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Long-Term Weight Loss and Metabolic Health in Adults Concerned With Maintaining or Losing Weight: Findings From NHANES

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Abstract

More than two-thirds of American adults are overweight or obese, with many attempting to lose weight to avoid adverse health outcomes and improve well-being. Achieving long-term weight loss (LTWL) success, defined as reaching at least a 5% to 10% weight loss goal, is challenging, yet important for overall metabolic health. It is currently unclear whether achieving higher thresholds of LTWL is associated with improved health. Therefore, the purpose of this study was to examine the association between LTWL thresholds (5%–9.9%, 10%–14.9%, 15%–19.9%, 20%) and metabolic health (metabolic syndrome and metabolic risk z score) among 7670 US adult respondents to the National Health and Nutrition Examination Survey (2007–2014) who were overweight or obese (past or present), were not underweight in the past year, not pregnant, and attempting to lose or maintain weight. A subsample of 3362 participants was used in the analysis of the metabolic risk z score. Multivariable regression models were constructed adjusting for covariates. Results indicate that the lowest and the 2 highest LTWL thresholds were related to lower odds for metabolic syndrome; for example, greater than or equal to 20% LTWL (odds

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ratio=0.52; 95% CI, 0.23–0.44; $P<.001$). All LTWL thresholds were significantly associated with the metabolic risk z score, with the largest effect among the 2 highest LTWL thresholds, that is, 15% to 19.9% LTWL ($\beta=-0.45$; 95% CI, -0.54 to -0.36; $P<.001$) and greater than or equal to 20% LTWL ($\beta=-0.35$; 95% CI, -0.53 to -0.17; $P<.001$). In conclusion, although achieving the currently recommended LTWL target was related to improved metabolic health, the 15% LTWL threshold was associated with more favorable outcomes.

Obesity is one of the major modifiable risk factors for diabetes mellitus and its accompanying metabolic abnormalities,¹ yet the most recent prevalence estimates indicate that 39.8% of adults in the United States are obese.² The prevalence of obesity is projected to rise over the next 10 years, resulting in an estimated loss of 0.78 mean years in life expectancy at age 40 years by the year 2030.³ Obesity often coincides with an interest in losing weight, and maintaining this weight loss, with the ultimate goal of improving overall health.⁴ Indeed, research indicates that 63% of obese adults have tried to lose weight in the past year,⁵ and there is strong evidence suggesting that weight loss and maintenance of this loss markedly improves overall metabolic health.⁶

The American College of Cardiology/American Heart Association recommends that overweight and obese individuals lose 5% to 10% of their starting body weight within 6 months, which should be maintained for at least 12 months (long-term weight loss [LTWL]).⁷ However, the body of research supporting these recommendations was obtained primarily from weight loss clinical trials, which may not generalize to a broader population-based sample.⁸ Furthermore, it is unclear whether higher levels (ie, beyond the recommended 5%–10%) of LTWL are incrementally related to better metabolic risk profiles, particularly among adults who were once either overweight or obese and aim to lose or maintain weight. Therefore, the primary objective of this study was to examine the relationship of various thresholds of LTWL and indicators of metabolic health including metabolic syndrome (a clustering of 3 or more risk factors for cardiometabolic health)⁹ and the metabolic risk z score (a continuous measure of metabolic health).^{10–13} For this, we leverage a nationally representative sample to identify adult participants who have been overweight or obese and attempted to lose and/or maintain weight loss

METHODS

Data are derived from multiple waves of the National Health and Examination Survey (NHANES). This survey uses a serial cross sectional design and collects information biannually on health and nutrition.¹⁴ Participants report health-related behaviors via interview and questionnaire, are administered physical examinations, and provide biological samples from serum, saliva, and urine samples. More details on NHANES appear elsewhere.¹⁵

The current study assessed participant questionnaire and physical examination data (n=40,617) from 4 data collection waves: 2007–2008, 2009–2010, 2011–2012, and 2013–2014. To be included in the analysis, participants must have been between the ages of 20 and 64 years (n=17,847). The selected age range is based on the American Society for Nutrition

and NAASO, The Obesity Society Position Statement¹⁶ that states that body composition stabilizes between the ages of 20 and 60 to 70 years.

