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Associations of weight cycling with cardiovascular health using American Heart Association's Life's Simple 7 in a diverse sample of women

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ABSTRACT

Prior research shows that weight cycling is associated with poorer cardiovascular health (CVH). Women experience unique life events (e.g. pregnancy, menopause) which may make them more prone to weight cycling. Examining the influence of weight cycling history (HWC) on CVH, quantified using the American Heart Association's Life's Simple 7 (LS7), may provide novel targets to improve CVH. A cross-sectional sample of 485 women at Columbia University Irving Medical Center (2016–2018) were scored on each LS7 metric (BMI, blood pressure, fasting cholesterol and glucose, physical activity, diet, and smoking): 0 (low), 1 (moderate) or 2 (high). Metric points were summed into a composite LS7 score as a measure of CVH: 0–8 (low), 9–10 (moderate), 11–14 (high). Multivariable-adjusted logistic and linear regression models were used for the associations between HWC and CVH. Most women (73%) reported HWC (range: 0–20); 26% had low CVH and 74% moderate/high CVH. Logistic models showed HWC was associated with higher odds of having poor CVH [OR (95%CI): 2.39 (1.36–4.20)]. Linear models showed each additional weight cycling episode was associated with lower LS7 scores [ß(SE): −0.37 (0.07); $p < 0.01$]. Associations between HWC and odds of having poor CVH were stronger among pre-menopausal women and those with no pregnancy history (p-interaction = 0.009, 0.004, respectively). In conclusion, HWC was associated with higher odds of poorer CVH with stronger associations seen in pre-menopausal and women with no pregnancy history. These findings suggest that in addition to having a healthy weight, maintaining a consistent weight may be important for achieving optimal CVH, but warrant prospective confirmation.

1. Introduction

Obesity is associated with increased risk of chronic illnesses such as hypertension, diabetes mellitus, and cardiovascular disease (CVD) (Managing overweight and obesity in adults, 2017). Weight loss is recommended for individuals who are overweight or obese to reduce their CVD risk (Gadde et al., 2018). While sustained weight loss can be achieved through intensive therapy and intervention (Gadde et al., 2018), more commonly, individuals lose and then regain weight (Sacks et al., 2009; Methods for voluntary weight loss and control, 1992). The repetitive pattern of weight loss and regain is termed "weight cycling" (Gadde et al., 2018). Nearly half (49.1%) of U.S. adults are trying to lose weight and weight loss efforts are significantly more prevalent in women than in men (Martin et al., 2018).

Prior research has demonstrated that weight cycling is associated with increased CVD risk (Bangalore et al., 2017; Lissner et al., 1991). However, there is limited data on the relation of lifetime history of weight fluctuations from adolescence through adulthood with CVH in individuals free from CVD. Studies focused on the history of weight cycling (HWC) over an individual's lifetime may provide important information on the role of weight consistency in CVH and identify critical life stages during which weight cycling may have a pronounced influence on CVH. The associations between HWC and CVH may be particularly important to decipher among women, as they may be more likely to weight cycle across their lifetime due to a higher prevalence of dieting (Martin et al., 2018), a greater desire for weight loss and a higher perceived social pressure (Lev-Ari et al., 2014; Whale et al., 2014) to lose weight compared to men (Bellisle et al., 1995). In addition to being more prone to weight cycling, there is an increasing trend for obesity to disproportionately affect females (Flegal et al., 2016; Levine et al., 2007). Furthermore, unique life events such as pregnancy and menopause may also make women particularly susceptible to the development of obesity during adulthood (Rooney and Schauberger, 2002; Kapoor et al., 2017).

