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## Health Risk Factor Modification Predicts Incidence of Diabetes in an Employee Population: Results of an 8-Year Longitudinal Cohort Study

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### Abstract

**Objective**—To understand risk factor modification effect on Type 2 Diabetes incidence in a workforce population.

**Methods**—Annual Health Risk Assessment (HRA) data (n=3125) in years 1 through 4 were used to predict diabetes development in years 5 through 8.

**Results**—Employees who reduced their BMI from 30 to < 30 decreased their chances of developing diabetes (OR 0.22, 95% CI 0.05 to 0.93), while those who became obese increased their diabetes risk (OR 8.85, 95% CI 2.53 to 31.0).

**Conclusions**—Weight reduction observed over a long period can result in clinically important reductions in diabetes incidence. Workplace health promotion programs may prevent diabetes among workers by encouraging weight loss and adoption of healthy lifestyle habits.

### Introduction

Approximately 8.3% of the U.S. population currently has diabetes<sup>1</sup> and although randomized studies have demonstrated ways to prevent this disease through lifestyle modification, operationally it is difficult to translate and apply clinical trial findings to large populations in a scalable, cost-effective, and sustainable manner. Research has shown that even small changes in behavior, such as eating a healthy diet, engaging in regular physical activity, and maintaining a healthy weight can decrease the incidence of diabetes.<sup>1-8</sup> The Diabetes Prevention Program (DPP) randomized trial illustrated that individuals at risk for developing diabetes who participated in an intensive behavioral modification program reduced their risk for developing diabetes by 58% compared to controls.<sup>2,3</sup> These data are of particular interest to employers who attempt to replicate these results in the workplace by offering population-based health promotion programs. Health promotion programs, otherwise known as wellness programs, if implemented properly, promise, through their

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impact on modifiable risk factors, to reduce the incidence of chronic and debilitating illnesses such as diabetes.<sup>9-14</sup>

With results from clinical studies as background, many employers have introduced workplace health promotion programs to support their workers who wish to improve their health, with the ultimate aim of preventing unnecessary health care spending and boosting productivity.<sup>11-18</sup> However, a challenge faced by practitioners and researchers alike is documenting the scalability of risk reduction programs and their ability to prevent chronic diseases, such as diabetes, in large populations. Few long-term studies have been performed in workplace settings in which workers are followed over several years in an attempt to determine whether changes in certain health habits and biometric measures lead to the onset of diseases or, alternately, their prevention. One exception is a 7-year study of Vanderbilt University employees, whose changes in health risks were reported previously.<sup>19</sup> At Vanderbilt University, researchers found that employees' participation in the workplace wellness program, including the Go for the Gold (GFTG) component, was associated with improved health habits and risk reduction over a sustained multi-year period.

The current study leverages the longitudinal database of employees at Vanderbilt University described in the prior study to examine the relationship between certain risk factors likely to result in the development of diabetes. We report on an 8-year cohort of employees who contributed self-reported behavioral and biometric risk data annually as part of the University's health promotion program.

## Methods

### Background

Vanderbilt University, a private institution located in Nashville TN, employs nearly 24,000 faculty and staff in its Research University and medical center. Vanderbilt University introduced a voluntary, incentive-based wellness program to its employees in 2003 and has maintained an 80% participation rate in the program over the past 4 years. The Vanderbilt University wellness program aims to support the health and productivity of faculty and staff by encouraging and facilitating the adoption or maintenance of healthy lifestyle practices. Targeted health improvement programs address weight management, physical inactivity, tobacco use, stress, poor nutrition, alcohol misuse, hypertension, and high cholesterol. Programs include educational seminars, incentives for adoption or maintenance of positive health habits, behavior change interventions, and a supportive physical and social environment. A detailed description of the program is offered by Byrne, et al.<sup>19</sup>

### Sample

The study sample consisted of 3125 Vanderbilt University employees who participated in the University's GFTG program and completed a Health Risk Assessment (HRA) each year during the 8-year study period (2003-2010) and did not have diabetes at any time during years 1-4. Employees who reported having diabetes at baseline or at any time during the first 4 years of the 8-year evaluation period were excluded (n=213). This study was submitted to and reviewed by the Vanderbilt Institutional Review Board and was exempted from the need for IRB approval.