The analytic sample size was further restricted to exclude those with a historical maximum body mass index (calculated as the weight in kilograms divided by the height in meters squared) of less than 25 kg/m² (n=4444). In addition, those with a body mass index of less than 18.5 kg/m² (underweight) within the last year were excluded (n=54) because of the potential for an underlying medical condition. Furthermore, participants who did not indicate their desire to lose weight (past year or lifetime) and/or not to gain weight (past year) were excluded (n=2815). There were no participants included in the analytic sample who were pregnant at the time of testing, which was an additional exclusion criterion that was considered. Further exclusions (n=2864) due to taking a complete case analysis approach resulted in an analytic sample of 7670 for metabolic syndrome as the dependent variable. The association of LTWL and metabolic risk z score was examined among a subsample of participants (n=3362) who completed the fasting glucose protocol and met the inclusion criteria.

The primary independent variable was LTWL. Specifically, participants reported weight 1 year ago or reported current weight (the higher of the 2) was subtracted from the reported maximum weight and then divided by maximum weight. This number was then multiplied by 100 to reach a weight loss percentage and then categorized into the following weight loss thresholds: less than 5% (referent group), 5% to 9.9%, 10% to 14.9%, 15% to 19.9%, and greater than or equal to 20%.⁷

The primary dependent variables were metabolic syndrome and its individual components (dichotomous variables based on clinically meaningful cutoff points), and metabolic risk z score, a continuous measure. Metabolic syndrome was defined on the basis of American Heart Association/National Heart, Lung, and Blood Institute criteria,⁹ if 3 or more of the following criteria were met: (1) elevated waist circumference (≥102 cm for men, or ≥88 cm for women), (2) elevated level of triglycerides (≥150 mg/dL) or reported prescribed medication use to lower cholesterol, (3) high blood pressure (≥130 mm Hg systolic or ≥85 mm Hg diastolic) or reported taking prescribed medication for hypertension, (4) fasting glucose level of greater than or equal to 100 mg/dL or reported prescribed medication for diabetes to lower blood sugar, and (5) low high-density lipoprotein cholesterol (HDL-C) level (<40 mg/dL for men, or <50 mg/dL for women) or reported prescribed medication use to lower cholesterol. This approach was identical to that taken by Moore et al¹⁷ to define metabolic syndrome using NHANES data, except that the current study relies on patients' medication use rather than physicians' prescription to enhance accuracy because some struggle with medication adherence.¹⁸ The continuous metabolic risk z score was used to supplement the dichotomous metabolic syndrome variable, because it incorporates components of metabolic disease risk into 1 variable.¹⁵ To derive this score, continuously distributed measures of waist circumference, triglycerides (mg/dL), blood pressure (mm Hg systolic + mm Hg diastolic/2), 2-hour fasting glucose (mg/dL), and inverted fasting HDL-C (mg/dL) were standardized by subtracting the sample mean from the individual mean, and then dividing by the SD of the sample mean. These values were then summed and standardized to create the metabolic risk z score.¹⁵

The bivariable relationships between LTWL and metabolic syndrome and the metabolic risk z score were estimated, and tested for differences using χ^2 and analysis of variance tests, respectively. Multivariable logistic regression models were built to estimate the relationship between LTWL and metabolic syndrome and its components as the dependent variables. In addition, separate multivariable ordinary least squares regression models were computed to examine the relationship between LTWL and metabolic risk z score. Covariates included sociodemographic characteristics (age, sex, race/ethnicity, marital status, education, household size, and income) and health variables (self-reported health status, and current smoking status based on an established cotinine cutoff point of 3.08 ng/mL).¹⁹ Metabolic risk z score additionally adjusted for participants' reported medication use. The NHANES survey weights (8-year mobile examination center [MEC8YR]) were used in all analyses. STATA 13.1 (Stata-Corp LP) was used for analyses.

