/A	N/A	N/A	1.788***	N/A	N/A
					(0.427)		
Cut-off 3	N/A	N/A	N/A	N/A	2.905***	N/A	N/A
					(0.434)		

Standard errors displayed in brackets and significance levels are:

*** $p < 0.01$,

** $p < 0.05$,

* $p < 0.1$.

† Excluding inpatient expenditures, N/A: Non Applicable.

Table 1

Sample size for HRQOL, absenteeism, presenteeism and health expenditures analyses

	HRQOL (NHLBI)		Absenteeism		Presenteeism (NHLBI)		Health expenditures	
	n	%	n	%	n	%	n	%
Eligible enrollees	933		1,868		933		1,868	
Completed HIPAA consent (% enrollees)	N/A		N/A		N/A		1,409	75%
Excluded for specific ICD-9 codes* (% consented)	N/A		N/A		N/A		365	26%
Not enrolled in State Health Plan (% consented)							106	11%
Completed absenteeism/EQ-5D-3L/presenteeism questions at baseline and follow-up (% enrollees)	641	70%	1,167	62%	632	68%	N/A	
Missing value in any covariate	10	1%	30	1.6%	10	1%	18	1%
Analysis sample (% of enrollees)	631	67%	1,137	61%	622	67%	920	49%
5% weight loss or greater (% analysis sample)	105	17%	197	17%	106	17%	111	12%

*Excluded ICD-9 codes are: 230–319 (mental health problems), V01 and V02 (infectious diseases), 042–044 and V08 (HIV), and 83 & 912 (genetic testing).

N/A:Non Applicable.

Table 2

Descriptive statistics for each sample analyzed according to weight loss status, mean (s.e.)

	HRQOL		Absenteeism		Presenteeism		Health Expenditures	
	< 5% weight loss	5+ % weight loss	< 5% weight loss	5+ % weight loss	< 5% weight loss	5+ % weight loss	< 5% weight loss	5+ % weight loss
Baseline sample characteristics								
Age	46.18	45.16	46.55	45.25*	46.06	45.38	47.50	46.64
	(0.423)	(1.003)	(0.314)	(0.711)	(0.424)	(1.004)	(0.370)	(0.950)
Male	0.152	0.152	0.155	0.173	0.151	0.151	0.199	0.174
	(0.016)	(0.035)	(0.012)	(0.027)	(0.016)	(0.035)	(0.016)	(0.040)
Baseline BMI	34.00	34.10	33.87	33.52	33.95	34.30	34.19	33.63
	(0.281)	(0.588)	(0.218)	(0.438)	(0.281)	(0.588)	(0.264)	(0.654)
Faculty	0.205	0.238	0.253	0.330**	0.202	0.236	0.282	0.250
	(0.018)	(0.042)	(0.014)	(0.034)	(0.018)	(0.041)	(0.018)	(0.045)
Unspecified job	0.0304	0.0190	0.0245	0.0203	0.0291	0.0377	0.0231	0.0435
	(0.007)	(0.013)	(0.005)	(0.010)	(0.007)	(0.019)	(0.006)	(0.021)
Comorbidities	0.154	0.114	0.148	0.112	0.151	0.123	0.177	0.130
	(0.016)	(0.031)	(0.012)	(0.022)	(0.016)	(0.032)	(0.015)	(0.035)
Weight change								
in pounds	0.917	−18.55	1.176	−18.70	0.926	−18.41	0.450	−18.38
	(0.314)	(1.092)	(0.227)	(0.729)	(0.319)	(1.068)	(0.229)	(1.100)
in percentage	−0.458	8.882	−0.598	9.124	−0.465	8.754	−0.260	8.896
	(0.147)	(0.451)	(0.109)	(0.313)	(0.149)	(0.434)	(0.113)	(0.463)
Outcome Variables (EQ-5D, Absent days, SPS-6)								
at baseline	0.906	0.925*	0.421	0.310	9.343	8.349**	N/A	N/A
	(0.005)	(0.010)	(0.046)	(0.072)	(0.220)	(0.377)		
at 12 months	0.882	0.925***	0.808	0.421***	8.672	7.566***	N/A	N/A
	(0.005)	(0.009)	(0.090)	(0.116)	(0.202)	(0.314)		
Average quarterly health expenditures†								
Pre-intervention period (1 year)	N/A	N/A	N/A	N/A	N/A	N/A	517.7	375.7***

	HRQOL		Absenteeism		Presenteeism		Health Expenditures	
	< 5% weight loss	**5+ % weight loss**	**< 5% weight loss**	**5+ % weight loss**	**< 5% weight loss**	**5+ % weight loss**	**< 5% weight loss**	**5+ % weight loss**
							(29.458)	(58.501)
Intervention period (1 year)	N/A	N/A	N/A	N/A	N/A	N/A	684.2	682.1
							(52.424)	(112.551)
Post-intervention period (1.5 years)	N/A	N/A	N/A	N/A	N/A	N/A	660.6	548.6
							(40.708)	(76.614)

Standard errors displayed in brackets and 95% confidence intervals in squared brackets.

Significance levels:

*** p < 0.01,

** *p*< 0.05,

* *p*< 0.1.

† Excluding inpatient expenses, N/A:Non Applicable.

Table 3

Difference-in-difference estimates of the effect of weight loss on HRQOL, absenteeism, presenteeism and health expenditures

		< 5% weight loss		5 % weight loss		Difference-in-Difference [95% percentile C.I]
		Coef.	(S.E)	Coef.	(S.E)	
Quality of Life	Baseline	0.907	(0.005)	0.923	(0.010)	0.026**
	12 months	0.883	(0.005)	0.925	(0.008)	[0.002;0.050]
Absenteeism	Baseline	0.419	(0.045)	0.311	(0.441)	−0.258*
	12 months	0.807	(0.087)	0.441	(0.119)	[−0.579;0.057]
Presenteeism						
None (6)	Baseline	0.484	(0.021)	0.198	(0.012)	0.063
	12 months	0.182	(0.013)	0.135	(0.013)	[−0.050;0.183]
Low (7–9)	Baseline	0.552	(0.042)	0.187	(0.014)	−0.029*
	12 months	0.155	(0.018)	0.106	(0.019)	[−0.065;0.004]
Moderate (10–15)	Baseline	0.582	(0.022)	0.180	(0.011)	−0.023
	12 months	0.143	(0.012)	0.095	(0.011)	[−0.069;0.021]
High (16–30)	Baseline	0.713	(0.044)	0.138	(0.018)	−0.011
	12 months	0.094	(0.017)	0.055	(0.012)	[−0.053;0.028]
Average Quarterly Health Expenditures†						
Pre-intervention period (12 months)		$550	($31)	398	($59)	
Intervention period (12 months)		$698	($45)	679	($106)	$134 [−$69;$375]
Post-intervention period (18 months)		$635	($34)	534	($73)	$52 [−$106;$232]

Standard errors displayed in brackets and 95% confidence intervals in squared brackets.

Significance levels:

** $p < 0.05$

* $p < 0.1$.

† Excluding inpatient expenses.