Startup Circuit Training Program Reduces Metabolic Risk in Latino Adolescents

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ABSTRACT

DAVIS, J. N., L. E. GYLLENHAMMER, A. A. VANNI, M. MEIJA, A. TUNG, E. T. SCHROEDER, D. SPRUIJT-METZ, and M. I. GORAN. Startup Circuit Training Program Reduces Metabolic Risk in Latino Adolescents. *Med. Sci. Sports Exerc.*, Vol. 43, No. 11, pp. 2195–2203, 2011. **Purpose**: This study aimed to test the effects of a circuit training (CT; aerobic + strength training) program, with and without motivational interviewing (MI) behavioral therapy, on reducing adiposity and type 2 diabetes risk factors in Latina teenagers. **Methods**: Thirty-eight Latina adolescents (15.8 ± 1.1 yr) who are overweight/obese were randomly assigned to control (C; n = 12), CT (n = 14), or CT + MI (n = 12). The CT classes were held twice a week (60–90 min) for 16 wk. The CT + MI group also received individual or group MI sessions every other week. The following were measured before and after intervention: strength by one-repetition maximum; cardiorespiratory fitness ($\dot{V}O_{2max}$) by submaximal treadmill test; physical activity by accelerometry; dietary intake by records; height, weight, waist circumference; total body composition by dual-energy x-ray absorptiometry; visceral adipose tissue, subcutaneous adipose tissue, and hepatic fat fraction by magnetic resonance imaging; and glucose/insulin indices by fasting blood draw. Across-intervention group effects were tested using repeated-measures ANOVA with *post hoc* pairwise comparisons. **Results**: CT and CT + MI participants, compared with controls, significantly increased fitness (+16% and +15% vs −6%, P = 0.03) and leg press (+40% vs +20%, P = 0.007). Compared with controls, CT participants also decreased waist circumference (−3% vs +3%; P < 0.001), subcutaneous adipose tissue (−10% vs 8%, P = 0.04), visceral adipose tissue (−10% vs +6%, P = 0.05), fasting insulin (−24% vs +6%, P = 0.03), and insulin resistance (−21% vs −4%, P = 0.05). **Conclusions**: CT may be an effective starter program to reduce fat depots and improve insulin resistance in Latino youth who are overweight/obese, whereas the additional MI therapy showed no additive effect on these health outcomes. **Key Words:** VISCERAL FAT, CIRCUIT TRAINING INTERVENTION, OVERWEIGHT LATINA ADOLESCENTS, FASTING INSULIN AND INSULIN RESISTANCE, MOTIVATIONAL INTERVIEWING

The prevalence of obesity in Los Angeles (LA) varies markedly by ethnic/racial group, with Latinos having among the highest rates (6), which puts them at an elevated risk for associated chronic diseases. We have previously shown that Latino children who are overweight and living in LA have elevated levels of visceral adiposity and liver fat, are extremely insulin resistant, and exhibit early signs of β-cell dysfunction and carotid thickness, all of which are linked to increased risk of type 2 diabetes, cardiovascular diseases, and nonalcoholic fatty liver disease (7,8,14,15,37,39). According to a recent diabetes study, the highest rates of pediatric type 2 diabetes are documented among 15- to 19-yr-old ethnic minority adolescents (29). It is projected that children born in the year 2000 will have a lifetime risk for diabetes that is approximately 50% for Latinos compared with 33% for non-Latino whites (29).

To date, few pediatric studies have examined the effects of a circuit training (CT) exercise program on specific fat depots and insulin resistance (2) or used Latino pediatric populations (38). Given that Latino youth are at risk for adiposity and related metabolic diseases, more interventions targeting this population, especially startup exercise interventions that are suitable for Latino youth who are overweight or obese, are warranted.

We have previously shown that a 16-wk CT (two times a week) intervention, which also included nutrition and motivational interviewing (MI) behavioral sessions, significantly improved fasting glucose levels and decreased overall adiposity levels in Latina adolescent girls who were overweight (9). In brief, MI is a goal-directed, client-centered counseling approach to help participants increase intrinsic motivation and strengthen commitment for change through the exploration and resolution of ambivalence (27). During the past 10 yr, MI has been touted as a compelling behavioral strategy to improve diet and physical activity behaviors and reduce pediatric obesity (33,34). However, no study,

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including our previous pilot study, has teased out the separate effects of an exercise intervention without behavioral therapy sessions or a nutrition component on adiposity and related metabolic outcomes.

Thus, the goal of this study was to test the effects of a 16-wk CT intervention, with and without MI sessions, on reducing specific fat depots (specifically VAT and hepatic fat) and other type 2 diabetes risk factors in Latina adolescent girls who are overweight or obese. We hypothesize that the effects of reducing adiposity and type 2 diabetes risk factors will be incremental: CT + MI > CT > control.

METHODS

Participants

Of the 64 participants who were prescreened and consented, 20 dropped out before pretesting for the following reasons: they were too busy, they thought the metabolic testing was too intense, they decided to join an athletic program, or their parents did not want them to participate. Participants satisfied the following criteria for inclusion: female, age- and gender-specific body mass index (BMI) ≥ 85th percentile (Centers for Disease Control and Prevention, 2000), Latino ethnicity (i.e., parents and grandparents of Latino descent by parental self-report), and grades 9–12 (age 14–18 yr). Participants were excluded based on the following criteria: 1) were using medication or were diagnosed with any disease that could influence dietary intake, exercise ability, body composition, or insulin indices; 2) were previously diagnosed with any major illness since birth; 3) had any diagnostic criteria for diabetes; or 4) participated in structured exercise, nutrition, or weight loss program in the past 6 months. In addition, all participants attended high schools where physical education classes were either not offered or offered less than 2 $d \cdot wk^{-1}$. Before any testing procedure, informed written consent from both parents and assent from the children were obtained. This study was approved by the institutional review board of the University of Southern California, Health Sciences Campus.

