Resistance Training Differentially Affects Weight Loss and Glucose Metabolism of White and African American Patients with Type 2 Diabetes Mellitus

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Objective: We aimed to identify whether racial differences in body composition and glucose metabolism occur in response to exercise and determine whether aerobic and resistance exercise modalities bring about differential changes in these parameters in African Americans and White persons with type 2 diabetes.

Research Design and Methods: Participants included 36 African American and 23 White men and women with type 2 diabetes who were randomly assigned to eight weeks of either resistance or aerobic exercise. Before and after this intervention, each participant underwent a series of measurements that assessed anthropometrics and glucose metabolism.

Results: African Americans responded more favorably to resistance training than did Whites. This difference was manifested by a significant improvement in BMI ($-2.57\% \pm .90\%$ vs $2.57\% \pm 1.09\%$, $P < .01$) and insulin resistance ($-19.15\% \pm 9.00\%$ vs $13.12\% \pm 11.86\%$, $P < .05$) in African Americans compared to Whites. When comparing exercise modalities within the races, African Americans demonstrated a preferential response to resistance training.

Conclusions: Eight weeks of resistance training by African Americans may have a more positive effect on weight loss and glucose metabolism than aerobic exercise training. Furthermore, the changes observed appear to be unique to African Americans, as no changes were observed in Whites after an equal amount of resistance training. When an exercise program is designed for a person with type 2 diabetes, race should be taken into consideration, and resistance exercise for African Americans may lead to increased weight loss and improved insulin sensitivity than does aerobic exercise. (*Ethn Dis*. 2008;18:152–156)

Key Words: Aerobic Training, Resistance Training, Insulin Sensitivity, DEXA, HOMA-IR

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Introduction

Diabetes mellitus is a metabolic disease that is characterized by insulin resistance, relative α-cell dysfunction, and elevated risk of complications such as vascular disease and other co-morbidities.[1] Diabetes is associated with obesity and reduced physical activity, and while weight loss can improve glucose metabolism in diabetes patients,[2] aerobic exercise training can further improve glucose metabolism.[3]

African Americans are more likely to develop diabetes, as well as suffer from associated complications compared to White Americans.[4] Although the etiology of this disparity is not entirely clear, it has been ascribed to the greater prevalence of obesity in African Americans.[5] While the etiology of racial differences in obesity is also not clear, it likely stems from both lower resting energy expenditure,[6,7] and physical inactivity[8] in African Americans.

In addition to these differences in factors pertaining to energy expenditure that predispose African Americans to a greater risk of obesity and the development of diabetes, there are also hormonal mechanisms that may contribute to this phenomenon. Previous research by Osei et al,[9–12] has suggested that African Americans are more insulin resistant than Whites, as demonstrated by higher basal insulin levels, reduced hepatic insulin extraction and impaired glucose tolerance in African Americans. A combination of these differences in determinants of body composition and glucose metabolism are therefore likely to play a significant role in the etiology of greater prevalence rates of diabetes in African Americans compared to Whites.

Resistance training has been associated with improved insulin sensitivity and weight loss due to gains in insulin-sensitive tissue (ie, skeletal muscle). These gains in metabolically active tissue can increase daily caloric expenditure, facilitating the loss of body fat over time.[13,14] Previous research demonstrated that resistance training by people with diabetes three days per week plus weight loss can decrease hemoglobin A1C levels, cause significant body fat loss, and maintain lean body mass compared to dieting alone.[15] However, when considering that African Americans have lower resting energy expenditure and greater insulin resistance than do Whites, African Americans and Whites may respond differently to resistance exercise, although this hypothesis has yet to be tested.

Similar to resistance exercise, aerobic exercise training can also improve both glucose metabolism and body fat percentage in Whites and African Americans,[2,14] and regular aerobic exercise is associated with a reduced risk of developing diabetes in African Americans.[16] Caloric restriction and moderate aerobic exercise resulted in weight loss and improved glucose metabolism after a one-year intervention in African Americans.[14] However, this study only characterized responses of African Americans to the intervention, and because improved insulin sensitivity is the primary mechanism by which aerobic exercise benefits glucose metabolism in diabetes, African Americans may experience changes in insulin

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sensitivity from aerobic exercise that are different from those in Whites.