### Data

Data on employee demographics (gender, age, race, and hourly/salaried status as defined by the Fair Labor Standards Act [FLSA]) were obtained from the Human Resources Employee Data System. Self-reported health behaviors and risk factors were obtained from answers

provided on an annual Wellsource HRA, an assessment instrument that remained consistent throughout the 8-year evaluation period.<sup>19,20</sup>

### Defining Risk Factors and Diabetes Outcomes

Operational definitions for each self-reported risk factor are noted in Appendix A. Self-reported diabetes, the main outcome variable, was determined by employees' response to the HRA question "Has a doctor informed you that you currently have diabetes (high blood sugar)?" Answer choices included "yes, but not taking medication", or "yes, and taking medication". Otherwise, the question was left blank.

### Tracking Health Risks and Diabetes

The employee sample was divided into high vs. lower risk (having a risk factor outlined in Appendix A vs. not having it) for each risk factor at baseline (year 1). Employees were then followed over years 2 through 4 to determine whether they gained or lost each risk factor when compared to baseline. HRA data were then examined during years 5-8 to determine whether employees reported having developed diabetes.

Dose-response relationships in risk factor modification for obesity and physical activity temporally over years 2, 3, and 4 as related to self-reported diabetes in years 5 through 8 were also evaluated. Those who had "mixed," or inconsistent, risk factor profiles (those who gained *and* lost the risk factor during the baseline period) were analyzed separately.

### Statistical Analysis

The study used the entire cohort that met the aforementioned inclusion criteria. The primary end point was development of diabetes during years 5-8 (2007-2010). The null hypothesis was that there would be no statistically significant differences in diabetes development when comparing employees who maintained a risk factor or a healthy habit compared to those who did not. Continuous variables were analyzed using the Mann-Whitney U test. Categorical variables were assessed using the Pearson Chi-Square test.

To test for a dose-response relationship between the years with or without the risk factor, and the subsequent development of diabetes, a chi-square test for trend was applied. Logistic regression models were used to compute the unadjusted odds ratio and 95% confidence intervals (CI) for the change in each risk factor as a predictor for diabetes. Two additional multivariate logistic regression analyses were performed. The first adjusted for the following demographic variables: age, gender, and race (coded as white vs. non-white). The second added job type (exempt vs. non-exempt) to the demographic variables to control for confounding. All tests were 2-tailed. The statistical analysis was performed with the following software, SPSS (version 20), R ([www.r-project.org](http://www.r-project.org)), and Stata (version 9).<sup>21</sup>

## Results

### Demographics of Workers Who Developed Diabetes

Table 1 reports the demographic characteristics of the 3125 employees who completed the HRA in all 8 years, separating those who did not develop diabetes in years 5-8 (N=3027) from those who did (N=98). Workers who developed diabetes were more likely to be hourly employees, obese, and non-white ( $p < 0.001$ ).

### Obesity as a Risk Factor for Diabetes

For workers who were obese at baseline but were able to maintain a BMI below 30 (non-obese) for 3 consecutive years (years 2-4), the development of diabetes decreased from

10.1% (in those who remained obese over years 2-4) to 2.4% -- a 78% reduction in risk (OR 0.22, 95% CI 0.05 to 0.93  $p = 0.039$ ) (Table 2). After adjusting for age, gender, race, and FLSA status, this relationship remained significant (OR 0.20, 95% CI 0.05 to 0.86,  $p = 0.030$ ) (Table 3).

Conversely, for employees with a BMI below 30 at baseline who became and remained obese for the following 3 consecutive years, the risk of diabetes increased approximately 9-fold, from 1.2% for those who remained non-obese to 9.4% for those who became obese (OR 8.85 95% CI 2.53 to 31.0,  $P=0.001$ ) (Table 2). Adjusting for age, gender, race, and FLSA status did not alter the results (Table 4).

A dose-response relationship between the number of years a worker remained obese in years 2-4 and the subsequent risk for developing diabetes in years 5-8 was also seen (table available upon request), with more years being non-obese being related to a lower likelihood of developing diabetes. Likewise, for those who became obese, the incidence of diabetes increased with the number of years workers were obese during the baseline period.