Randomization

Allocations were concealed from participants until after pretesting. Forty-five participants were randomized to one of three groups: control (n = 13), CT (n = 18), or CT + MI (n = 14). Randomization was blocked by intervention group to achieve balance in randomization. Siblings (six pairs) were randomized into the same experimental group (one in C, two in CT, and three in CT + MI), and data from both siblings were used.

Description of Interventions

Control group. Participants randomized to the control (C) group received no intervention during the 16 wk between preintervention and postintervention data collection. After posttesting, participants were offered an abbreviated 1-month delayed intervention, consisting of biweekly CT classes. No testing was done after the abbreviated delayed intervention.

CT only. Participants received CT exercise training two times per week for approximately 60–90 min per session for 16 wk at Veronica Atkins Lifestyle Intervention Laboratory. An overview of CT program is shown in Table 1. The exercise sessions were held on two nonconsecutive days per week and included 30–45 min total of cardiovascular activity (e.g., treadmill, elliptical machines, and aerobic classes) coupled with 30–45 min total of strength training. The CT program occurred in three phases and was personalized and progressive such that the intensity, resistance, and volume of the cardiovascular and strength training exercises were increased as the participant's fitness and strength improved. The strength training used in this program adhered to many of the recommendations from the American College of Sports Medicine Position Stand on the progression for resistance training for healthy adults (1) including progressive overload (i.e., gradually increasing intensity, volume and repetitions, and altering speed), linear periodization (i.e., varying the volume and intensity), utilization of different types of muscle action (i.e., using concentric, eccentric, and isometric exercises), exercise selection (i.e., inclusion of single- and multiple-joint exercises performed both unilaterally and bilaterally), and exercise order (i.e., performing multiple-joint exercises in the early part of the workout). Participants would complete two different strength training exercises (upper and lower body exercise were paired together), each 1 min without stopping or rest, followed by 2–3 min of cardiovascular exercises. Participants wore HR monitors (Polar FS1 model; Warminster, PA) in every exercise session and were instructed and supervised to maintain their HR between 70% and 85% of their maximum throughout the session, even while strength training. A 5:1 child-to-trainer ratio was used. Participants were required to

TABLE 1. CT program overview.

Weeks 1–4	Weeks 5–10	Weeks 11–16
• ~60 min • 5-min warm-up • 8–9 circuits: each consisted of two ST exercises (1 min each) and one cardiovascular exercise (2 min): ○ Low to moderate weight ○ 12–14 repetitions ○ 70%–75% of HR_{max} sustained	• ~75 min • 5-min warm-up • 6–7 circuits repeated twice: each consisted of two ST exercises (1 min each) and one cardiovascular exercise (2.5 min): ○ Moderate weight ○ 10–12 repetitions ○ 70%–80% of HR_{max} sustained	• ~90 min • 5-min warm-up • 7–8 circuits repeated twice: each consisted of two ST exercises (1 min each) and one cardiovascular exercise (3 min): ○ Moderate to heavy weight ○ 8–10 repetitions ○ 70%–85% of HR_{max} sustained
• 5-min stretching	• 5-min stretching	• 5-min stretching
Examples of circuits:		
• Circuit 1: ○ Leg press ○ Chest press ○ Brisk walk on treadmill	• Circuit 3: ○ Squats ○ Shoulder press ○ Row machine	• Circuit 5: ○ Leg extension ○ Triceps extensions ○ Stationary bicycle
• Circuit 2: ○ Leg curls ○ Lat pull-down ○ Elliptical	• Circuit 4: ○ Calf raises ○ Bicep curl ○ Stationary bicycle	• Circuit 6: ○ Planks ○ Abdominal crunches ○ Stair stepping

attend at least 28 of the 32 sessions and could not miss more than two consecutive classes. Makeup classes were provided when needed.

CT + MI. Participants in the CT + MI group received the same CT classes as described above but also received four individual MI and four group MI sessions throughout the 16-wk program by two trained research staff (both members of the Motivational Interviewing Network of Trainers). MI is a client-centered counseling approach designed to enhance motivation for behavior change by creating, exploring, and resolving ambivalence toward changing behaviors and habits (27). All MI sessions were recorded, and a subsample (10%) was doubly coded using the Motivational Interviewing Treatment Integrity Code (28), which is a behavioral coding system designed to measure treatment fidelity for MI. Tapes were randomly selected and coded by Motivational Interviewing Network of Trainers research staff not involved in this study. The range of the five global ratings (i.e., evocation, collaboration, autonomy/support, direction, and empathy) was from 3 to 5 with an average of 3.8, with 3.5 being considered proficient. The intraclass correlations across each of the global ratings were assessed, and the average Cronbach α was 0.77, which is in the excellent range (5).

Testing visit at the clinical trials unit. The following measures were performed at baseline (within 1 wk before the intervention) and at week 16 (within 1 wk after the intervention) in the University of Southern California Clinical Trials Unit.