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Given that over half of adult US women are attempting to lose weight (Martin et al., 2018) and the strong possibility of weight regain, it is important to highlight the potential risks weight cycling poses in relation to women's cardiovascular health (CVH). In 2010, the American Heart Association (AHA) published "Life's Simple 7 (LS7)," (Thacker et al., 2014) as a tool to measure CVH. The seven metrics of CVH include smoking, diet, physical activity, BMI, blood pressure (BP), total cholesterol and fasting glucose (Thacker et al., 2014). The primary aim of the present study was to investigate whether lifetime HWC, regardless of body weight status, was associated with meeting the overall and individual AHA LS7 metrics in women of diverse body weight status, and to evaluate potential differences in these associations by menopausal status and/or pregnancy history to identify critical periods during which the influence of HWC on CVH may be more pronounced.

2. Methods

2.1. Study population and design

This was a cross-sectional analysis of baseline data from a population-based prospective cohort of 485 English and Spanish speaking women between the ages of 20 and 79 years, recruited as part of the AHA Go Red for Women (GRFW) Strategically Focused Research Network population study at Columbia University Irving Medical Center (CUIMC AHA GRFW). The CUIMC AHA GRFW population study was established to examine sleep patterns in relation to cardiometabolic risk factors among women throughout adulthood. Participants were a community-based sample recruited from Northern Manhattan and included visitors, employees and students from New York-Presbyterian Hospital/CUIMC or nearby hospitals, living in the neighboring communities, or referred to the study by affiliated physicians. All participants were required to give written informed consent and the study was approved by the CUIMC Institutional Review Board.

Participants were screened for eligibility to participate in the CUIMC AHA GRFW population study. Anyone willing to provide informed consent to participate and willing to give permission to have their medical records released for the purpose of outcomes assessment and validation were included in the study. Participants were excluded from the study for any of the following reasons: (1) unable to read or understand English or Spanish; (2) unable or unwilling to complete the baseline or 6-month or 1-year evaluations; (3) uncooperative; (4) dementia or significant cognitive impairment; and (5) currently pregnant or < 6-months post-partum.

Research staff identified 3123 women, of which 2593 declined participation or were ineligible for the study (Mosca et al., 2017). Of the 506 participants who completed baseline study visits consisting of at least one questionnaire and/or a blood sample, 21 were excluded due to missing data on the HWC or the CVH metrics of interest; the final analytical dataset for the present study consisted of 485 women.

2.2. Assessment of weight cycling history

The primary exposures of interest were having HWC and the number of weight cycling episodes experienced. HWC was self-reported by answering the following question: "How many times in your life have you lost and gained at least 10 lb in one year (don't include pregnancies)?" This question was formulated based on previous studies (Welti et al., 2017; Atkinson et al., 1994) on weight cycling, which established 10 lb as the minimum threshold for defining significant weight gain versus being weight stable. All forms were available in English and Spanish.

2.3. Assessment of cardiovascular health metrics

2.3.1. Body mass index

Participant height was measured by a trained member of the study staff using a standardized height rod. Weight was measured using a research grade scale. BMI was calculated using the standard equation of weight (kg)/height (National Health and, 2017) (m^2). Participants who were underweight (BMI < 18.5 kg/m^2) overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2) or obese (BMI ≥ 30 kg/m^2) were classified as having abnormal BMI (Body mass index, 2017).

2.3.2. Blood pressure

Systolic and diastolic blood pressure (BP) were measured in the non-dominant arm using an automated oscillometric blood pressure monitor (Welch Allyn® Vital Signs Monitor 300 Series [Model 53NTO]) (Jones et al., 2001) and appropriately sized cuff following five minutes of seated rest (Pickering et al., 2005).

2.3.3. Physical Activity, Diet, smoking

Physical activity was assessed by the International Physical Activity Questionnaire (Craig et al., 2003). A combined total physical activity score was expressed continuously (MET/minutes/week) (Craig et al., 2003). Diet was assessed by the Block Brief 2000 Food Frequency Questionnaire (Block et al., 1990), and healthy diet patterns scores were created based on the Dietary Approaches to Stop Hypertension eating type pattern (Llyod-Jones et al., 2010). Smoking history was self-reported by answering the following questions: "What is your smoking status?" and "When was your last cigarette?"