This study received exempt status by The University of Texas Health Science Center at Houston (UTHealth) Institutional Review Board.

RESULTS

Survey-weighted participant characteristics for the analytic sample are presented in Table 1. Most (62.4%) participants had successfully lost 5% or less of their historical maximum weight, and only 5.5% of participants had 20% or greater LTWL. More than one-third of participants (35.6%) were classified as having metabolic syndrome.

Bivariable analyses of metabolic syndrome and LTWL thresholds revealed that 38.1% of participants with less than 5% LTWL were classified as having metabolic syndrome. The proportion of participants with metabolic syndrome in the other LTWL thresholds (5%–9.9%, 10%–14.9%, 15%–19.9%) was around 30% (31.9%, 33.2%, and 31.3%, respectively), and 26.2% for those achieving at least 20% LTWL. Regarding the metabolic z score, the mean (standard error) values for participants in each LTWL threshold (<5%, 5%–9.9%, 10%–14.9%, 15%–19.9%, 20%) were 0.02 (0.03), 0.07 (0.03), 0.15 (0.08), 0.41 (0.07), and 0.36 (0.09), respectively. Tests for differences revealed significant differences ($P<.001$) across all LTWL thresholds for metabolic syndrome and metabolic risk z score.

The adjusted odds of metabolic syndrome and individual components by LTWL thresholds are presented in Table 2. Specifically, participants achieving at least 5% LTWL exhibited lower odds of metabolic syndrome relative to the reference LTWL group (<5% LTWL). These findings were statistically significant for the 5% to 9.9%, 15% to 19.9%, and greater than or equal to 20% LTWL thresholds, yet did not reach significance for the 10% to 14.9% LTWL threshold (odds ratio [OR]=0.79; 95% CI, 0.61–1.02; $P=.07$). Those able to achieve at least 15% to 19.9% and greater than or equal to 20% LTWL experienced the lowest relative odds of metabolic syndrome. With regard to the metabolic z score (Figure), significant associations between all LTWL thresholds and the z score were observed. More specifically, those in the highest LTWL thresholds (15%–19.9% and 20%) were associated with the lowest metabolic risk z scores ($\beta=-0.45$; 95% CI, -0.54 to -0.36 ; $P<.001$; $\beta=-0.35$; 95% CI, -0.53 to -0.17 ; $P<.001$, respectively).

DISCUSSION

Study findings indicate that, among a population-based sample of historically over-weight or obese individuals who aimed to lose or maintain weight, successful LTWL (>5%) is associated with a more favorable metabolic disease risk profile. Results additionally indicate that although a clear incremental pattern was not apparent, reaching the 15% LTWL threshold is associated with even lower odds for metabolic syndrome and a lower metabolic risk z score. When considering the individual components of metabolic syndrome, all levels of LTWL were associated with a lower likelihood of dyslipidemia (ie, elevated triglyceride levels and lower HDL-C levels). Interestingly, LTWL was not associated with hypertension. This finding requires further study considering the well-established beneficial effects of weight loss on hypertension.^{20,21}

In the context of the literature, current findings are consistent with results from randomized controlled trials. For example, the Diabetes Prevention Program found that after 10 years of follow-up, prediabetic patients who maintained 7% weight loss had a 34% reduction in type 2 diabetes incidence compared with the placebo group.²² More recent results from the Look AHEAD (Action for Health in Diabetes) trial found that individuals (diagnosed with type 2 diabetes) who lost at least 10% body weight over a 10-year period had approximately 20% lower risk of cardiovascular events.²³ In comparison, the current study similarly finds that 5% to 10% weight loss is related to a healthier metabolic profile, with the 15% threshold associated with even greater benefit. However, it should be noted that the current study differs in several ways. More specifically, the current study is a population-based cross-sectional study with inherent limitations related to the study design, yet strengths with regard to the larger representative sample. Moreover, the current study sample focuses on historically overweight/obese individuals attempting to lose or maintain weight, rather than those already at high risk for, or diagnosed with, a chronic condition (eg, type 2 diabetes).

