Abstract

Background: Obesity is a major risk factor for development and progression of hypertension and diabetes, which often coexist in obese patients. Losing weight by means of energy restriction and physical activity has been effective in preventing and managing these diseases. However, weight control behaviors among overweight/obese adults with these conditions are poorly understood.

Methods: Using self-reported data from 143,386 overweight/obese participants (aged ≥ 18 years) in the 2003 Behavioral Risk Factor Surveillance System, we examined the proportion of overweight/obese adults who tried to lose weight and their weight control strategies by hypertension and/or diabetes status.

Results: Among all participants, 58% of those with hypertension, 60% of those with diabetes, and 72% of those with both diseases tried to lose weight, significantly higher than the 50% of those with neither condition (Bonferroni corrected P < 0.017 for all comparisons). The multivariate-adjusted odds ratio (AOR) for trying to lose weight was 1.11 (95% confidence interval [CI]: 1.05–1.17) in participants with hypertension, 1.02 (95% CI: 0.90–1.15) in participants with diabetes, and 1.18 (95% CI: 1.07–1.29) in participants with both diseases (participants with neither condition as the referent). Among 78,446 participants who tried to lose weight, 23% of those with hypertension only and 28% of those with both hypertension and diabetes reported adopting a low fat/low calorie (LF/LC) diet in controlling their weight, significantly higher than 19% of those with neither disease (Bonferroni corrected P < 0.017 for all comparisons). Participants with both diseases had a significantly lower percentage of adopting physical activity in controlling their weight than those with neither condition (6% versus 12%, P < 0.01). After multivariate adjustment, the AOR for adopting a LF/LC diet plus physical activity to lose weight was 1.46 (95% CI: 1.15–1.84) in participants with both diseases. The AOR for adopting a LF/LC diet only to lose weight was 1.72 (95% CI: 1.35–2.20) in participants with both diseases and was 1.21 (95% CI: 1.03–1.40) in participants with hypertension only.

Conclusion: The proportion of overweight/obese patients with diagnosed hypertension and/or diabetes who attempted to lose weight remains suboptimal and the weight control strategies varied significantly among these patients.
Introduction
The rising trend in overweight and obesity has been a serious and growing public health problem in the United States [1-3]. From 1976–1980 to 2001–2004, the prevalence of overweight/obesity increased by 39% (from 47.4 to 66.0%) and the prevalence of obesity increased by 113% (from 15.1 to 32.1%) [1,2], the latter has increased slightly to 34.3% during 2005–2006 [4]. Obesity is associated with an increased risk of developing hypertension and diabetes [5-14]. In fact, the prevalence of diagnosed hypertension and diabetes has increased significantly from 1988–1994 to 2001–2004 (21.7% versus 26.7% for hypertension, 5.4% versus 7.3% for diabetes) [1]. In addition, the prevalence of obesity has doubled from 25.7% during 1976–1980 to 50.8% during 1999–2004 among people with hypertension [15]. Moreover, strong associations between a higher body mass index (BMI) and risk of hypertension or diabetes exist even among people within a normal BMI range [9,16].

A growing body of evidence has shown that losing weight by means of energy restriction and/or increasing physical activity has beneficial effects on the prevention and management of both diseases. A meta-analysis of randomized controlled trials on people with or without hypertension showed that an average weight loss of 5.1 kilograms reduced systolic blood pressure by 4.4 mm Hg and diastolic blood pressure by 3.6 mm Hg [17]. Among overweight/obese adults, increasing amount of intentional weight loss was associated with a linear decrease in diabetes incidence [10,18], and active weight loss is an effective approach to the treatment of people with diabetes [19-22]. Moreover, intentional weight loss is also associated with a significant reduction in all-cause mortality rate in people with or without diabetes [23-26].

Presently, little is known about weight control behaviors among overweight/obese adults with hypertension, diabetes, or both in the U.S. Given an increasing scientific and media attention on the multiple health benefits weight control/weight loss confers, we hypothesized that overweight/obese people with either hypertension or diabetes are more likely to attempt to lose weight (with the highest seen in people with both hypertension and diabetes) compared to people with neither condition. Using data from a nationally representative sample, we examined the proportion of overweight/obese people who attempted to lose weight and their weight control strategies among those with diagnosed hypertension, diabetes or both. We hope this study will increase our understanding concerning weight control behaviors in light of the increasing trends in overweight/obesity, hypertension, and diabetes in the U.S. population.