Fasting blood draw. Participants were instructed not to eat or drink anything (except water) past 8 p.m. the night before. Participants were picked up from their homes and arrived at the clinical trials unit at approximately 7:30 a.m. After fasting condition was confirmed, a blood draw was performed by a certified phlebotomist or nurse. Blood samples were centrifuged immediately for 10 min at 2500 RPM and 8°C–10°C to obtain plasma, and aliquots were frozen at −70°C until assayed. Glucose was assayed in duplicate on a Yellow Springs Instrument 2700 Analyzer (Yellow Springs Instrument, Yellow Springs, OH; interassay coefficient of variation <2%), which uses a membrane-bound glucose oxidase technique. Insulin was assayed in duplicate using a specific human insulin ELISA kit from Linco (St. Charles, MO; intra-assay coefficient of variation = 4.7%–7.0%, interassay coefficient of variation = 9.1–11.4%, cross reaction with human proinsulin = 0%). The homeostasis model assessment of insulin resistance (HOMA-IR) was calculated [fasting insulin ($\mu U \cdot mL^{-1}$) × fasting glucose ($mmol \cdot L^{-1}$)/22.5] (25).

Anthropometrics, blood pressure, and body composition. A certified healthcare provider preformed a detailed physical exam where Tanner staging was determined using established guidelines (23). Weight and height were measured first thing in the morning, after the overnight fast, to the nearest 0.1 kg and 0.1 cm, respectively, using a beam medical scale and wall-mounted stadiometer; BMI and BMI percentiles were then calculated (26). Waist and hip circumference was measured in triplicate, and the average was recorded to the nearest 0.1 cm. Sitting blood pressure was obtained according to recommendations of the American Heart Association (16).

Either in the morning after the overnight fast or in the afternoon after a 3-h fast, the following body composition measures were performed. Total fat mass and total lean mass were measured by dual-energy x-ray absorptiometry using a Hologic QDR 4500W (Hologic, Bedford, MA). Abdominal fat distribution (visceral, subcutaneous, and hepatic fat) was assessed by magnetic resonance imaging using a General Electric 1.5-T magnet (Waukesha, WI). The magnetic resonance imaging protocol was based on a sensitive three-point chemical-shift fat–water separation method previously described by Dixon (10) and Glover and Schneider (13), which has been validated by several independent research groups (21,40). Multiple-slice axial TR 400/16 view of the abdomen at the level of the umbilicus was analyzed for cross-sectional area of the adipose tissue. The standard body transmit and receive coil was used, along with a rectangular field of view of 420 mm (right/left) by 315 mm (anterior/posterior). The slice thickness was 10 mm with no interslice gaps. The fat-only data set was used in the subsequent quantification of subcutaneous and visceral adipose tissue volume, whereas the fat fraction data set was used to assess percent hepatic fat content. A commercially available image segmentation and quantification software (SliceOmatic, Tomovision, Inc., Magog, Canada) was used. Subcutaneous and visceral volumes were computed across all 19 image slices in each participant. Hepatic fat fraction was computed as the mean fat fraction in all imaging slices within which the liver was present.

Dietary intake. Dietary intake was assessed by 3-d diet records (two weekdays, one weekend day), which has been widely used and validated with adolescents (4). All records were administered or clarified by a bilingual dietary technician in person or via telephone. Nutrition data were analyzed using the Nutrition Data System for Research (NDS-R version 5.0_35).

Strength and physical fitness and activity assessment. The single-stage submaximal treadmill test was used to estimate $\dot{V}O_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$), which gives a measure cardiorespiratory fitness, and has been validated in children (11). Using established procedures (12), upper- and lower-body strength assessments were completed before and after the intervention by one-repetition maximum in the bench press and leg press, respectively.

To assess habitual physical activity, subjects were instructed to wear an ActiGraph accelerometer (models 7164 and GT1M; Computer Science and Application, Shalimar, FL) for 7 d. The ActiGraph accelerometer is a reliable instrument, valid for measuring activity in children and adolescents (32). The accelerometers were set to monitor activity in 15-s epochs. Accelerometry data downloaded from the ActiGraph devices were reduced using an adapted

TABLE 2. Baseline physical and metabolic characteristics of intervention groups (n = 38).[a]