### Sedentary Behavior as a Risk Factor for Diabetes

Table 5 shows the relationship between changes in physical activity of workers at baseline and the development of diabetes in later years. Of those who remained sedentary for the first 4 years, 8.1% developed diabetes. This rate decreased to 3.5% for those who exercised at least one day per week in years 2, 3, and 4. Of those who moved from physically active to sedentary in years 2 through 4, the risk of diabetes more than doubled (from 2.1% to 5.4%); however, there were only 37 people in this group. After adjusting for age, race, gender, and FLSA status, moving from a sedentary to a physically active lifestyle was no longer a statistically significant predictor for diabetes onset, with FLSA status most affecting this change in outcome (hourly employees were more likely to develop diabetes compared to salaried workers) (Tables 3 and 4).

Of note, as gender was not a statistically significant variable when determining demographic differences in those who did and did not develop diabetes (see Table 1), analysis excluding gender as an adjustment factor was also performed. It produced no statistically significant effects of physical activity changes on development of diabetes.

The A dose-response relationship in the number of years of physical activity on the development of diabetes was also noted. (table available upon request). The development of diabetes was, in general, related to the years sedentary in a dose-response fashion, meaning employees who were sedentary for more years at baseline were also more likely to develop diabetes.

### Other Risk Factors

Of the other risk factors investigated with regard to their association with the incidence of diabetes, moving from a high fat to low fat diet approached statistical significance after adjusting for age, gender, race, and FLSA status, as did better stress management. Changes in amount of sleep, type of grain in diet, amount of salt in diet, fruit and vegetable intake, alcohol use, blood pressure, total cholesterol, and tobacco use had no significant effect on future development of diabetes in this population. Ultimately, of the twelve risk factors analyzed, only weight was strongly associated with the subsequent development of diabetes. Physical activity status was also associated with diabetes development, though this association lost its statistical significance once adjustments for other factors were made.

## Discussion

Our analysis showed that development of diabetes was influenced primarily by two modifiable risk factors: obesity, and to a slightly lesser degree, physical inactivity. Employees who were obese at baseline year 1 but lost that risk in years 2-4, were about a quarter as likely to develop diabetes as those who remained obese (2.4% vs. 10.1%). Similarly, employees who were not obese at baseline year 1, but became obese, were almost 8 times more likely to develop diabetes at follow-up, compared to those who remained non-obese (9.4% vs. 1.2%). Further, the number of years employees remained non-obese was associated with a lower likelihood of developing diabetes, while the reverse was also true – number of years employees remained obese was associated with a higher likelihood of developing diabetes.

Similar patterns were found when looking at changes in exercise habits at baseline vs. follow-up. Employees who were sedentary throughout the first 4 years had a higher likelihood of developing diabetes (8.1%) when compared to those who were physically active all 4 years (2.1%). Here too, a dose-response relationship was found whereby the development of diabetes was, in general, related to the number of years of being sedentary across years 1-4 of the study period. However, unlike the obesity findings, the adjustment for other factors, particularly employment status (hourly vs. salaried), made the effect of exercise not statistically significant. Few salaried employees were sedentary and few developed diabetes.

This is one of the largest workplace-based studies in which a cohort of employees was followed over a lengthy time period to determine whether disease onset was affected by changes in modifiable risk factor status. As shown here, and in our previous study, positive behavior changes can be sustained over an extended time. For example, 10% of sedentary employees in this cohort became physically active and remained so over a 3-year period. Another 5% made more modest, but still significant, positive changes in physical activity.

Previously reported trends in the 7-year (2003-2009) cohort of Vanderbilt University wellness program participants documented decreases in physical inactivity, tobacco use, poor nutrition, and stress.<sup>19</sup> In addition, the percent of employees categorized as overweight or obese remained relatively stable over the study period (27.3% in 2003 vs. 28.0% in 2009), as compared to State of Tennessee adults (25.0% vs. 32.8%) and U.S. adults (22.9% vs. 26.9%),<sup>22</sup> both of whose obesity rates increased during the same time period.

The Diabetes Prevention Program study referenced earlier was a controlled clinical trial with relatively short intervention and follow-up periods. The current study underscores the opportunity for employers to apply clinical research findings in a workplace setting, albeit with significant economic and practical constraints.