The present study has limitations that should be noted. Although this was a cross-sectional analysis of LTWL and metabolic syndrome, the weight loss variable was based on historical maximum body weight in comparison to current weight loss or weight loss in the past year (the higher weight of the 2), and there-fore enables deriving change in body mass over time. Nonetheless, the caveats for cross-sectional data, including preclusions on inferring temporality and causality, still apply. In addition, body weights (historical, 1 year ago, and current) are self-reported and subject to recall bias. Previous studies, however, suggest that recall of historical weights is relatively stable over time and minimally biased.²⁴ In addition, when examining the correlation between self-reported and objectively measured current weight (using available NHANES data), a high correlation was observed (Pearson $r=0.97$).

Finally, the use of a categorical definition of metabolic syndrome has limitations. There are several definitions for metabolic syndrome (which may lead to confusion), and it is unclear whether metabolic syndrome is a specific syndrome or merely a compilation of several risk factors.²⁵ Hence, to increase the robustness of the findings, we supplemented this variable with the z score, which integrates the various metabolic risk components into one score.

CONCLUSION

In sum, the current study uses clinical measures of cardiometabolic risk as well as historical information on weight change from a large, population-based sample of adults to assess the relationship between LTWL and metabolic health among those attempting to lose or maintain their weight. Study findings suggest that higher levels of LTWL might provide more protection against metabolic disease risk, though further longitudinal research is needed to sub-ststantiate these findings. Future research should continue to examine strategies leading to LTWL to reduce cardiovascular disease risk factors and subsequent morbidity and mortality.

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Abbreviations and Acronyms:

HDL-C	high-density lipoprotein cholesterol
LTWL	long-term weight loss
NHANES	National Health and Examination Survey

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FIGURE.

Adjusted means (95% CI) of metabolic risk z score by long-term weight loss thresholds among adults (n=3362) concerned with maintaining or losing weight who were previously overweight or obese. Data are adjusted for sex, age, race/ethnicity, marital status, household size and income, education, health status, smoking status, medication use for cholesterol, high blood pressure or hypertension, and diabetes. $P < .01$ was observed for all long-term weight loss thresholds. Metabolic risk z score is estimated by standardizing and summing continuously distributed measures waist circumference; triglycerides (mg/dL); blood pressure (mm Hg systolic + mm Hg diastolic/2); 2-hour fasting glucose (mm/dL); inverted fasting HDL-C (mg/dL). HDL-C = high-density lipoprotein cholesterol.

TABLE 1.

Weighted Measures of Sociodemographic Characteristics, Long-Term Weight Loss, and Metabolic Health
Among Adults Concerned With Maintaining or Losing Weight (2007–2014 NHANES)^{a,b,c}

Characteristic	Weighted % (n=7670)
Age (y), mean (SE)	44.0 (0.23)
Household size, mean (SE)	3.1 (0.03)
Women	50.6
Current smoking status ^d	27.1
Race/ethnicity	
Non-Hispanic white	69.7
Non-Hispanic black	13.3
Hispanic	11.3
Other	5.7
Marital status	
Married	59.4
Never married	16.6
Divorced/separated	15.1
Widow	1.8
Educational attainment	
Less than high school	11.7
High school	21.3
Some college	33.9
College graduate	33.1
Self-reported health status	
Poor	2.5
Fair	14.1
Good	41.1
Very good	32.9
Excellent	9.5
Household income (US \$)	
<20,000	11.8
20,000–44,999	22.6
45,000–74,999	23.7
75,000–99,999	13.5
100,000	28.5
Percentage of long-term weight loss	
<5	62.4
5–9.99	18.9
10–14.99	8.8
15–19.99	4.3
20	5.5
Metabolic syndrome and components	

Characteristic	Weighted % (n=7670)
Metabolic syndrome ^e	35.6
Elevated waist circumference ^f	68.6
Low HDL-C ^g	45.0
Elevated blood pressure ^h	41.1
Elevated triglycerides ⁱ	27.7
Elevated fasting glucose ^j	26.1

^a HDL-C = high-density lipoprotein cholesterol; MEC = mobile examination center; NHANES = National Health and Examination Survey; SE = standard error.