	CT + MI (n = 12)	CT (n = 14)	Control (n = 12)	P^b
Age (yr)	15.7 ± 1.2	15.7 ± 1.1	15.8 ± 1.0	0.93
Tanner (4 or 5)	2/10	1/13	2/10	0.85
Blood pressure (mm Hg)				
Systolic	65.0 ± 7.0	64.0 ± 6.7	69.2 ± 6.4	0.19
Diastolic	114.6 ± 9.4	111.6 ± 9.8[c]	121.9 ± 10.4[d]	0.04
Body composition				
Weight (kg)	88.5 ± 16.8	80.2 ± 10.7[c]	94.4 ± 13.4[d]	0.04
Height (cm)	159.5 ± 3.7	157.0 ± 5.9	160.3 ± 4.9	0.24
BMI (kg·m^{-2})	34.6 ± 6.0	32.4 ± 3.2	36.4 ± 5.2	0.10
BMI z score	2.1 ± 0.4	2.0 ± 0.3	2.2 ± 0.2	0.12
BMI percentile	97.3 ± 2.6	97.1 ± 1.9	98.4 ± 0.9	0.17
Waist (cm)	142.5 ± 15.1	103.7 ± 72.2	113.2 ± 12.5	0.14
Total fat (kg)	36.3 ± 10.6	31.8 ± 5.2[c]	40.0 ± 8.3[d]	0.05
Percent fat (%)	41.5 ± 6.1	40.6 ± 3.9	43.1 ± 3.2	0.38
Total lean (kg)	47.8 ± 7.9	44.3 ± 6.7	49.7 ± 5.2	0.12
VAT (L)	2.1 ± 0.8	2.0 ± 1.0	2.5 ± 0.3	0.58
SAT (L)	17.0 ± 5.2	15.2 ± 3.6	18.4 ± 4.8	0.17
Hepatic fat (%)	5.9 ± 2.1	6.4 ± 4.0	8.2 ± 4.2	0.27
Pancreatic fat (%)	7.5 ± 3.0	6.5 ± 2.8	6.8 ± 2.3	0.65
Glucose/insulin indices				
Fasting glucose (mg·dL^{-1})	90.5 ± 4.9	89.8 ± 5.0	90.8 ± 4.5	0.85
Fasting insulin (μU·mL^{-1})	15.7 ± 7.0	14.7 ± 8.5	19.6 ± 9.2	0.33
HOMA-IR	3.5 ± 1.6	3.2 ± 1.9	4.9 ± 2.9	0.33
SI ($\times 10^{-4}$ min^{-1}·μU^{-1}·mL^{-1})[e]	1.6 ± 0.5	2.0 ± 0.7	1.2 ± 0.2	0.06
AIR (μU·mL^{-1} × 10 min)[e]	1075.7 ± 535.1	1033.6 ± 259.0	1579.2 ± 532.2	0.12
DI ($\times 10^{-4}$ min^{-1})[e]	1680.7 ± 719.4	1936.4 ± 569.3	1904.5 ± 820.9	0.72

[a] Data are mean ± SD.
[b] ANOVA with Bonferroni adjustments and χ^2 tests (for Tanner only) were used to determine significant differences between intervention groups. The P value represents the overall significance between intervention groups. Analyses were based on log scores for the following variables: weight, BMI, total fat mass, fasting glucose and insulin, HOMA, SI, and AIR.
[c,d] Means not sharing a common superscript letter are significantly different at ($P \le 0.05$) based on Bonferroni multiple comparisons.
[e] Subsample for insulin indices using FSIVGTT: n = 10 for CT + MI, n = 7 for CT, n = 6 for C.
AIR, acute insulin response; DI, disposition index; FSIVGTT, Frequently sampled intravenous glucose tolerance test; SAT, subcutaneous abdominal adipose tissue; SI, insulin sensitivity; VAT, visceral adipose tissue.

version of the SAS code used to reduce the accelerometry data in the 2003–2004 National Health and Nutrition Examination Survey (30). Because the adolescents in the current study had an average BMI of 35, the intensity thresholds used for adults and older adolescents in National Health and Nutrition Examination Survey were used to designate moderate plus vigorous intensities. In addition, a sedentary cut point of 100 was used (24). Days with <10 h of wear data and participants with at least ≥4 d of measurement before and after testing were included in the analysis for this study. Data were immediately downloaded, and accelerometers were reissued if the minimum of 4 d of 10 h of wear date was not met.

Statistical considerations. ***Sample size.*** Power calculations, based on a target of 80% power and 0.05 probability of type 1 error, were performed based on between-group mean differences (mean ± SD) from our CT pilot study comparing control (n = 7) with nutrition only (n = 10)

TABLE 3. Baseline strength, physical activity/fitness, and dietary characteristics of interventions groups (n = 38).[a]

	CT + MI (n = 12)	CT (n = 14)	Control (n = 12)	P^b
Dietary[c]				
Energy (kcal·d^{-1})	1703.2 ± 472.8	1761.1 ± 391.3	1701.0 ± 486.1	0.93
Carbohydrate (% kcal)	51.2 ± 9.5	52.5 ± 4.8	52.9 ± 7.1	0.84
Protein (% kcal)	15.5 ± 3.9	15.7 ± 3.6	16.0 ± 3.6	0.95
Fat (% kcal)	33.3 ± 7.4	31.6 ± 5.2	31.1 ± 8.2	0.72
Strength				
Bench press (kg)	65.0 ± 18.6	63.1 ± 20.2	61.1 ± 11.6	0.48
Leg press (kg)	299.6 ± 86.3	272.8 ± 80.6	258.6 ± 60.4	0.07
Physical fitness				
$\dot{V}O_{2max}$ (mL·kg^{-1}·min^{-1})	24.1 ± 7.9	19.7 ± 7.6	21.9 ± 8.7	0.26
Accelerometry				
Counts (min^{-1})	310.3 ± 96.2	285.9 ± 97.0	310.6 ± 116.8	0.80
SPA (%)	63.0 ± 8.2	63.3 ± 8.2	63.9 ± 6.5	0.96
LPA (%)	33.3 ± 7.8	33.5 ± 7.5	32.1 ± 6.6	0.89
SLPA (%)	96.3 ± 2.1	96.9 ± 2.1	96.0 ± 3.2	0.67
MPA (%)	3.7 ± 2.1	3.1 ± 2.1	4.0 ± 3.1	0.67
VPA (%)	0.02 ± 0.05	0.03 ± 0.07	0.04 ± 0.06	0.70
MVPA (%)	3.7 ± 2.1	3.1 ± 2.1	4.0 ± 3.2	0.67