2.3.4. Laboratory measurements

Fasting total cholesterol and plasma glucose samples were analyzed by certified personnel at the Biomarker Core Laboratory at CUIMC. Samples were measured using an Ektachem DT II System (Johnson and Johnson Clinical Diagnostics, Rochester, NY) with appropriate standards and reagents.

2.4. Assessment of other covariates

Participants completed standardized questionnaires to provide information on sociodemographic factors (age, race/ethnicity, education, employment, and income), medical history, menopausal status, pregnancy history and medication use. All forms were available in English and Spanish.

2.5. Creation of AHA Life's Simple 7 score

The primary outcome of interest was CVH, measured as an AHA LS7 score based on meeting the guidelines for seven health behaviors and health factors: BMI, BP, total cholesterol, fasting plasma glucose, physical activity, diet and smoking. Participants were given a score based on their level of meeting each AHA LS7 metric as follows: 0 (low), 1 (moderate) or 2 (high) points in each of the categories. A composite AHA LS7 score was computed as the sum of the seven metric scores. Composite scores ranged from 0 to 14 points such that higher scores reflected a more favorable CVH profile. Further, we categorized individuals with AHA LS7 scores of 0–8, 9–10 and 11–14 points as having low, moderate and high CVH, respectively, consistently with previous studies that demonstrated associations between favorable CVH and lower risk of cardiovascular and non-cardiovascular outcomes using these definitions (Ogunmoroti et al., 2017; Mok et al., 2018; Kulshreshtha et al., 2013). The AHA LS7 metric scoring categories are listed in Table A.1.

2.6. Statistical analysis

Participant characteristics were described using mean ± standard deviation (SD) for continuous variables and frequencies for categorical variables. Categorical variables were compared using Fisher's exact test and continuous variables were compared using Student's t-tests. Multivariable-adjusted linear regression models were used to examine

Table 1
Descriptive Characteristics of the Study Participants in the Overall Sample and by History of Weight Cycling.

Characteristics	Total (N = 485) % or Mean (SD)	History of Weight Cycling	
		Present (n = 352) % or Mean (SD)	Absent (n = 133) % or Mean (SD)
Mean Age (years)	37.0 (15.7)	37.2 (15.6)	36.3 (16.0)
Race			
White	57%	**59%**	**51%**
Black	20%	**21%**	**16%**
Asian	19%	**15%**	**29%**
Other	4%	**5%**	**4%**
Hispanic	28%	30%	23%
Married/Living with partner	30%	30%	29%
Have Health Insurance	76%	76%	75%
Postmenopausal	28%	28%	29%
History of Pregnancy	29%	30%	29%
Education: College and above	77%	78%	74%
Current/Former Smoker	24%	25%	20%
History of Chronic Disease*	61%	64%	55%
Diabetes	5%	5%	5%
Hypertension	31%	34%	25%
Hypercholesterolemia	21%	21%	21%
CVD†	5%	5%	5%
Mean BMI (kg/m^2)	25.9 (5.7)	**26.7 (6.1)**	**23.8 (3.7)**
Normal	44%	**44%**	**70%**
Overweight	34%	**34%**	**22%**
Obese	22%	**22%**	**8%**
Weight Cycling Episodes	2.1 (2.6)		
Mean Waist Circumference (inches)	35.4 (5.5)	**36.1 (5.9)**	**33.6 (3.8)**
Mean Systolic Blood Pressure (mm Hg)	117 (14.3)	**118 (15.1)**	**115 (11.9)**
Mean Diastolic Blood Pressure (mm Hg)	73 (10.8)	73 (11.2)	72 (9.6)
Mean Total Cholesterol (mg/dL)	182.0 (36.4)	181.9 (37.8)	182.4 (32.6)
Mean HDL Cholesterol (mg/dL)	61.2 (15.7)	60.6 (15.6)	62.7 (16.0)
Mean LDL Cholesterol (mg/dL)	104.6 (32.1)	105.1 (33.5)	103.2 (28.2)
Mean Triglycerides (mg/dL)	81.2 (40.8)	80.6 (40.2)	83.0 (42.6)
Mean Fasting Glucose (mg/dL)	88.7 (17.2)	89.0 (18.5)	88.2 (13.2)

Bolded cells indicate $p < 0.05$ for the comparison between participants with a history of weight cycling and those without. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.