Therefore, the purposes of this study were to identify whether racial differences in changes to body composition and glucose metabolism exist in response to exercise training between African American and White subjects with diabetes. We also sought to determine whether aerobic and resistance exercise training modalities bring about differential changes in body composition and glucose metabolism in African American and White persons with diabetes.

RESEARCH DESIGN AND METHODS

Participants

The study sample consisted of African American and White subjects with type 2 diabetes that were able to participate in vigorous exercise. All participants were recruited from the diabetes and endocrine clinics at The Ohio State University Medical Center and surrounding areas. Before participating, each person gave his or her informed consent, and the study was approved by The Ohio State University Human Subject Review Board.

We included African American and White type 2 diabetes patients, ages 25–60 years, with comparable socioeconomic status and who were able to perform treadmill exercise. Patients were previously treated for diabetes by either diet, oral antidiabetic medication, insulin, or a combination of these treatments. Women who were not taking oral contraceptives and had a negative result on a pregnancy test were allowed to participate in the study. Patients were ineligible to participate in the study if they met any of the following criteria: history of poorly controlled hypertension; heart, renal, liver or thyroid disease; body mass index (BMI) >150% ideal body weight; serum triglyceride concentration >400 mg/dL; proliferative retinopathy; severe autonomic neuropathy; severe peripheral vascular disease; or amputation. Those patients who reported engaging in moderate or vigorous physical activity more than one day a week were not eligible to participate.

Exercise Protocol

Each participant was randomized by ethnicity to perform eight weeks of either aerobic or resistance exercise training. In the aerobic exercise group, participants walked for 30–40 minutes three days per week on a motorized treadmill during the first four weeks. For the final four weeks, exercise was increased to five days per week. The intensity of exercise for each participant was calculated to result in expenditure of ≈600 kcal/week during the first four weeks and ≈1000 kcal/week during the final four weeks.

In the resistance exercise group, 10 repetition maximum assessments were performed on each of eight machines at the onset of training and again after four weeks of training to stimulate hypertrophy of large and small muscle groups. The program was modified after four weeks in accordance with performance outcomes. A progressive resistance training program was set up to minimize muscle soreness and injury.

For both resistance and aerobic training protocols, participants filled out weekly exercise training logs that included the number of sets and repetitions performed (resistance training) or speed, grade, and exercise duration (aerobic training). Exercise logs were reviewed by the investigators on a weekly basis to ensure compliance with the exercise protocol. When compliance was not 100%, participants received a phone call from one of the investigators as a reminder to comply with the parameters of the study. Participants who did not complete >85% of the prescribed exercise program were excluded from the study.

All subjects reported to the General Clinical Research Center (GCRC) of The Ohio State University Medical Center at 8AM after a 10–12 hour overnight fast both before and after completion of 8 weeks of prescribed exercise.

Measures

Body composition and anthropometric measures were assessed before and after the exercise program. Dual energy x-ray absorptiometry (DEXA) was used to assess body composition.[17] Body composition was determined by using a total body scanner (model DPX, Lunar Radiation Corp., Madison Wisc). Glucose metabolism was evaluated by using fasting plasma glucose and insulin concentrations in the homeostasis modeling assessment (HOMA).[18] This method has been previously validated in the type 2 diabetes population.[19] Serum glucose was determined by glucose oxidase methods with a Beckman glucose analyzer (Beckman Instruments, Fullerton, Calif). Glycosylated hemoglobin was measured by using cationic, microcolumn chromatographic technique (Isolab, Akron, Ohio). Serum insulin levels were measured by using a double-antibody radioimmunoassay method.