[a] Data are mean ± SD.
[b] ANOVA with Bonferroni adjustments were used to determine significant differences between intervention groups. The P value represents the overall significance between intervention groups. Analyses were based on log scores for the following variables: $\dot{V}O_{2max}$, and all accelerometry data.
[c] One subject missing dietary intake in the CT + MI group.

with CT + nutrition (n = 15). The observed difference in fat mass change between the CT and control intervention arms was 1.8 kg (−1.4 ± 1.3 vs 0.4 ± 1.3 kg). The observed difference in fasting glucose change between the CT and nutrition group was 6.8 mg·dL^{-1} (−4.3 ± 6.1 vs 2.5 ± 5.3). Hence, with the available ≥12 subjects in each group, we should have adequate power to detect meaningful differences in body composition and glucose values between CT and control. *Post hoc* power calculations were performed based on the between-group mean differences (mean ± SD). The correlation among repeated-measures ranged from 0.6 (for bench press) to 0.98 (for total body fat). The effect sizes ranged from 0.3 (for total fat), 0.5 (for HOMA, visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT)) to 0.7–0.8 (fasting insulin, waist), with a total sample size of 38 or >12 in each group being sufficient to detect significance in most health outcomes.

Statistical analyses. All baseline and postintervention variables were evaluated for normality, and transformations were made to the following variables: bench and leg press, $\dot{V}O_{2max}$, weight, BMI, BMI percentile, dual-energy x-ray absorptiometry fat mass, and all glucose/insulin indices except fasting glucose. However, the nontransformed values are presented in the tables and figures for ease of interpretation. Across-group comparisons of baseline physical and metabolic characteristics were conducted for evaluable participants using ANOVA and χ^2 (for Tanner only) to identify possible randomization imbalance.

The overall effects of the interventions were tested for evaluable participants using repeated-measures ANOVA. When significant differences across groups were identified, *post hoc* pairwise comparisons with Bonferroni adjustments were conducted. Homogeneity tests were conducted, and all were nonsignificant. All analyses were performed using SPSS version 16.0 (SPSS, Chicago, IL), with significance level set at $P \leq 0.05$.

RESULTS

Of the 130 potential subjects who were available for consenting, 44 subjects qualified for the program. Of these, 38 completed the program (evaluable participants), 12 in the C group, 14 in the CT group, and 12 in the CT + MI group. Reasons for dropouts included lost interest (n = 1), too many absences to exercise class (n = 4), and taking college preparation classes (n = 1). There were no statistically significant differences in baseline demographics, anthropometrics, or body composition measures between the seven participants who dropped out of the program and the 38 participants who completed the program. All evaluable participants in the intervention groups attended a minimum of 28 of the 32 exercise classes. However, the average attendance for the classes was 31, and the average makeup classes offered was 2.

Table 2 presents baseline physical and metabolic characteristics for the evaluable participants stratified by intervention group. Participants were 15.8 ± 1.1 yr and 11% were Tanner stage 4 and 89% were Tanner stage 5. There were significant across-group effects for baseline diastolic blood pressure (P = 0.04), weight (P = 0.04), and body fat (P = 0.05). CT participants compared with C had a 9% lower diastolic blood pressure (P = 0.03), an 18% lower body