* Chronic diseases include diabetes, hypertension, hypercholesterolemia, and CVD.

† CVD defined as diagnosis or history of angina, coronary revascularization, coronary artery disease, heart failure, venous thromboembolism, peripheral artery disease, stroke and transient ischemic attacks.

the change in the AHA LS7 composite score per each additional weight cycling episode. Associations of HWC (≥1 vs. 0 episodes) with odds of having a low (0–8) versus moderate to high (9–14) AHA LS7 score were evaluated using multivariable-adjusted logistic regression models. We also used logistic regression models to examine associations of HWC with odds of meeting versus not meeting each of the seven CVH metrics. Models were adjusted *a priori* for the following established socio-demographic risk factor characteristics: age (years), race/ethnicity (white/non-Hispanic vs. minority/Hispanic) and having health insurance (Yes vs. No). We tested for multiplicative interaction between menopausal status and history of pregnancy variables with HWC and stratified analyses were reported. SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA) was used for all statistical analyses. A 2-sided p-value < 0.05 was considered statistically significant.

Table 2
AHA Life's Simple 7 Guideline Score Distributions in the Overall Sample and by History of Weight Cycling.

AHA LS7 Guideline Score Distributions	Total (N = 485) % or Mean (SD)	History of Weight Cycling	
		Present (n = 352) % or Mean (SD)	Absent (n = 133) % or Mean (SD)
Composite AHA LS7 Score			
Low (n = 125)	26%	**29%**	**17%**
Moderate/High (n = 360)	74%	**71%**	**83%**
BMI Metric			
Low (n = 88)	18%	**22%**	**8%**
Moderate/High (n = 397)	82%	**78%**	**92%**
Blood Pressure Metric			
Low (n = 50)	10%	11%	8%
Moderate/High (n = 435)	90%	89%	92%
Total Cholesterol Metric			
Low (n = 30)	6%	7%	4%
Moderate/High (n = 455)	94%	93%	96%
Fasting Glucose Metric			
Low (n = 13)	3%	3%	3%
Moderate/High (n = 472)	97%	97%	97%
Physical Activity Metric			
Low (n = 137)	28%	28%	28%
Moderate/High (n = 348)	72%	72%	72%
Diet Metric			
Low (n = 242)	50%	51%	48%
Moderate/High (n = 243)	50%	49%	52%
Smoking Metric			
Low (n = 19)	4%	4%	3%
Moderate/High (n = 466)	96%	96%	97%

Bolded cells indicate $p < 0.05$ for the comparison between participants with a history of weight cycling and those without. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.

3. Results

3.1. Baseline characteristics

The baseline characteristics of the study participants are listed in Table 1. The mean (SD) age was 37.0 (15.7) years, 24% were current or former smokers, and 28% of women were post-menopausal. Overall, 73% of women reported at least one episode of weight cycling. Compared to women without a HWC, those who reported at least one HWC had a higher BMI [mean (SD) 26.7 (6.1) kg/m^2 vs. 23.8 (3.7) kg/m^2; $p < 0.01$], larger waist circumference [36.1 (5.9) inches vs. 33.6 (3.8) inches; $p < 0.01$] and higher systolic blood pressure [118 (15) mmHg vs. 115 (12) mmHg; $p < 0.01$]. There were no other statistically significant differences in baseline characteristics between women with and without HWC.