In developing its workplace program, Vanderbilt University was guided by the RE-AIM formulation for translating rigorous study findings into a non-research setting -- by reaching a target population, demonstrating program effectiveness, adopting the programs to the institution, successfully implementing the intervention, and maintaining program fidelity over the long term.<sup>23</sup> Particularly important in this study was the ability to illustrate the “maintenance” aspect of the RE-AIM model – something not easily accomplished in clinical trials that are, by design, of a finite duration. This study illustrates how early changes in behavior can achieve long-term reductions in disease prevalence. Studies have shown that behavioral interventions on weight loss for patients can produce “modest” weight loss of 4-7 kgs in obese individuals, but these changes, in turn, can impact clinical outcomes such as glucose metabolism and blood pressure.<sup>24,25</sup> This study also reinforces the notion that even small improvements in health risks, such as moving individuals from obese to non-obese

status (as opposed to a normal weight), or encouraging them to be physically active for even one day a week, can impact workers' risk of diabetes. This is important for employers to understand since they often expect to achieve large-scale behavior changes from their employees who participate in wellness programs, which can be daunting.

We also found a consistent relationship between the length of time for adopting and maintaining a lifestyle change and subsequent development of diabetes. Individuals who developed a healthy habit (specifically increased weight loss and increased physical activity) in year 2 and sustained that habit through years 3 and 4 also experienced a lower likelihood of diabetes development, compared to those whose change occurred later in year 3 or year 4. This strengthens the argument that there is “dose-response” relationship between length of time certain habits are adopted and subsequent health outcomes. Indeed, similar dose-response relationships were seen in the converse; individuals who became and stayed obese or sedentary for a longer period over years 2-4 had a higher risk of developing diabetes than those whose change developed over a shorter period of time.

We also observed that a large proportion of employees were able to maintain healthy habits over a long period. A common concern for those sponsoring worksite programs is that workers will revert to poor health habits once an intensive, structured intervention is withdrawn. In this study, we noted that 72% of individuals were able to maintain non-obese status and 73% remained physically active over a 3 to 4 year period. These findings reinforce the idea that non-clinical interventions offered through worksite wellness programs can foster long-term adoption of healthy lifestyle habits that can pay dividends in overall health outcomes.

Our finding that FLSA status may moderate the relationship between health risks and disease occurrence was interesting. This is likely because there was a very small subset of exempt staff that moved from being physically active to sedentary. These findings suggest that work status may be an important influence on lifestyle habits and that the greater flexibility in work schedules that comes with exempt status may be a relevant consideration when focusing on worksite characteristics and policy interventions that may influence a workplace program's success.

## Limitations

There are several limitations to this study. One is a concern for selection bias. Although real, this limitation is not unique to this study, as any cohort can be subject to selection bias at the outset of a study. Attrition is another concern since only a small subset of the entire Vanderbilt University employee population was followed for the duration of the study. This limitation affects the generalizability of study findings. However, following a cohort increases the internal validity of the study since specific individuals can be followed longitudinally and the cohort is subject to the effects of aging which, by themselves, often negatively influence risk factors. The prior study published by Vanderbilt University with a 7-year cohort examined health risks for both cohort and aggregate population segments and found no meaningful differences in the trends for the two groups. The results shown here should be generalizable to other University-based worksite settings, and the diversity of the workplace population in this study could be expected to provide a degree of generalizability to the larger population. However, certain socioeconomic factors, such as access to health insurance, as well as overall education level of a University and Medical Center-based employee population, may limit the wider generalizability to the population as a whole.

Another potential limitation is the possibility that diabetes in this cohort was underreported at baseline. Studies have shown that knowledge of a condition, recall of information, and willingness to report information can potentially confound self-reported data.<sup>26,27</sup> Thus our

baseline diabetes designations could have missed those who a) had never previously been screened for diabetes, b) did not truly correlate a diagnosis of “high sugar” (as it is often known in lay terms) with diabetes, or c) were fearful about reporting a chronic health condition on an employer-sponsored survey. Accuracy of self-reported data with regard to disease states, as well as lifestyle and biometric data, has generated some concern,<sup>26-30</sup> although the validity of self-reported responses on an HRA have been documented.<sup>19,31</sup> Similarly, systems such as the CDC's Behavioral Risk Factor Surveillance System utilizes self-reported information to track health and behavior information of the US population,<sup>22</sup> lending added validity to such methods of obtaining information on a population level. Additionally, as noted in a previous paper, self-reported data from this program's 2003 HRA were compared to measured biometric data with good correlation.<sup>19</sup> If underreporting of diabetes was present during the baseline year, it is reasonable to expect similar underreporting in subsequent years.