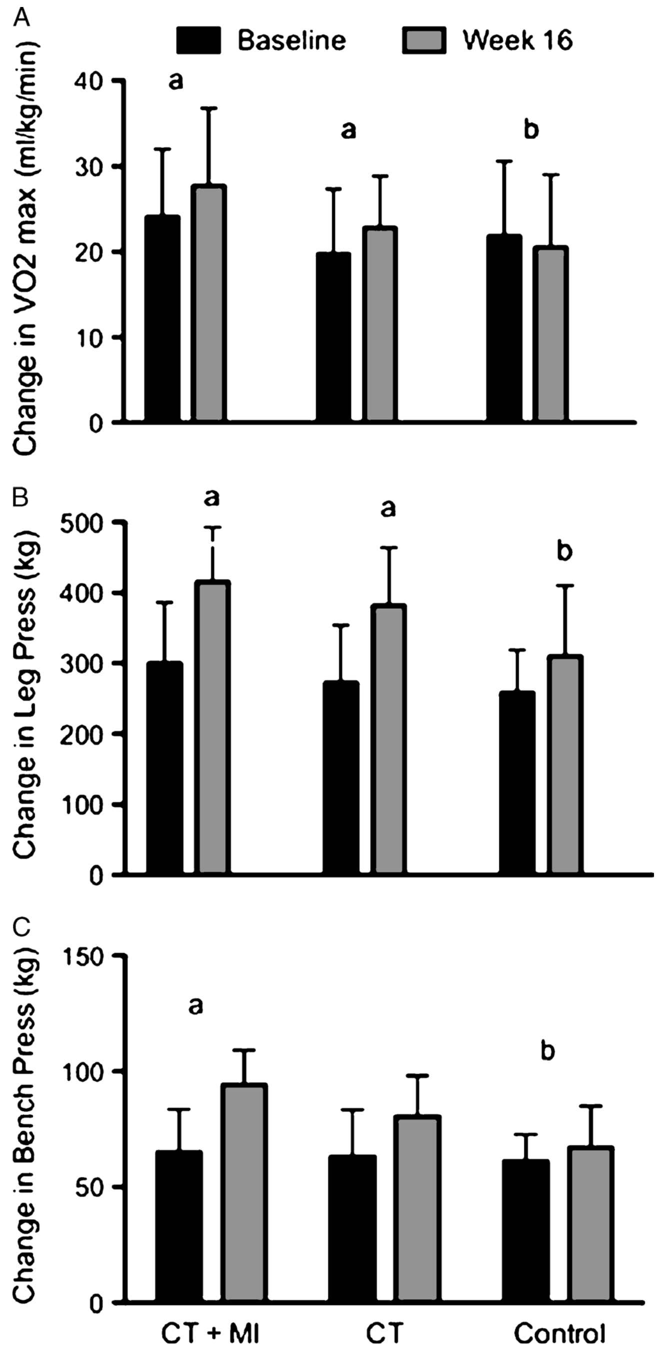

FIGURE 1—A–C, Change in $\dot{V}O_{2max}$, leg press, and bench press values between each intervention groups. Data are presented as mean ± SD. Changes in fitness and strength levels were calculated with repeated-measures ANOVA. There was an overall effect for $\dot{V}O_{2max}$ (P = 0.04), leg press (P = 0.007), and bench press (P = 0.02). [a,b]Means not sharing a common superscript letter are significantly different at $P \leq 0.05$ based on Bonferroni multiple comparisons.

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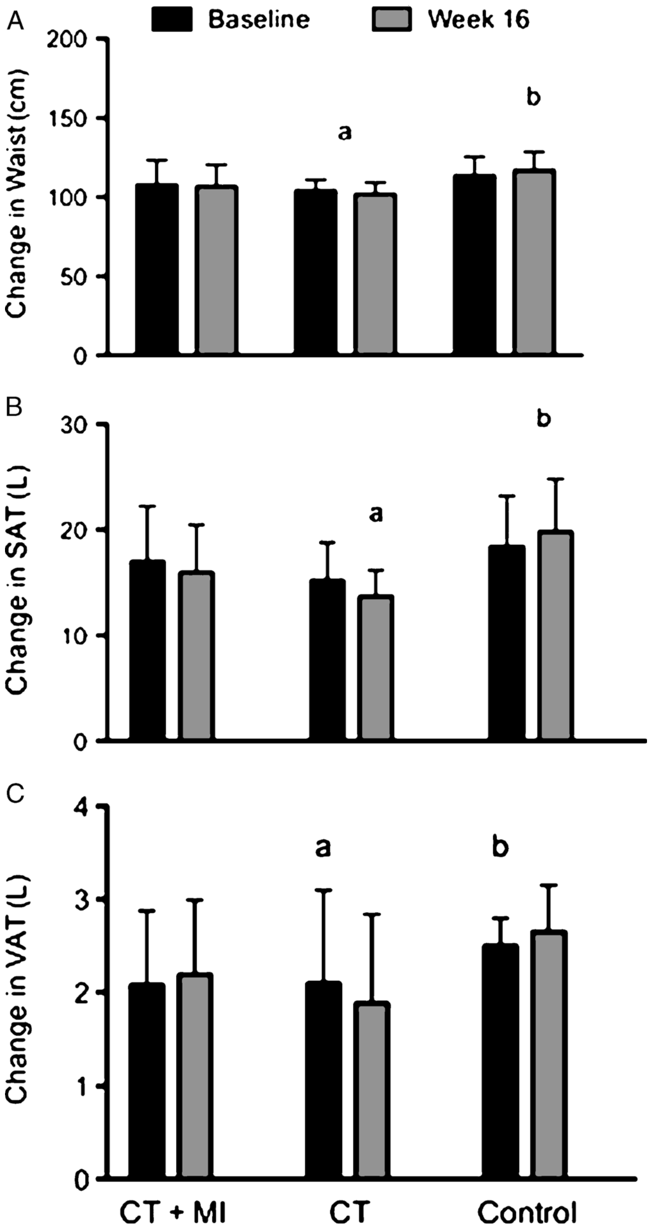

FIGURE 2—A–C, Change in adiposity measures (i.e., waist circumference, SAT and VAT) between intervention groups. Data are presented as mean ± SD. Changes in adiposity measures were calculated with repeated-measures ANOVA. There was an overall effect for waist (P < 0.001), SAT (P = 0.04), and VAT (P = 0.05). [a,b]Means not sharing a common superscript letter are significantly different at $P \leq 0.05$ based on Bonferroni multiple comparisons.

weight (P = 0.04), and a 26% lower body fat (P = 0.05). Table 3 presents baseline strength, habitual physical activity, physical fitness, and dietary characteristics for evaluable participants stratified by intervention group. There were no significant across-group effects for any dietary, physical activity, or fitness values.

Figure 1 shows the significant differences in changes in physical fitness and strength between intervention groups. There was a significant across-group effect for change in estimated $\dot{V}O_{2max}$ (P = 0.04), with CT + MI and CT groups increasing by 15% and 16% compared with a 6% decrease in C group (both P values = 0.05). There were significant across-group effects for change in leg press (P = 0.007) and change in bench press (P = 0.02). CT + MI and CT participants increased leg press by 40% compared with a 20% increase in C group (both P values = 0.04). CT + MI participants increased bench press by 45% compared with a 10% increase in C group (P = 0.03).