3.2. AHA Life's Simple 7 Guideline score Distributions

The majority of participants received moderate/high scores for the AHA LS7 composite score and individual metrics (Table 2). When examined among women with and without HWC, women with at least one HWC were significantly more likely to have low vs. moderate/high BMI metric score ($p < 0.01$) and were more likely to have low vs. moderate/high CVH based on their AHA LS7 composite score compared to women without HWC ($p = 0.01$) (Fig. 1).

3.3. History of weight cycling in relation to overall cardiovascular health

In the multivariable-adjusted linear regression model that examined associations of number of episodes of weight cycling with the AHA LS7 composite score (Table 3), each additional weight cycling episode was associated with a lower AHA LS7 composite score (ß (SE): −0.37

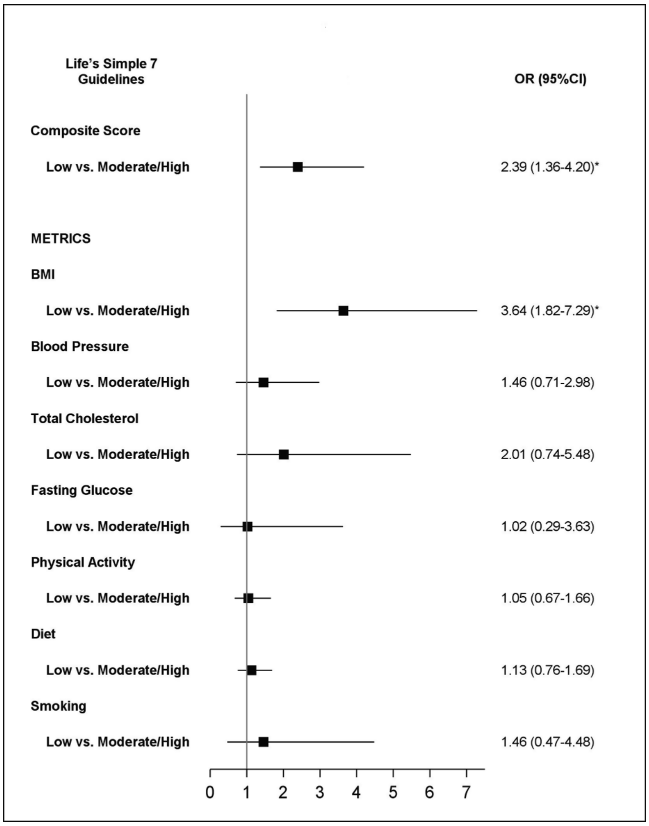

Fig. 1. Multivariable-adjusted Logistic Regression Model: History of Weight Cycling in Relation to Odds of Meeting the AHA's Life's Simple 7 Metrics in Overall Sample (N = 485). Logistic regression models presenting odds ratios and 95% confidence intervals for the relation between weight cycling history and meeting the AHA Life's Simple 7 metrics. Models were adjusted for age, race, ethnicity and health insurance. * indicates $p < 0.05$. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.

Table 3
Multivariable-adjusted Linear Regression Model: History of Weight Cycling in Relation to Composite AHA LS7 Score*

Population	ß (SE)			
	ß (SE)	p-value	ß (SE) Adjusted†	p-value
Overall (N = 485)	−0.45 (0.08)	< 0.01	−0.37 (0.07)	< 0.01
Pre-menopausal‡ (N = 349)	−0.32 (0.09)	< 0.01	−0.26 (0.08)	< 0.01
Post-menopausal‡ (N = 136)	−0.62 (0.15)	< 0.01	−0.62 (0.14)	< 0.01
No Pregnancy History‡ (N = 342)	−0.31 (0.09)	< 0.01	−0.27 (0.08)	< 0.01
Pregnancy History‡ (N = 143)	−0.50 (0.14)	< 0.01	−0.52 (0.14)	< 0.01

*Results shown are per each additional weight cycling episode in relation to AHA LS7 score modeled on a continuous scale. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.
† Adjusted for age, race/ethnicity, and health insurance.
‡ P-interactions between menopausal status and weight cycling episode, and pregnancy history and weight cycling episode were 0.009 and 0.004, respectively.