Methods
Data for our analyses came from the Behavioral Risk Factor Surveillance System (BRFSS), a population-based telephone survey of health-related behaviors regarding the leading causes of death among noninstitutionalized U.S. adults aged ≥18 years. The BRFSS survey design, sampling methods and weights have been described elsewhere [27], and BRFSS data have consistently been found to provide valid and reliable estimates when compared to other national household surveys in the U.S. [27-29]. The survey was reviewed by the Human Research Protection Office at the Centers for Disease Control and Prevention and determined to be exempt from human subject guidelines. Further information on BRFSS is available at http://www.cdc.gov/brfss/.

In 2003, a total of 149,324 participants who were overweight/obese (BMI ≥25 kg/m², calculated from self-reported weight and height) were interviewed in all 50 states, the District of Columbia, and three U.S. territories of Guam, Puerto Rico and the Virgin Islands. The median cooperation rate (the percentage of eligible persons contacted who completed the interview) was 74.8%.

Respondents' hypertension and diabetes status were assessed by asking them whether they had ever been told by a doctor or other health professional that they had had these conditions. Those who answered that they had not been told they had hypertension (or diabetes) or they had these conditions only during pregnancy were categorized as "no diagnosed hypertension (or diabetes)". Respondents were then categorized as 1) having both hypertension and diabetes, 2) having hypertension only, 3) having diabetes only, and 4) having neither disease. Weight control status was assessed by asking respondents whether they were trying to lose weight. For those who responded with a "yes" to the question, they were further asked whether they were eating less fat and/or fewer calories (defined as a low fat/low calorie [LF/LC] diet) or participating in physical activity or exercise to lose weight. The receipt of doctors' advice on weight loss was assessed by asking respondents whether in the previous 12 months a doctor, nurse or other health professional had given them advice about their weight. Their responses were 1) yes, lose weight; 2) yes, gain weight; 3) yes, maintain current weight; 4) no advice; and 5) don't know/not sure. We treated the first category as "receipt of weight-loss advice" and combined the rest 4 categories into "receipt of no advice on weight loss".

The demographic variables in our analyses included respondents' age, sex, BMI, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and others), education levels (< high school diploma, high school graduate, some college/technical school, and ≥ college graduate),
marital status (married, divorced, never married, and others), and employment status (employed for wages, self-employed, unemployed, and retired). Current smokers were those participants who had smoked ≥ 100 cigarettes during their lifetime and were still smoking. Current non-smokers were those who had either had smoked <100 cigarettes during their lifetime or had smoked ≥ 100 cigarettes in their entire life but stopped.

After excluding from the analytical sample participants who refused to answer, had missing responses to any questions, or responded "don’t know/not sure" to any questions (except for the question on receiving weight-loss advice), a total of 143,386 participants were included in our analyses. The percentages of overweight/obese adults who attempted to lose weight and adopted a LF/LC diet and/or physical activity to lose weight by hypertension and/or diabetes status were weighted to the state populations and age-standardized to the 2000 U.S. population. A Bonferroni corrected P-value (labeled as P value only in the text) was used for multiple comparisons. Logistic regression analyses were conducted to assess the odds ratios for trying to lose weight and for adoption of a LF/LC diet and/or physical activity to lose weight among people with hypertension and/or diabetes using people with neither condition as the referent. We used SUDAAN software (release 9.0, Research Triangle Institute, Research Triangle Park, NC) to account for the multi-stage, disproportionate stratified sampling design.

Results
Of all participants, 10,963 had both hypertension and diabetes, 40,666 had hypertension only, 5,143 had diabetes only, and 86,614 had neither condition. Overall, 72.1% (95% confidence interval [CI]: 68.7–75.2%) of those with both hypertension and diabetes, 57.8% (95% CI: 56.4–59.1%) of those with hypertension only, and 60.0% (95% CI: 56.2–63.8%) of those with diabetes only attempted to lose weight, significantly higher than the 49.8% (95% CI: 49.1–50.4%) of those with neither condition (P < 0.017 for all comparisons). The percentages of adults who tried to lose weight also varied significantly by gender and BMI levels (Figure 1 and Table 1). Overweight/obese women had a higher prevalence of trying to lose weight than overweight/obese men did except for those who were obese (BMI ≥ 30 kg/m²) and had both hypertension and diabetes concomitantly (i.e., 81% among obese women and men with both conditions). In addition, the prevalence of trying to lose weight increased with age till the age of 50–59 years and thereafter decreased; it was lower in non-Hispanic blacks than in non-Hispanic whites (P = 0.008), and was the lowest in those who were educated at less than a high-school diploma (P < 0.008) and who were current smokers among the selected categories (P < 0.017, Table 1). However, the prevalence of trying to lose weight was significantly higher in participants who received weight-loss advice than in those who did not (P < 0.001).