This does bring attention, however, to the possibility of detection bias. Interestingly, the reduction in diabetes development in this observational study was greater than was the reduction seen in the Diabetes Prevention Program study (78% vs. 58%), which was an intensive clinical research study. Underreporting of diabetes during the follow-up time period (years 5-8) could potentially have occurred as a result of individuals developing healthier habits, subsequently feeling better and/or resulting in better symptomatic control of their disease, and thus undergoing fewer visits to their medical providers during the follow-up period. Identification of number of visits to a medical provider for each individual in the cohort would be needed to test this theory.

Additionally, as this cohort was not limited to those with pre-existing impaired glucose tolerance (as was the Diabetes Prevention Program study) this cohort may contain more “metabolically fit” individuals than did the Diabetes Prevention Program study. The fact that that trend results were comparable, however, could also underline the impact of early adoption of healthy lifestyle habits – before early evidence of the disease process is present.

Questions regarding gestational diabetes and family history were not asked on the HRA and these potential non-modifiable risk factors would need to be controlled if these data were available. Data analysis could also be affected by the possibility of a dose-response relationship with regard to the amount of physical activity needed in a given time period (e.g., per week) to affect diabetes development. By stratifying activity as sedentary vs. not sedentary, the differential effect of increasing levels of physical activity was not measurable and thus stratification of diabetes risk by exercise days is a research question to be addressed in future investigations.

Finally, those deemed to have an inconsistent pattern of behavior were excluded. It is possible that even intermittent change could have an impact on diabetes development, thus providing even stronger results. Given that these inconsistent behavior patterns are found in a real world population, subsequent larger studies that further investigate the various permutations of behavior patterns would certainly be beneficial to increase power and confirm statistical significance of these initial findings.

## Conclusions

This study provides encouraging data on the relationships between longitudinal, consistent behavioral risk factor changes and the subsequent development of diabetes in a working population. The study illustrates several key points to consider when designing workplace wellness programs. First, even small changes in behavior and biometric risks can have

lasting benefits related to the onset of disease. Second, the study demonstrates that lifestyle changes can be maintained over time which, in turn, produces long-term health benefits.

Other important and clinically relevant lessons include an observation that workplace wellness programs focused on obesity and physical activity may be most important in preventing future diseases, in this case diabetes. Further, our findings support the concept of keeping low risk employees at low risk while at the same time helping high-risk employees move to low risk status.

Risk factors other than obesity and physical activity, such as diet, stress, and alcohol use, also deserve investigation, though time to effect on overall health may be longer and thus may necessitate a longer time course of study. Indeed, this study opens the door for more in-depth investigation of the magnitude of the change, as well as the possible effect of other lifestyle factors on the health of our population and the role worksite wellness programs can have in affecting these changes.

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### Appendix A: Risk Factor Definitions

Characteristic	Definition of Risk
Biometric Risks	
High Cholesterol	Reported blood cholesterol (with or without taking medication) ≥ 240 mg/dL
High Blood Pressure	Reported blood pressure (with or without taking medication) of ≥ 140/90
Obesity	Body Mass Index ≥ 30
Behavioral Risks	
Sedentary	Exercise <1 time per week
Inadequate Fruits and Vegetables	<5 servings of fruits and vegetables per day
Smoking	Current cigarette smoker (chewing tobacco and pipe smoking were not included)
Alcohol Use	<1 alcoholic drink per day
High Fat Diet	As much or more high fat than low fat foods in daily diet
Inadequate Sleep	Get 7-8 hours of sleep on average per night less than half the time, seldom, or never
High Salt Intake	Adding salt to food or eating salty foods most meals or nearly every meal
Inadequate Whole Grain Intake	Eat as much or more refined grains than whole grains
Psychosocial Risks	
High Stress	Have trouble coping with current stress load at times, often, or unable to cope anymore