(0.07); $p < 0.01$) and therefore with poor overall CVH. In the multivariable-adjusted logistic regression model (Table 4), participants with HWC were at greater than 2-fold higher odds of having poor CVH (OR (95%CI): 2.39 (1.36–4.20)), based on their AHA LS7 composite score. Associations did not vary by race/ethnicity (p = 0.05).

Table 4
Multivariable-adjusted Logistic Regression Model: History of Weight Cycling in Relation to Odds of Meeting the AHA's Life's Simple 7.

Population	OR (95% CI) Low vs. Moderate/High AHA LS7 Composite Score	
	Unadjusted	Adjusted*
Overall (N = 485)	**2.09 (1.25–3.48)**	**2.39 (1.36–4.20)**
Pre-menopausal (N = 349)	**2.69 (1.22–5.90)**	**2.72 (1.22–6.08)**
Post-menopausal (N = 136)	2.06 (0.96–4.44)	2.14 (0.95–4.84)
No Pregnancy History (N = 342)	**2.98 (1.30–6.85)**	**3.09 (1.31–7.32)**
Pregnancy History (N = 143)	1.80 (0.85–3.81)	1.92 (0.88–4.22)

*Adjusted for age, race/ethnicity, and health insurance. Bolded cells indicate $p < 0.05$. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.

3.4. Differences in association between history of weight cycling and cardiovascular health by menopausal status

There was a statistically significant multiplicative interaction for HWC with menopausal status (p = 0.009). In analyses stratified by menopausal status (Table 3), each additional weight cycling episode was associated with poor CVH in both pre- (ß (SE): −0.26 (0.08); $p < 0.01$) and post-menopausal (ß (SE): −0.62 (0.08); $p < 0.01$) women. In the multivariable-adjusted logistic regression model (Table 4), a significant association between HWC and odds of having poor CVH was observed in pre-menopausal women only (OR (95%CI): 2.72 (1.22–6.08)).

3.5. Differences in associations between history of weight cycling and cardiovascular health by pregnancy history

A statistically significant multiplicative interaction for HWC with pregnancy history (p = 0.004) was also observed. In analyses stratified by pregnancy history (Table 3), each additional weight cycling episode was associated with poor CVH in both women with (ß (SE): −0.52 (0.14); $p < 0.01$) and without a pregnancy history (ß (SE): −0.27 (0.14); $p < 0.01$). (Table 4) However, in logistic regression models, HWC was associated with higher odds of having poor CVH only in women without a pregnancy history (OR (95%CI): 3.09 (1.31–7.32)).

4. Discussion

In this diverse cohort of women encompassing different life stages, lifetime HWC was associated with poor CVH, assessed using the AHA LS7 metrics. Each additional weight cycling episode was associated with worse CVH in the overall sample and also in analyses stratified by menopausal status and pregnancy history. Women with HWC had higher odds of having poor CVH in the overall sample. This association was stronger in pre-menopausal and nulliparous women. When HWC was examined in relation to individual CVH metrics, HWC was associated with greater odds of having a poor AHA LS7 BMI criterion score, and no significant associations were observed between HWC and the other CVH metrics.

Our findings are consistent with results of previous studies, which demonstrate detrimental associations between weight cycling and cardiovascular health in other populations. The Chicago Western Electric Company Study showed that the 25-year risk of coronary death was two times greater in men who had a single episode of weight cycling during young adulthood compared to those who had no fluctuations in weight. (Hamm et al., 1989) Similarly, the Framingham Heart Study showed that weight cycling is associated with morbidity and mortality from coronary heart disease in both men and women in the original cohort. (Lissner et al., 1991) In contrast, the Nurses' Health study and an Italian cohort of adults ages 19–65 years found no association between weight cycling history and cardiovascular mortality (Field et al., 2009) or cardiovascular risk factors (blood pressure, cholesterol levels and insulin resistance), (Graci et al., 2004) respectively. However, these studies examined weight fluctuations in populations with pre-existing coronary disease (Bangalore et al., 2017) or collected only adult weight cycling data. (Lissner et al., 1991) Few studies have examined the relation of lifetime history of weight fluctuations in women from adolescence to adulthood with CVH.