![Figure 1](image_url)

**Figure 1**
Age-standardized percentages of men and women who attempted to lose weight by BMI and by hypertension and diabetes status, BRFSS, 2003. HTN: hypertension; DM: diabetes.
Among those who attempted to lose weight, 63.5% (95% CI: 62.8–64.2%) of them tried to lose weight by adopting a LF/LC diet and participating in physical activity, 21.0% (95% CI: 20.5–21.6%) by adopting a LF/LC diet only, and 10.9% (95% CI: 10.4–11.4%) by participating in physical activity only (Table 2). Overall, the percentages of adults who adopted a LF/LC diet plus physical activity did not differ significantly by hypertension/diabetes status; however, among those who were overweight, participants with both hypertension and diabetes had the highest prevalence (73.8%, 95% CI: 69.0–78.1%) of adopting a LF/LC diet plus physical activity to lose weight (P < 0.008). In addition, participants either with both hypertension and diabetes (27.6%, 95% CI: 24.4–31.1%) or with hypertension only (23.3%, 95% CI: 21.8–24.8%) had significantly higher percentages of adopting a LF/LC diet in controlling their weight, compared to those with neither condition (19.0%, 95% CI: 18.2–19.7%, P < 0.008 for both comparisons, Table 2). Among those who were overweight, participants with diabetes tended to have a higher prevalence of adopting a LF/LC diet only to lose weight; however, among those who were obese, participants with both hypertension and diabetes had a higher prevalence of adopting a LF/LC diet only than those with diabetes only (30.0% versus 22.0%, P < 0.008) or than those with neither condition (19.0%, 95% CI: 18.2–19.7%, P < 0.008). Overall, participants with both hypertension and diabetes had a lower percentage of participating in physical activity to lose weight than those with hypertension only (6.3% versus 10.2%, P < 0.008) or than those with neither condition (6.3% versus 11.8%, P < 0.008).

Compared to participants with neither disease, participants with either hypertension or diabetes or both were 2.3 to 3.9 times as likely to receive doctors’ advice on weight loss (Table 3). However, after adjustment for socio-demographic variables and the receipt of weight-loss advice, only participants with both hypertension and diabetes or with hypertension only were significantly more likely to try to lose weight (Table 3). Among participants who attempted to lose weight, participants with both hypertension and diabetes were significantly more likely to lose weight by adopting a LF/LC diet only after multivariate adjustment. In addition, participants with hypertension only were significantly more likely to adopt a LF/LC diet to control their weight (Table 3).

**Table 1: Age-standardized percentages of overweight/obese adults who attempted to lose weight by selected characteristics, BRFSS 2003**

| Characteristic                      | n   | % (SE)  |
|-------------------------------------|-----|---------|
| Total                               | 143,386 | 52.8 (0.3) |
| Disease status                      |     |         |
| Having hypertension and diabetes    | 10,963 | 72.1 (1.7) |
| Having hypertension only            | 40,666 | 57.8 (0.7) |
| Having diabetes only                | 5,143  | 60.0 (1.9) |
| Having neither                      | 86,614 | 49.8 (0.3) |
| Sex                                 |     |         |
| Men                                 | 67,734 | 44.5 (0.4) |
| Women                               | 75,652 | 64.2 (0.4) |
| BMI (kg/m²)                         |     |         |
| 25.0–<30.0                          | 87,200 | 44.3 (0.3) |
| ≥30.0                               | 56,186 | 66.6 (0.4) |
| Age (y)                             |     |         |
| 18–29                               | 15,458 | 51.0 (0.8) |
| 30–39                               | 24,678 | 51.8 (0.6) |
| 40–49                               | 31,197 | 55.6 (0.6) |
| 50–59                               | 30,016 | 59.2 (0.5) |
| 60–69                               | 21,935 | 55.4 (0.6) |
| ≥70                                 | 20,102 | 43.4 (0.7) |
| Race                                |     |         |
| Non-Hispanic white                  | 111,158 | 53.1 (0.3) |
| Non-Hispanic black                  | 13,290  | 50.9 (0.8) |
| Hispanic                            | 10,872  | 52.9 (1.0) |
| Other                               | 8,066   | 51.7 (1.3) |
| Education                           |     |         |
| < high school diploma               | 16,557  | 46.8 (0.9) |
| High school graduate                | 46,201  | 50.7 (0.5) |
| Some college/technical              | 39,301  | 55.4 (0.5) |
| ≥ college graduate                  | 41,327  | 55.5 (0.5) |
| Marital status                      |     |         |
| Married                             | 81,690  | 53.0 (0.4) |
| Divorced                            | 20,482  | 51.8 (1.1) |
| Never married                       | 19,091  | 53.9 (0.8) |
| Other                               | 22,123  | 52.5 (0.9) |
| Employment                          |     |         |
| Employed for wages                  | 72,302  | 52.3 (0.5) |
| Self-employed                       | 13,588  | 49.5 (1.0) |
| Unemployed                          | 28,203  | 57.5 (0.6) |
| Retired                             | 29,293  | 59.3 (5.3) |
| Smoking                             |     |         |
| Current smoker                      | 28,346  | 44.8 (0.6) |
| Former smoker                       | 42,275  | 54.9 (0.6) |
| Never smoked                        | 72,765  | 54.7 (0.4) |
| Receipt of weight loss advice        |     |         |
| Yes                                 | 29,972  | 80.6 (0.5) |
| No                                  | 113,414 | 46.0 (0.3) |

