Cardiometabolic and Fitness Improvements in Obese Girls Who Either Gained or Lost Weight during Treatment

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Objective To evaluate the quality of weight change (change in fat mass vs fat-free mass [FFM]), changes in cardiorespiratory fitness (CRF), and frequencies of metabolic risk factors in adolescent females with obesity who either lost or gained weight following lifestyle treatment.

Study design Fifty-eight girls (mean age = 13.0 ± 1.6 years; 77% black; mean body mass index = 36.5 ± 4.5 kg/m^2) completed a 6-month lifestyle intervention combining dietary and behavioral counseling with aerobic and resistance exercise training. We examined baseline to 6-month differences in weight (kg), body composition, CRF, and frequencies of metabolic risk factors between weight loss and weight gain groups.

Results In the weight loss group, body weight (−4.50 ± 3.53 kg, $P < .001$), fat mass (−4.50 ± 2.20 kg, $P < .001$), and body fat percentage (−2.97% ± 1.45%, $P < .001$) decreased, and FFM was unchanged at 6 months. In the weight gain group, body weight (4.50 ± 2.20 kg, $P < .001$), fat mass (1.52 ± 3.16 kg, $P < .024$), and FFM (2.99 ± 2.45 kg, $P < .001$) increased, and body fat percentage was unchanged. Both groups improved CRF ($P < .05$). Frequencies of metabolic risk factors were reduced across all participants after the 6-month treatment.

Conclusions Participation in a weight management program might elicit health improvements in obese adolescent females who increase weight and fat mass, provided that FFM gains are sufficient to negate increases in body fat percentage. *(J Pediatr 2015;166:1364-9).*

Trial registration ClinicalTrials.gov: NCT00167830.

The long-standing position that weight loss is requisite for health improvements in obese adults has been challenged by a new paradigm that emphasizes health promotion and the adoption of healthy lifestyle behaviors over weight loss as a primary goal of interventions.[1] There is evidence that high levels of physical activity and/or cardiorespiratory fitness (CRF) attenuate the health risks associated with obesity in adults.[2,3] Short- and long-term improvements in body composition, CRF, and metabolic risk factors have been reported in adolescents, independent of weight loss.[4-9] In the absence of weight loss, reduced frequencies of metabolic risk factors were coincident with the preservation of fat-free mass (FFM).[4,5,7,8] Fat mass, however, did not increase in any of the aforementioned studies, and, importantly, the association between CRF and metabolic syndrome (MetS) appears to be mediated by adiposity.[10] The inability to distinguish the respective effects of body fatness, FFM, and CRF on MetS in obese adolescents precludes any clear interpretation as to which outcomes should be of most concern to clinicians.

It is unclear whether improvements in CRF and metabolic risk factors might be realized in adolescents whose body weight and fat mass increase during the treatment period. Because body weight is positively associated with metabolic disease risk in adolescents,[11] the risk of transitioning from the metabolically healthy to the metabolically unhealthy phenotype with weight gain is also of concern. Therefore, the aim of this study was to compare the quality of weight change (change in fat mass vs FFM) and changes in CRF and frequencies of metabolic risk factors in obese female adolescents who either lost weight or gained weight following participation in a multidisciplinary weight management program.

Methods

This study evaluated outcomes from obese adolescent females aged 11-18 years enrolled in the Teaching, Encouragement, Exercise, Nutrition, and Support

BMI	Body mass index
BP	Blood pressure
CRF	Cardiorespiratory fitness
FFM	Fat-free mass
HDL	High-density lipoprotein
MetS	Metabolic syndrome
MHO	Metabolically healthy obese
TEENS	Teaching, Encouragement, Exercise, Nutrition, and Support
TG	Triglycerides
VO_{2peak}	Peak oxygen consumption

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(TEENS) weight management program at Children's Hospital of Richmond at Virginia Commonwealth University. In order to enroll in the TEENS program, participants were between 11 and 17 years of age, had a body mass index (BMI) ≥85th percentile, weighed less than 182 kg (400 lbs), were free of any medical conditions that preclude weight loss, and had a primary care physician. In the current study, we chose to evaluate only females to control for the potential influence of sex on the outcome measures of interest.[12,13] Given the challenges associated with attrition in this population[14] and the intent of this report to examine the influence of body weight and composition changes on cardiometabolic disease risk factors, only those who completed 6 months of the intervention were included in the analyses. All measures were recorded at baseline and after 6 months of program participation. Participants were retrospectively assigned to either the weight gain or weight loss group, depending on whether the 6-month weight change was positive or negative. The Virginia Commonwealth University Institutional Review Board approved all study procedures.