There are a number of potential biological mechanisms to explain the relation between weight cycling and CVH metrics. Weight cycling may contribute to CVD risk by leading to preferential deposition of visceral fat (Chang et al., 2018) or perivascular adipose tissue, (Costa et al., 2018) which are more strongly associated with CVD risk. The biological mechanisms behind preferential fat deposition are not fully elucidated in humans, (Montani et al., 2006) but there are studies showing preferential changes in body composition after weight regain may be due to metabolic adaptation or slowing of resting metabolic rate. (Fothergill et al., 2016) Metabolic adaptation acts to counter weight loss and contribute to weight gain leading to higher BMI in the long-term. (Fothergill et al., 2016) In humans, the "repeated overshoot theory" is also proposed to explain how weight cycling may increase CVD risk. CVD risk factors, including blood pressure, heart rate, plasma glucose and triglycerides, are elevated to higher than normal values during weight regain. Continued increases in these variables, or "repeated overshoots," during each weight regain period leads to stresses on the cardiovascular system and increased CVD risk. (Montani et al., 2006)

Life events such as pregnancy and the onset of menopause may make women particularly susceptible to the development of obesity during adulthood. Increased weight accumulation during pregnancy and the challenges associated with losing excess weight once it has been gained (Rooney and Schauberger, 2002) can exacerbate weight cycling. Physiological factors also contribute to higher prevalence of weight cycling among women over the life course. Decreased estrogen levels and changes in body fat distribution associated with menopausal transition (Kapoor et al., 2017) can make women more prone to weight gain and obesity. Therefore, understanding how weight cycling contributes to CVH at different life stages may provide necessary insights to tailor screening and educational tools aimed at reducing CVD risk in women. (Johnson et al., 2014) To address this, we examined whether associations varied by menopausal status and pregnancy history. Stratification by menopausal status and pregnancy history suggest potential adverse effects of weight cycling occurring in pre-menopausal women and women without a pregnancy history.

Our finding that associations may be stronger in pre-menopausal women are consistent with results from the Women's Health Initiative, which is the only study to date to evaluate the timing of weight cycling during adulthood. That study showed that increased all-cause mortality risk was associated with weight gained during early- and mid-adulthood in overweight and obese women. (Taing et al., 2012) These results highlight that weight cycling may be particularly detrimental in younger women. While the menopausal transition is generally associated with weight gain and obesity, (Kapoor et al., 2017) weight cycling occurring in pre-menopausal women may be more detrimental due to staying in a weight cycling-related obesogenic state for a longer period of time. In addition, weight cycling beginning at a younger age may result in women becoming lifetime weight cyclers and having a greater number of weight cycling episodes during the course of their lives.

There are no studies indicating how women without a pregnancy history may have poorer CVH due to weight cycling, but potential explanations mirror those of pre-menopausal women. Women without a pregnancy history are generally younger and are subject to the same detrimental effects of having higher numbers of weight cycling episodes and staying in the weight cycling-related obesogenic state for a greater portion of their lifetime. Nevertheless, these results indicate that there may be differential impacts of weight cycling at different times over the life course. Additional studies are needed to further identify time periods during which interventions may be more effective.

To our knowledge, this study is the first to evaluate the association between lifetime weight cycling history and CVH, as assessed using the AHA LS7 guidelines in a diverse population of women and to elucidate differences by menopausal status and pregnancy history. In this study, HWC was defined as the loss and gain of ≥10 lb in one year. Recent studies have also incorporated the loss and gain of 10 lb in their definition of weight cycling in association to cardiovascular outcomes (Folsom et al., 2015). The AHA LS7 score that was used as a measure of CVH in this study is consistent with previous studies and has been validated in other populations to predict risk of heart failure (Ogunmoroti et al., 2017; Jensen et al., 2014) and prognosis after myocardial infarctions. (Kulshreshtha et al., 2013).