BRFSS: Behavioral Risk Factor Surveillance System; SE: standard error
loss in control of hypertension and diabetes have been demonstrated.

To our knowledge, this is the first large study to examine weight control behaviors in overweight/obese people by hypertension and/or diabetes status. A few earlier studies reported that, during 1996–2000, 24% to 33% of men and 38% to 46% of women in the general U.S. population were trying to lose weight regardless of their BMI levels [30-32]. Among overweight/obese people, 48% of men and 66% of women were trying to lose weight [33]. We have previously reported that 59% of hypertensive women attempted to lose weight [34]. In the present study, we further demonstrated that only 58% to 72% of people with either hypertension or diabetes or both tried to lose weight. Moreover, contrary to expectations, we found that overweight/obese patients with diagnosed diabetes were only as likely as those with neither condition (hypertension and diabetes) to attempt to lose weight after multivariate adjustment for socio-demographic characteristics, smoking status and receipt of doctors’ advice on weight loss, suggesting intensive intervention or education programs are needed for diabetes patients.

Weight loss by various strategies significantly reduces body fat mass, blood pressure, fast glucose and hemoglobin A1c, and improves the 2-h glucose tolerance test, beta-cell function, and insulin sensitivity [17,19-22,35-37].

| Table 2: Age-standardized percentages of overweight/obese adults who attempted to lose weight by adopting a low fat/low calorie diet and/or engaging in physical activity, by BMI and hypertension/diabetes status, BRFSS 2003 |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                               | HTN/DM (n = 6,909) | HTN (n = 22,910) | DM (n = 3,015) | Neither (n = 45,612) | Total (n = 78,446) |
| Adopting a LF/LC diet and engaging in physical activity | % (SE) | % (SE) | % (SE) | % (SE) | % (SE) |
| BMI (kg/m²) |
| 25–<30  | 73.8 (2.3) | 65.3 (1.2) | 58.7 (4.9) | 66.5 (0.6) | 65.9 (0.5) |
| ≥ 30    | 60.6 (2.4) | 59.2 (1.2) | 63.5 (2.7) | 61.3 (0.7) | 60.9 (0.5) |
| total   | 63.2 (2.0) | 61.9 (0.9) | 62.4 (2.4) | 64.5 (0.5) | 63.5 (0.4) |
| Adopting a LF/LC diet only |
| BMI (kg/m²) |
| 25–<30  | 18.1 (2.0) | 18.6 (0.8) | 29.0 (5.1) | 16.5 (0.4) | 17.7 (0.4) |
| ≥ 30    | 30.0 (2.0) | 26.9 (1.1) | 22.0 (1.8) | 23.0 (0.7) | 24.7 (0.4) |
| total   | 27.6 (1.7) | 23.3 (0.8) | 23.9 (2.1) | 19.0 (0.4) | 21.0 (0.3) |
| Engaging in physical activity only |
| BMI (kg/m²) |
| 25–<30  | 5.0 (1.1) | 11.7 (1.0) | 7.7 (1.6) | 12.8 (0.4) | 12.2 (0.4) |
| ≥ 30    | 6.5 (1.4) | 9.0 (0.8) | 9.5 (2.3) | 10.4 (0.4) | 9.5 (0.3) |
| total   | 6.3 (1.2) | 10.2 (0.6) | 9.0 (1.8) | 11.8 (0.3) | 10.9 (0.2) |