## References

1. Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.
2. National Diabetes Information Clearinghouse. Diabetes Prevention Program (DPP). National Institute of Diabetes and Digestive and Kidney Diseases. US Department of Health and Human Services, National Institutes of Health; Oct. 2008
3. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med.* 2002; 346(6):393–403. [PubMed: 11832527]
4. Hu FB, Manson JE, Stampfer MJ, Colditz G, Liu S, Solomon CG, et al. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med.* 2001; 345(11):790–7. [PubMed: 11556298]
5. Manson JE, Rimm EB, Stampfer MJ, Colditz GA, Willett WC, Krolewski AS, et al. Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. *Lancet.* 1991; 338(8770):774–8. [PubMed: 1681160]
6. Mozaffarian D, Kamineni A, Carnethon M, Djousse L, Mukamal KJ, Siscovick D. Lifestyle risk factors and new-onset diabetes mellitus in older adults: the cardiovascular health study. *Arch Intern Med.* 2009; 169(8):798–807. [PubMed: 19398692]
7. Reis JP, Loria CM, Sorlie PD, Park Y, Hollenbeck A, Schatzkin A. Lifestyle factors and risk for new-onset diabetes: a population-based cohort study. *Ann Intern Med.* 2011; 155(5):292–9. [PubMed: 21893622]
8. Salmeron J, Hu FB, Manson JE, Stampfer MJ, Colditz GA, Rimm EB, et al. Dietary fat intake and risk of type 2 diabetes in women. *Am J Clin Nutr.* 2001; 73(6):1019–26. [PubMed: 11382654]
9. Sorenson G, Landsbergis P, Hammer L, Amick B, Linnan L, Yancey A, et al. Preventing chronic disease in the workplace: a workshop report and recommendations. *Am J Public Health.* 2011; 101(S1):S196–S207. [PubMed: 21778485]
10. Quintiliani L, Sattelmair J, Sorensen G. World Health Organization. The workplace as a setting for interventions to improve diet and promote physical activity: Background paper prepared for the WHO/WEF joint event on preventing noncommunicable diseases in the workplace. 2007
11. Soler RE, Leeks Kimberly D, Razi Sima, Hopkins David, Griffith Matt, et al. A systematic review of selected interventions for worksite health promotion. The assessment of health risks with feedback. *Am J Prev Med.* 2010; 38(2S):S237–S62. [PubMed: 20117610]
12. Task Force on Community Preventive Services. Recommendations for worksite-based interventions to improve workers' health. *Am J Prev Med.* 2010; 38(2 Suppl):S232–6. [PubMed: 20117609]
13. Carnethon M, Whitsel LP, Franklin BA, Kris-Etherton P, Milani R, Pratt CA, et al. Worksite wellness programs for cardiovascular disease prevention: a policy statement from the American Heart Association. *Circulation.* 2009; 120(17):1725–41. [PubMed: 19794121]
14. Silberman J, Schwartz S, Giuseffi DL, Wang C, Nevedal D, Bedrosian R. Reductions in employee productivity impairment observed after implementation of web-based worksite health promotion programs. *J Occup Environ Med.* 2011; 53(12):1404–12. [PubMed: 22173284]
15. Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, absence, disability, and presenteeism cost estimates of certain physical and mental health conditions affecting U.S. employers. *J Occup Environ Med.* 2004; 46(4):398–412. [PubMed: 15076658]
16. Schultz AB, Edington DW. Employee health and presenteeism: a systematic review. *J Occup Rehabil.* 2007; 17(3):547–79. [PubMed: 17653835]
17. Baicker K, David C, Song Ziui. Workplace wellness programs can generate savings. *Health Aff.* 2010; 29(2):304–11.
18. Thygeson NM. A health plan perspective on worksite-based health promotion programs. *Am J Prev Med.* 2010; 38(2 Suppl):S226–8. [PubMed: 20117607]
19. Byrne DW, Goetzel RZ, McGown PW, Holmes MC, Beckowski MS, Tabrizi MJ, et al. Seven-year trends in employee health habits from a comprehensive workplace health promotion program at vanderbilt university. *J Occup Environ Med.* 2011; 53(12):1372–81. [PubMed: 22104977]