There are limitations to our study that should be considered. First, this was a cross-sectional analysis, which limits our ability to determine causal relations between HWC and CVH. We used self-reported data for HWC, which may be subject to recall bias, and we did not query regarding the intention behind weight loss and regain. Therefore, it is unclear how intention may have influenced the observed associations. In addition, HWC was classified as "presence-" or "absence of weight cycling" using the definition of loss and gain of ≥10 lb in one year, and we are unable to distinguish between the effects of weight cycling which occurred in young, middle, or later adult life. Furthermore, HWC did not include a time variable to account for women who may have gained ≥10 lb and have crossed over to an overweight/obese BMI category or lost ≥10 lb to a normal BMI category. With obesity as a known risk factor for CVD (Managing overweight and obesity in adults, 2017), we do not know whether there is a time-dependent response with staying in the overweight/obese BMI category for a certain length of time then losing the weight, or vice versa. Another limitation is that our findings, while consistent with previous work, may be due to chance given the number of multiple comparisons and warrant confirmation in larger prospective studies. Finally, although we recruited a racially and ethnic diverse sample with overweight and obesity rates similar to national estimates, this was a community-based sample that may not be representative of the US population.

5. Conclusion

In this community-based sample of women encompassing different life stages, HWC was associated with poorer overall CVH as assessed by the AHA LS7 composite score. Weight loss continues to be recommended for improved cardiometabolic health (Jensen et al., 2014) but weight maintenance after weight loss is difficult to achieve (Sacks et al., 2009; Methods for voluntary weight loss and control, 1992) and the long-term effects of these fluctuations in weight on CVH warrant further investigation. The results of this study suggest that maintenance of a healthy body weight and prevention of weight regain after weight loss may be critical for achieving optimal CVH. Future studies should expand on the definition of weight cycling to not only include intention, but also the time duration in the specific stages of weight cycling. In addition, prospective studies are needed to determine the long-term effects of weight cycling on CVH across the life course and to identify critical periods of exposure during which weight cycling may have a more pronounced effect on CVD risk.

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Disclosures

The authors report no disclosures.

Appendix

Table A.1

Table A1
American Heart Association's Life's Simple 7 Guideline Definitions.

	Metric Scores		
	Low (0 points)	Moderate (1 point)	High (2 points)
Overall Composite Score	0–8 total points	9–10 total points	11–14 total points
BMI (kg/m^2)	≥30	25–29.9	18.5 < BMI < 25
Blood Pressure (systolic/diastolic) (mm Hg)	≥130/≥80	120–129/ < 80 OR on treatment	< 120/ < 80 (untreated)
Total Cholesterol (mg/dL)	≥240	200–239 OR on treatment	< 200 (untreated)
Fasting Glucose (mg/dL)	≥126	100–125 OR on treatment	< 100 (untreated)
Physical Activity (minutes/week)	0	1–149 moderate intensity OR 1–74 vigorous intensity OR 1–149 combination	≥150 moderate intensity OR ≥75 vigorous OR combination
Diet	0–1 components of healthy diet pattern*	2–3 components of healthy diet pattern*	4–5 components of healthy diet pattern*
Smoking	Current Smoker	Former ≤ 12 months	Never OR quit greater than 12 months ago

Adapted from the American Heart Association Life's Simple 7 Guidelines. Study conducted at Columbia University Irving Medical Center from 2016 to 2018.
*A healthy diet pattern consisted of 5 components: ≥4.5 cups/day of fruits and vegetables, ≥2 servings/week of fish, ≥3 servings/day of whole grains, no more than 36 oz/week of sugar-sweetened beverages, and no more than 1,500 mg/day of sodium (Llyod-Jones et al., 2010).

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