Figure 2 shows the significant differences in changes in waist circumference, SAT, and VAT between intervention groups. There was a significant across-group effect for change in waist (P < 0.001), with CT participants decreasing by 3% compared with a 3% increase in Controls (P = 0.03). There was a significant across-group effect for change in SAT (P = 0.04), with CT participants decreasing by 10% compared with 8% increase in C group (P = 0.01). There was a significant across-group effect for change in VAT (P = 0.05), with the CT participants decreasing by 10% compared with C group increasing by 6% (P = 0.05). There were no significant across-intervention group effects for changes in weight, BMI, BMI z scores/percentiles, total fat

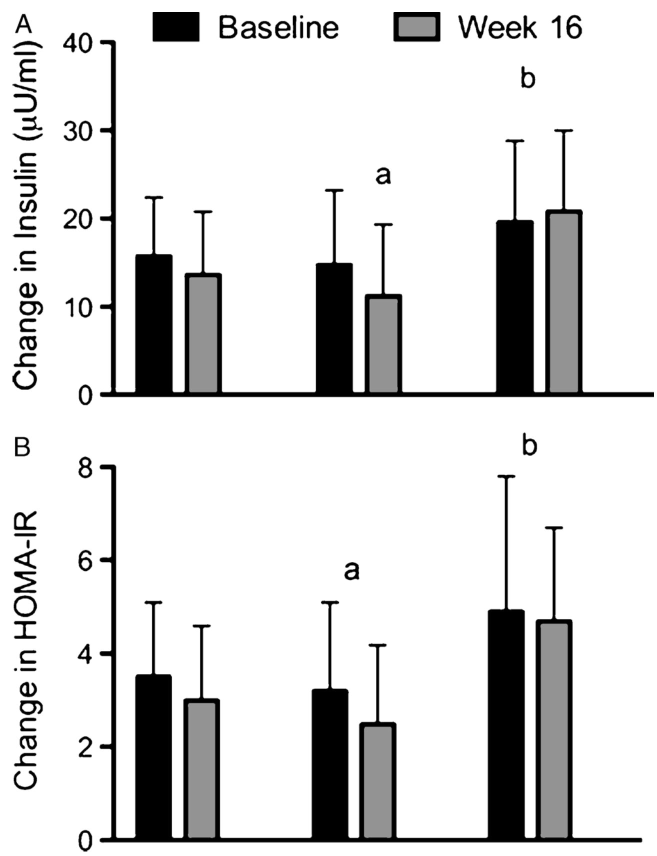

FIGURE 3—A and B, Change in fasting insulin and HOMA-IR between intervention groups. Data are presented as mean ± SD. Change in fasting insulin and HOMA-IR was calculated with repeated-measures ANOVA. There was a significant overall effect for fasting insulin (P = 0.03) and for HOMA-IR (P = 0.05). [a,b]Means not sharing a common superscript letter are significantly different at $P \leq 0.05$ based on Bonferroni multiple comparisons.

(expressed in kilograms or percent fat), lean tissue mass, or liver fat.

Figure 3 displays the significant differences in changes in fasting insulin and HOMA-IR between groups. There was a significant across-group effect for changes in fasting insulin ($P = 0.03$), with the CT participants decreasing by 24% compared with the C group increasing by 6% ($P = 0.05$). There was a significant across-group effect for changes in HOMA-IR ($P = 0.05$), with CT participants decreasing by 21% compared with a 4% decrease in C group ($P = 0.05$). There were no significant across-intervention group effects for fasting glucose.

DISCUSSION

We have previously shown that a CT intervention with integrated nutrition and MI sessions significantly decreased overall adiposity levels and improved fasting glucose in Latina adolescent girls who were overweight (8). However, for this study, we wanted to know how much the CT, without nutrition and MI sessions, contributed to these effects. The current study shows that the CT only group reduced waist circumference, VAT, SAT, fasting insulin, and insulin resistance in Latina adolescent girls. These results suggest that the CT exercise approach, without additional nutritional or behavioral therapy sessions, may be an excellent starter program for Latino youth who are overweight or obese to reduce adiposity and improve metabolic parameters.

To date, few studies have examined the combined effect of aerobic exercise and strength training on body composition and insulin resistance. In an intense 10-month afterschool exercise program (80 min of a combination of sport skill development, aerobic exercise, and strength training × 5 d·wk^{-1}) conducted in 200 black girls (8–12 yr old), participants in the exercise program decreased body fat percent, BMI, and VAT compared with C group ($P = 0.003$) (2). Bell et al. (3) showed that an 8-wk combined aerobic and strength training program (60 min × 3 d·wk^{-1}), without weight loss, resulted in decreased insulin resistance in Caucasian children and adolescents (age 9–16 yr) who were sedentary and obese. Our previous 16-wk CT pilot intervention, which included nutrition (60 min × 1 d·wk^{-1}), CT (60–90 min × 2 d·wk^{-1}), and MI sessions (8 × 20-min sessions throughout) with 41 Latina adolescent girls who were overweight, significantly improved fasting glucose levels and decreased overall adiposity levels compared with a nutrition-plus-strength-training program (9). The current study was the first to show the positive effects of CT alone on reducing specific fat depots and insulin resistance in Latino youth who are overweight or obese.