20. Inc W Personal Wellness Profile, Concise Assessment Plus Clackamas OR1987-2010
21. Institute for Statistics and Mathematics WW. The R Project for Statistical Computing. [cited 2012]; Available from: <http://www.r-project.org/>
22. Centers for disease Control and Prevention, United States Department of Health and Human Services. Behavioral Risk Factor Surveillance System Prevalence and Trends Data. 2011. [cited 2012 July 3]; Available from: <http://apps.nccd.cdc.gov/brfss/page.asp?cat=XX&yr=2010&state=All#XX>
23. National Cancer Institute UNIoH. Reach Effectiveness Adoption Implementation Maintenance (RE-AIM). 2012. [cited 2012 March 7]; Available from: <http://cancercontrol.cancer.gov/is/reaim/>
24. US Preventive Services Task Force. Screening for Obesity in Adults: Recommendations and Rationale. [cited 2012 July 30] <http://www.uspreventiveservicestaskforce.org/uspstf11/obeseadult/obesers.htm#rationale>
25. Joint National Committee on Prevention D, Evaluation, and Treatment of High Blood Pressure. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. United States Department of Health and Human Services, National Institutes of Health, National Heart Lung, and Blood Institute; Aug. 2004 NIH Publication No. 04-5230
26. Molenaar EA, Van Ameijden EJ, Grobbee DE, Numans ME. Comparison of routine care self-reported and biometrical data on hypertension and diabetes: results of the Utrecht Health Project. *Eur J Public Health*. 2007; 17(2):199–205. [PubMed: 16887835]
27. Goldman N, Lin IF, Weinstein M, Lin YH. Evaluating the quality of self-reports of hypertension and diabetes. *J Clin Epidemiol*. 2003; 56(2):148–54.
28. Newell SA, Girgis A, Sanson-Fisher RW, Savolainen NJ. The accuracy of self-reported health behaviors and risk factors relating to cancer and cardiovascular disease in the general population: a critical review. *Am J Prev Med*. 1999; 17(3):211–29. [PubMed: 10987638]
29. Johansson J, Hellenius ML, Elofsson S, Krakau I. Self-report as a selection instrument in screening for cardiovascular disease risk. *Am J Prev Med*. 1999; 16(4):322–4. [PubMed: 10493290]
30. Oliveira A, Ramos E, Lopes C, Barros H. Self-reporting weight and height: misclassification effect on the risk estimates for acute myocardial infarction. *Eur J Public Health*. 2009; 19(5):548–53. [PubMed: 19304731]
31. Edington, DW.; Yen, L.; Braunstein, A. The reliability and validity of health risk assessments. In: Hyner, G.; Peterson, K.; Travis, J.; Dewet, J.; Forester, J.; Frammer, E., editors. *SPM Handbook of Health Assessment Tools*. Pittsburgh, PA: The Society of Prospective Medicine and Institute for Health and Productivity Management; 1999.

### **Clinical Significance**

Weight reduction observed over a long period can result in clinically important reductions in diabetes incidence. Workplace health promotion programs may prevent diabetes among workers by encouraging weight loss and adoption of healthy lifestyle habits.

**Table 1**  
**Characteristics of the 3125 Participants and the Development of Diabetes Between Year 5 and Year 8**

	Did Not Develop Diabetes (n=3027)	Developed Diabetes (n=98)	Row Percent Developing Diabetes	P value
<b>Baseline Age (Year)</b>	43.6 ± 9.3	45.5 ± 8.8		0.047a
<b>Gender</b>				0.272b
<b>Female</b>	2130 (70.4%)	74 (75.5%)	3.4%	
<b>Male</b>	897 (29.6%)	24 (24.5%)	2.6%	
<b>Race</b>				<0.001b
<b>White</b>	2472 (81.7%)	72 (73.5%)	2.8%	
<b>African-American</b>	266 (8.8%)	21 (21.4%)	7.3%	
<b>Hispanic</b>	36 (1.2%)	3 (3.1%)	7.7%	
<b>Asian</b>	241 (8.0%)	1 (1.0%)	0.4%	
<b>Other</b>	12 (0.4%)	1 (1.0%)	7.7%	
<b>Baseline BMI</b>	26.9 ± 6.9	34.0 ± 7.9		<0.001a
<b>Fair Labor Standards</b>				<0.001b
<b>Act Status</b>				
<b>Exempt</b>	1906 (63.0%)	41 (41.8%)	2.1%	
<b>Nonexempt</b>	1121 (37.0%)	57 (58.2%)	4.8%	

a-Denotes a P values based on a Mann-Whitney U test; b-Pearson chi-square.

\* Plus - minus values are means ± SD.