Table 3: Adjusted odds ratios (AORs) for trying to lose weight and receiving weight-loss advice in overweight/obese adults with hypertension and/or diabetes, or the AORs for adopting a low fat/low calorie diet and/or engaging in physical activity among those who attempted to lose weight (using people with neither disease as the referent), BRFSS 2003

| Among overweight/obese people (n = 143,386) |
|--------------------------------------------|
| Trying to lose weight† | 1.18 (1.07–1.29) | 1.11 (1.05–1.17) | 1.02 (0.90–1.15) | 1.00 |
| Receipt of weight-loss advice‡ | 3.88 (3.52–4.29) | 2.28 (2.14–2.44) | 3.23 (2.81–3.71) | 1.00 |

| Among overweight/obese people who attempted to lose weight (n = 78,446) |
|---------------------------------------------------------------------|
| Adopting a LF/LC diet/engaging physical activity† | 1.46 (1.15–1.84) | 1.07 (0.92–1.23) | 1.03 (0.77–1.37) | 1.00 |
| Adopting a LF/LC diet only† | 1.72 (1.35–2.20) | 1.21 (1.03–1.40) | 1.05 (0.78–1.43) | 1.00 |
| Engaging in physical activity only† | 0.96 (0.70–1.31) | 0.95 (0.79–1.13) | 0.80 (0.55–1.16) | 1.00 |

†: Adjusted for age, sex, race/ethnicity, body mass index, education, marital status, employment, smoking, and receipt of weight-loss advice
‡: Adjusted for the same variables as listed above except for receipt of weight-loss advice.

BRFSS: Behavioral Risk Factor Surveillance System; HTN/DM: having both hypertension (HTN) and diabetes (DM); LF/LC: low fat/low calorie
A variety of weight-loss strategies have been implemented in the U.S. population including eating less fat or fewer calories, increasing physical activity or exercise, skipping meals, eating food supplements, taking diet pills, and taking water pills or diuretics [46]. Among those trying to lose weight, reducing fat/calorie intake was the most common strategy [31,33]. In the present study, two common strategies for weight control – eating less fat/fewer calories and increasing exercise/physical activity were examined. An encouraging finding of our study is that over 60% of overweight/obese patients attempted to lose weight by the combined strategies regardless of their disease status. Patients with both hypertension and diabetes were 46% more likely to lose weight by the combined strategies and 72% more likely to lose weight by eating a low fat/low calorie diet only than those with neither condition. In addition, patients with hypertension were 21% more likely than those with neither condition to lose weight by consuming a low fat/low calorie diet. However, our results indicate that greater weight control efforts are needed among overweight/obese patients with diabetes since, at the national level, we found these patients were not more likely to lose weight, and even in those who attempted to lose weight, they were neither more likely to eat a low fat/low calorie diet nor more likely to engage in physical activity. It is possible that overweight/obese people with diabetes only are not in severe condition so they may think weight management is not imperative in controlling their diabetes. However, given the great benefits of weight loss on improved glucose tolerance and insulin sensitivity in people with pre- or newly diagnosed diabetes [37,47], it is important to educate and encourage these patients to lose excess weight.

Our study has several limitations. First, all measures including weight control behaviors, disease status and BMI were self-reported, thus subject to recall bias. Second, our analyses were based on people with diagnosed hypertension and diabetes; therefore, the prevalence of trying to lose weight in undiagnosed hypertension and diabetes remains unknown. Moreover, as mentioned previously, the less frequent weight-loss strategies such as eating food supplements, taking diet or water pills, or taking diuretics were not evaluated by disease status because of lack of information on these weight control strategies. Those who reported trying to lose weight but neither adopted a low fat/low calorie diet nor engaged in physical activity may have used these strategies. Finally, five years have passed since the data for this analysis were collected (from the 2003 BRFSS). Abid et al. has reported that the proportion of obese persons who reported being counseled by a healthcare professional to lose weight was in a declined trend during the period of 1994–2000 [48]. Thus, updated weight control behaviors should be continuously monitored at local, state, and national levels.
ers to interact with their patients to set suitable behavioral goals for weight loss and to provide appropriate education to promote effective weight-loss strategies in these patients. In addition, population-based obesity interventions to promote healthy eating, physical activity and energy balance would benefit all including patients with hypertension and/or diabetes.

Abbreviations
AOR: adjusted odds ratio; BMI: body mass index; BRFSS: Behavioral Risk Factor Surveillance System; CI: confidence interval; DM: diabetes; HTN: hypertension; LF/LC: low fat/low calorie.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
GZ conducted the data analyses, interpreted the data and prepared the manuscript. CL and AHM made critical revisions of the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript.

Disclaimer
The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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