Body weight and height were measured by trained research staff using a digital scale and stadiometer to the nearest 0.1 kg and cm, respectively, and BMI was calculated as weight (kg) divided by height (m^2). BMI percentiles and Z-scores were determined using the 2000 Centers for Disease Control and Prevention growth charts.[15] Waist circumference was measured at the umbilicus and recorded to the nearest 0.1 cm using an anthropometric measuring tape. Pubertal status was classified by study physicians according to Tanner Staging.[16] Body composition was assessed by dual energy X-ray absorptiometry (Hologic D4500a/Discovery, Bedford, Massachusetts).

Resting blood pressure (BP) was assessed in triplicate with the participant in a seated position using an automated BP analyzer (Connex Vital Signs Monitor 6000 Series; Welch Allyn, Inc, Skaneateles Falls, New York). Elevated BP was defined as either systolic or diastolic BP >90th percentile for age, sex, and height.[17] Blood samples were collected from an antecubital vein after an overnight 12-hour fast. An automated clinical chemistry analyzer (Advia 1800 Chemistry System; Siemens Healthcare, Malvern, Pennsylvania) was used to measure total cholesterol, high-density lipoprotein (HDL), and triglycerides (TG). Glucose oxidase methodology was used to determine plasma glucose concentrations (2300 Stat Plus; YSI Life Sciences, Yellow Springs, Ohio). We also calculated the TG-to-HDL ratio (TG:HDL), as an elevated TG:HDL is associated with an increased risk of cardiometabolic disease in adolescents.[18,19]

Our classification of MetS in obese adolescents was contingent upon the participant exhibiting ≥3 of the following risk factors: moderate obesity (BMI >97th percentile for age and sex); TG ≥110 mg/dL; HDL-cholesterol ≤40 mg/dL; systolic or diastolic BP >90th percentile for age, sex, and height; and fasting glucose ≥100 mg/dL.[20] In the current study, BMI percentiles were converted to Z-scores and moderate obesity was defined as having a BMI Z-score >2.0 in order to standardize for age and sex.[21]

After excluding BMI Z-score from the classification criteria, participants who were absent of any remaining MetS risk factors were identified as having the metabolically healthy obese (MHO) phenotype.[11,22] Alternatively, participants with 1 MetS risk factor other than BMI Z-score >2.0 were considered metabolically unhealthy obese.

Peak oxygen consumption (VO_{2peak}), a measure of CRF, was assessed using a metabolic cart (Vmax Encore; Sensormedics, Yorba Linda, California) during a graded treadmill test to volitional fatigue. The treadmill protocol consisted of an initial 4-minute stage at 2.5 mph, followed by a 2-minute stage at 3.0 mph. During subsequent 2-minute stages, speed was held constant, and grade was increased to 2%, 5%, 8%, 11%, 14%, and 17%. The final two stages were performed at a treadmill speed of 3.5 mph and grades of 17% and 20%. Heart rate was monitored throughout the test with a heart rate monitor (E600; Polar Electro, Lake Success, New York). To account for the influence of body weight and composition on CRF, VO_{2peak} was assessed in absolute terms ($L\ O_2 \cdot min^{-1}$) as well as in relation to body weight ($mL\ O_2 \cdot kg^{-1}\ min^{-1}$) and FFM ($mL\ O_2 \cdot kg\ FFM^{-1}\ min^{-1}$).

The TEENS weight management intervention has been described in detail elsewhere.[20,23,24] In brief, participants attended weekly nutritional education or behavioral support sessions and engaged in supervised aerobic and resistance training 3 days per week. The nutrition education sessions followed a standardized lesson plan[23] targeting high risk eating behaviors (eg, sugared beverage intake and breakfast consumption) associated with obesity. Behavioral support sessions (on alternating weeks as nutrition education sessions) used a behavior therapy approach to change, including goal-setting, stimulus control, social support, reinforcement, and examination of barriers and facilitators to program participation. The aerobic exercise component included 30 minutes of continuous activity performed at a heart rate ≥150 beats per minute, and the resistance training component included 2-3 sets of 12-15 repetitions of at least 10 resistance exercises. Two additional days of physical activity outside of the structured sessions were encouraged, and family YMCA memberships were provided to participants. After the first 3 months, participants were only required to attend supervised exercise sessions twice per week, although additional exercise sessions were encouraged.

Statistical Analyses

All statistical analyses were performed using SPSS v 22 for Windows (SPSS Inc, Chicago, Illinois). Paired samples *t* tests were used to determine if changes in continuous outcome variables were significant across all subjects and within the weight gain and weight loss groups. One-way ANOVA was used to determine whether 6-month changes in anthropometric, and VO_{2peak} measures differed between the weight gain and weight loss groups. Fisher exact tests were used to determine if pubertal status, race, and frequencies of MetS risk factors differed between weight change groups. The prevalence of MetS and metabolic risk factors was compared across time points using McNemar procedure. We also