Statistical Analysis

Data were analyzed as percentage change from baseline by using repeated

Baseline characteristics of African American and White diabetes patients randomized to eight weeks of either aerobic exercise or resistance training

	Whites		African Americans	
Outcome Measure	**Aerobic Training (*n*=15)**	**Resistance Training (*n*=8)**	**Aerobic Training (*n*=24)**	**Resistance Training (*n*=12)**
Age (years)	49.5±2.9	50.3±3.5	50.7±2.0	46.2±2.0
Height (cm)	164.0±2.8	166.6±4.6	169.2±2.1	172.6±3.6
Weight (kg)	99.1±6.1	98.1±7.1	99.5±3.5	109.5±11.4
SBP (mm Hg)	138.5±5.7	133.3±6.1	131.1±2.8	138.0±3.5
DBP (mm Hg)	77.2±2.3	79.8±3.4	78.6±2.2	86.3±3.3
BMI (kg/m^2)	36.5±1.7	35.1±2.0	34.2±1.2	33.6±1.7
Waist-to-hip ratio	.93±.02	.92±.03	.94±.02	.90±.03
BIA (% fat)	39.7±2.7	39.4±4.2	35.8±2.0	36.7±3.7
DEXA (% fat)	38.6±2.4	40.2±4.4	38.3±2.0	38.5±3.3
HOMA IR	10.6±2.2	6.8±1.7	8.6±1.5	5.8±.7
HOMA %B	180.8±53.2	159.1±60.6	232.5±104.1	231.1±53.6
Hemoglobin A1C (%)	7.8±.3	7.9±.7	7.6±.3	6.5±.3

SBP=systolic blood pressure, DBP=diastolic blood pressure, BMI=body mass index, BIA=bioelectrical impedance analysis, DEXA=dual x-ray absorptiometry, HOMA=homeostasis modeling assessment.

measures analysis of variance (race by exercise modality). In the event of a significant main effect or interaction, post hoc analyses were performed as appropriate. Values are reported as means plus or minus the standard error of the mean, unless otherwise stated. Values were considered significant at $P<.05$.

RESULTS

Participants included 36 African Americans and 23 Whites of similar age and BMI who were randomly assigned to perform eight weeks of either aerobic or resistance exercise. No significant differences were detected between the four groups for any of the baseline measures (Table).

In response to resistance training, African Americans experienced a significant improvement in BMI (−2.57%±0.89%) compared to Whites (2.57%±1.09%, $P<.05$). No significant differences were observed between African Americans (−.67%±0.66%) and Whites (−1.18%±.76%) in response to aerobic training. However, African Americans experienced a greater change in BMI in response to resistance training compared to aerobic training ($P<.05$), while Whites experienced a significant improvement in BMI in response to aerobic training compared to resistance training. In response to resistance training, no significant differences were observed between the change in waist-to-hip ratio (WHR) between African Americans (.13%±1.04%) and Whites (.70%±1.07%). Furthermore, no differences in WHR were observed in response to aerobic training between African Americans (−.98±.69%) and Whites (.40%±.88%). No differences in WHR change were observed when comparing exercise modalities within each race.

Despite an apparent pattern of improved body fat percentage for African Americans (−.85%±1.74%) compared to Whites (1.38%±1.38%), no significant differences were detected in response to resistance training ($P>.05$). Furthermore, no significant differences were detected in body fat percentage between African Americans (−.40%±.81%) and Whites (−.22%±1.19%) in response to aerobic training. No differences were detected when comparing exercise modalities within each race.

To assess glucose metabolism in this study, we used fasting glucose and insulin levels, which were interpreted by using HOMA. Our results suggest that for HOMA-IR assessment, resistance training in African Americans resulted in a greater percent change of HOMA-IR (−19.15%±9.00%) compared to Whites (13.12%±11.86%, $P<.05$), indicating a more favorable change in insulin sensitivity (Figure 1). In response to aerobic training, no racial differences were detected in the change in HOMA-IR between African Americans (3.79±7.57) and Whites (−3.68±9.43, $P>.05$). No differences were detected when comparing exercise modalities within each race.