^b NHANES 8-y MEC exam weights were used in analyses.

^c There were 3362 participants included in the metabolic risk z-score analysis.

^d Current smoking status is measured through serum cotinine levels (cutoff point of 3.08 ng/mL).

^e If 3 or more of the individual components (defined below) of elevated waist circumference, low HDL-C, elevated blood pressure, elevated triglyceride, elevated fasting glucose, were met.

^f 102 cm for men, or 88 cm for women.

^g <40 mg/dL for men, or <50 mg/dL for women or reported prescribed medication use to lower cholesterol.

^h 130 mm Hg systolic or 85 mm Hg diastolic or reported taking prescribed medication for hypertension.

ⁱ 150 mg/dL or reported prescribed medication use to lower cholesterol.

^j 100 mg/dL or reported prescribed medication for diabetes to lower blood sugar.

TABLE 2.

Adjusted Relative Odds of MetSyn and Its Components Among LTWL Thresholds of Adults Concerned With Maintaining or Losing Weight: Multiple Logistic Regression (NHANES 2007–2014)^{a,b,c,d}

LTWL	OR (95% CI) <i>P</i>					
	MetSyn ^e	Elevated WC	Low HDL-C	Elevated BP	Elevated TRI	Elevated FG
<5%	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
5%–9.9%	0.78 (0.66–0.92) .003	0.60 (0.47–0.77) <.001	0.75 (0.64–0.88) .001	0.92 (0.77–1.10) .34	0.68 (0.55–0.84) <.001	0.82 (0.70–0.97) .02
10%–14.9%	0.79 (0.61–1.02) .07	0.64 (0.52–0.80) <.001	0.67 (0.55–0.81) <.001	0.90 (0.69–1.16) .40	0.71 (0.54–0.94) .02	0.94 (0.71–1.24) .64
15%–19.9%	0.63 (0.42–0.95) .03	0.43 (0.32–0.57) <.001	0.55 (0.40–0.76) <.001	0.90 (0.66–1.24) .53	0.70 (0.46–1.06) .09	0.93 (0.66–1.31) .66
>20%	0.47 (0.35–0.63) <.001	0.32 (0.22–0.45) <.001	0.52 (0.39–0.70) <.001	0.82 (0.62–1.09) .17	0.54 (0.35–0.82) .004	0.59 (0.46–1.31) .002

^aBP = blood pressure; FG = fasting glucose; HDL-C = high-density lipoprotein cholesterol; MEC = mobile examination center; MetSyn = metabolic syndrome; NHANES = National Health and Examination Survey; Ref. = reference; TRI = triglycerides; WC = waist circumference.

^bThe NHANES 8-y MEC exam weights were used in analyses (n=7670).

^cThe LTWL was calculated by taking the participants' reported weight 1 y ago or current weight (the higher of the 2), subtracting that figure from their historical maximum weight, and then dividing by their historical maximum weight and multiplying by 100.

^dModels were adjusted for age, sex, race, marital status, education, household income, household size, smoking status, and self-rated health status.

^eThree or more of the following criteria were met: (1) elevated WC (102 cm for men, or 88 cm for women), (2) elevated level of TRI (150 mg/dL) or reported prescribed medication use to lower cholesterol, (3) high blood pressure (130 mm Hg systolic or 85 mm Hg diastolic) or reported taking prescribed medication for hypertension, (4) FG level of 100 mg/dL or reported insulin or oral medications for diabetes, and (5) low HDL-C level (<40 mg/dL for men, or <50 mg/dL for women) or reported prescribed medication use to lower cholesterol.