Some pediatric exercise intervention studies have examined the effects on reducing specific fat depots, like visceral adiposity. Owens et al. (31) showed that an intense 4-month aerobic exercise intervention (40 min × 5 d·wk^{-1}) with 74 children (age 7–11 yr) who were obese significantly decreased SAT and attenuated increases in VAT compared with a nonexercising control group. Similarly, Gutin et al. (17) showed that an intensive 8-month aerobic physical activity intervention (30 min × 5 d·wk^{-1}) resulted in significant improvements in cardiovascular fitness and reductions in total body composition and VAT compared with a lifestyle education intervention group (20). A recent study by van der Heijden et al. (38) conducted with 15 Hispanic adolescents who were obese showed that a 12-wk aerobic exercise intervention (30 min × 4 d·wk^{-1}) resulted in significant improvements in cardiovascular fitness and reductions in VAT and hepatic fat, fasting insulin, and HOMA-IR, without weight loss or change in BMI; however, there was no control group in this study. Yet, the above studies included relatively high frequency of exercise sessions (4 or 5 d·wk^{-1}) and the current study showed that 2 d·wk^{-1} of CT could result in significant reductions in both VAT and SAT. Starting a 2-d·wk^{-1} CT program might be easier and more feasible for adolescents who are overweight or obese and seems to be just as effective at reducing metabolic risk.

The CT approach may a good starter program for children population who are overweight or obese because it includes only short bouts of cardiovascular components (2 min in length) coupled with strength training. The intense aerobic intervention may not be initially feasible, or as easily attainable, for children who are overweight or obese. CT allows children who are overweight/obese to accumulate 30–45 min of cardiovascular exercise and 30–45 min of strength training in an achievable fashion. This approach allows participants to maintain their HR between 70% and 85% of their max for every exercise session (~60–90 min). Thus, the CT approach may allow individuals who are overweight or obese to enhance fitness and strength while promoting initial fat loss and improvements in metabolic profiles, thereby serving as a good "jump start" to an exercise program.

To our knowledge, the current study was the first to show that MI sessions did not significantly improve health outcomes, and CT alone showed more promising results. During the past 10 yr, MI has been incorporated into pediatric obesity prevention and treatment efforts to improve diet and physical activity behaviors (33). In a 6-month, church-based, nutrition and physical activity program called "Go Girls" with 123 African American adolescent girls, a high-intensity intervention (30 min × 20–26 sessions) with four to six telephone MI calls (20–30 min) compared with moderate-intensity groups (6 sessions) did not result in reductions in obesity (34). In another nonrandomized clinical trial of 91 children (3–7 yr), children who received a total of four MI sessions from their physician and a registered dietitian did not have significant reductions in BMI percentiles compared with those receiving control and minimal intervention (36). However, most of the studies utilizing MI use it in combination with other exercise or diet programs, and the separate or additive effects of using MI techniques in obesity prevention/treatment programs have not been thoroughly evaluated.

The CT group reduced VAT and insulin resistance, whereas the CT +MI group did not, despite similar increases in strength and fitness in both groups. Although there were no significant differences in habitual intake and physical activity (as measured by diet records and accelerometer before and after intervention), there may have been acute changes in these variables throughout the intervention. It is possible that the CT group compared with the CT + MI group increased habitual physical activity outside of the exercise sessions and/or decreased energy intake or consumed healthier foods/beverages (i.e., lower in fat and sugar) throughout the intervention, and these changes were simply not captured by the postintervention measures. Interestingly, MI sessions in this intervention were designed to specifically target improved dietary and physical activity behaviors outside the exercise sessions. Some possible explanations for the null MI effects might be that the MI sessions were too frequent (eight sessions for 4 months) and were held before or immediately after the exercise sessions (for logistical and transportation issues). It is possible that the MI sessions will lead to more long-term changes in behaviors and subsequent improvements in health. However, these results suggest that MI in a startup program may not be necessary for initial metabolic improvements.

One possible mechanism to explain why the CT intervention reduced VAT, without reductions in weight and BMI, is that visceral fat is more metabolically active and responsive to catecholamines than other fat depots (19) and catecholamines are known to increase with exercise (35). More is known about the mechanism on how exercise affects insulin sensitivity. Strength training has also been shown to increase insulin-mediated glucose uptake and enhance insulin sensitivity (18,22). Strength training improves up-regulation of components of the insulin-signalizing cascade, such as protein concentrations of the insulin receptor, protein kinase B, glycogen synthase, and GLUT-4 (22). These mechanisms support our findings that the combination of aerobic and strength training can reduce adiposity, specifically VAT, and reduce insulin resistance.

There are limitations of this study that should be considered. The first limitation is that this study was conducted in Latina adolescent girls who are overweight or obese and cannot be generalized to other pediatric populations or males. However, the homogeneity of this population allows us to test the efficacy of an exercise intervention in a high-risk sample. Another limitation is the relatively small sample size (n = 38). Additional studies in larger samples that include males, subjects who are lean, and/or other ethnicities are warranted to further understand the effects of CT on reducing specific fat depots and improving metabolic parameters. The current CT intervention was also conducted in a fully equipped and well-supervised exercise gym, and future research examining the effects of CT interventions conducted in home, school, or community settings is warranted.

In conclusion, these findings suggest that a 16-wk starter CT program can reduce adiposity depots, specifically VAT, and insulin resistance, thus decreasing metabolic disease risk in Latino adolescents who are overweight or obese. The MI sessions had no additive beneficial effect on improving health outcomes in the short term. Given that CT approach included a fairly modest dosage of two times a week for 60–90 min, and only required short bouts of cardiovascular and strength training, this may be an excellent starter exercise program for adolescents who are overweight or obese and has the potential to have far reaching improvements on metabolic parameters. Interventions examining the effects of the CT approach, on improving metabolic profiles with larger samples, mixed ethnicities, genders, comparing it with other established exercise approaches, and expanding the duration are warranted.

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APPLIED SCIENCES

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