**Table 2**

**Obesity**

Group	Year 1	Years 2-4	Developed Diabetes in Years 5-8	OR (95% CI)	P value
<b>Keep Risk Factor</b>	BMI ≥30	BMI ≥30	55 / 544 (10.1%)		
<b>Lose Risk Factor</b>	BMI <30	BMI <30	2 / 82 (2.4%)	0.22 (0.05 – 0.93)	0.039
<b>Keep Healthy Habit</b>	BMI <30	BMI <30	25 / 2163 (1.2%)		
<b>Lose Healthy Habit</b>	BMI <30	BMI ≥30	3 / 32 (9.4%)	8.85 (2.53 – 31.0)	0.001
<b>Mixed/Unstable Weight Pattern (“yo-yo”)</b>			13 / 304 (4.3%)		

P<0.001 using a chi-square test with 5 groups.

**Table 3**  
**Summary of the association between a losing a risk factor between Year 1 and 2-4, and the development of diabetes between Year 5-8**

Losing a Risk Factor	Unadjusted		Adjusted <sup>**‡</sup>		Adjusted <sup>**‡</sup>	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
<b>Obesity</b>	0.22 (0.05-0.93)	0.039	0.20 (0.05 – 0.86)	0.030	0.20 (0.05 – 0.86)	0.030
<b>Sedentary</b>	0.41 (0.17 – 0.99)	0.046	0.42 (0.17 – 1.01)	0.054	0.49 (0.20 – 1.22)	0.123
<b>High Fat Diet</b>	0.45 (0.19 – 1.08)	0.074	0.38 (0.16 – 0.92)	0.033	0.41 (0.17 – 1.004)	0.051
<b>High Stress</b>	0.19 (0.03 – 1.20)	0.078	0.17 (0.03 – 1.14)	0.068	0.17 (0.02 – 1.15)	0.069

\* Adjusted for baseline age, gender, race (white vs. nonwhite)

\*\* Adjusted for baseline age, gender, race (white vs. nonwhite), FLSA status

‡ Adjustments excluding gender were also done but this exclusion had no impact on statistical significance.

Note: Other risk factors, including inadequate sleep, inadequate whole grain intake, high salt intake, high blood pressure, alcohol use, inadequate fruit/vegetable intake, high cholesterol, and smoking, were also evaluated, though were not included in the table, as none were statistically significant in unadjusted or adjusted status.

**Table 4**  
**Summary of the association between a losing a healthy habit between Year 1 and 2-4, and the development of diabetes between Year 5-8**

	Unadjusted		Adjusted **‡		Adjusted ***‡	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
<b>Losing a Healthy Habit</b>						
<b>Non-Obese</b>	8.85 (2.53 – 31.0)	0.001	8.80 (2.48 – 31.2)	0.001	8.72 (2.44 – 31.20)	0.001
<b>Exercise</b>	2.62 (0.61 – 11.25)	0.195	2.96 (.068 – 12.91)	0.148	2.94 (0.67 – 12.86)	0.115

\* Adjusted for baseline age, gender, race (white vs. nonwhite)

\*\* Adjusted for baseline age, gender, race (white vs. nonwhite), FLSA status

‡ Adjustments excluding gender were also done but this exclusion had no impact on statistical significance.

Note: Other healthy habits, including adequate sleep, adequate whole grain intake, low salt intake, normal blood pressure, alcohol use, adequate fruit/vegetable intake, normal cholesterol, and nonsmoking, were also evaluated, though were not included in the table, as many had a low number of participants who had healthy habit at baseline but lost them for 3 consecutive years and none were statistically significant in unadjusted or adjusted status.

**Table 5**

**Exercise**

<b>Group</b>	<b>Year 1</b>	<b>Years 2-4</b>	<b>Developed Diabetes in Years 5-8</b>	<b>OR (95% CI)</b>	<b>P value</b>
<b>Keep Risk Factor</b>	Sedentary	Sedentary	10 / 123 (8.1%)		
<b>Lose Risk Factor</b>	Sedentary	Exercise	11 / 316(3.5%)	0.41 (0.17 – 0.99)	0.046
<b>Keep Healthy Habit</b>	Exercise	Exercise	42 / 1967 (2.1%)		
<b>Lose Healthy Habit</b>	Exercise	Sedentary	2 / 37 (5.4%)	2.62 (0.61 – 11.25)	0.195
<b>Mixed/Unstable Exercise Pattern</b>			33 / 682 (4.8%)		