Analysis of HOMA-B data, an indicator of pancreatic α-cell function, revealed that despite an apparent pattern ($P<.10$) toward improved α-cell function in response to resistance training in African Americans (84.70%±32.40%) compared to Whites (−10.70%±42.87%), no significant differences were found between races. In response to aerobic training, no significant differences were detected between the change in HOMA-B between African Americans (47.80%±26.6%) and Whites (18.95%±32.87%). No differences were detected for HOMA-B change when comparing exercise modalities within each race.

CONCLUSIONS

In a clinical setting, exercise training is often prescribed to a diabetic patient because of its efficacy for improving glucose metabolism, reducing body fat percentage, and improving vascular health.[20] However, race is generally not considered when developing an exercise program for the patient. This study was designed to determine whether eight weeks of either aerobic or resistance exercise training resulted in racial differences in body composition and glucose metabolism between sedentary African American and White patients with type 2 diabetes. The main findings of this study suggest that 1)

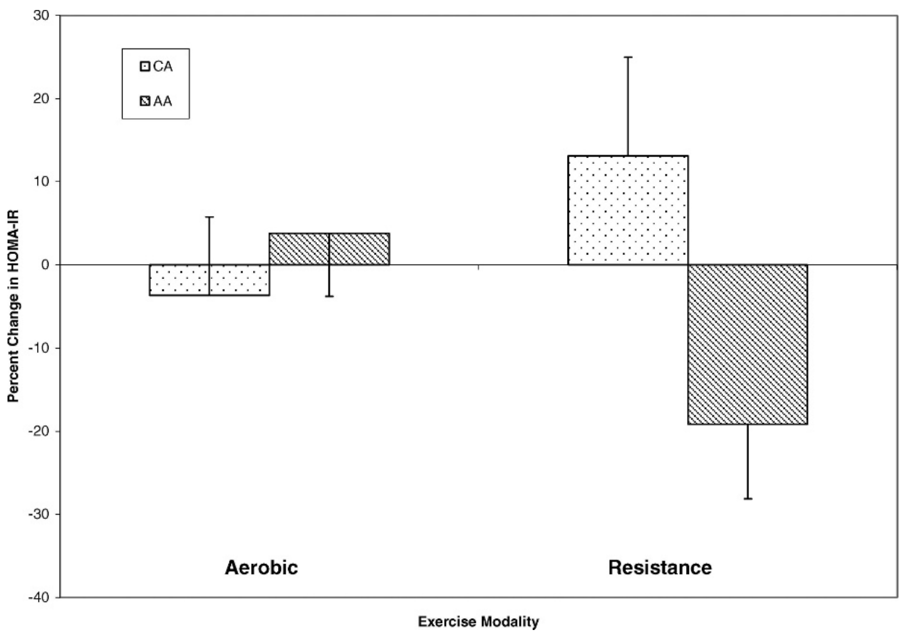

Fig 1. Insulin sensitivity percent change in African Americans and Whites in response to eight weeks of either aerobic or resistance exercise training. *P*<.05 for African American resistance vs White resistance

eight weeks of resistance training by African American patients may lead to weight loss and improved glucose metabolism in a manner different from aerobic training and 2) similar improvements were not observed in Whites who underwent an identical volume of resistance training. To our knowledge, this is the first study that has shown racial differences in weight loss and glucose metabolism between African Americans and Whites in response to resistance training.

Resistance training can been performed safely in type 2 diabetes mellitus patients,[21] and although it is considered an efficacious means for improving glucose metabolism regulation, it is not recommended for all patients because of the risk of worsening retinopathy and retinal hemorrhage and because of the acute increases in blood pressure during and after resistance exercise. However, resistance training has some potential benefits, particularly increasing muscle mass, which provides additional insulin-sensitive tissue for glucose uptake.

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In response to resistance training in our study, African Americans experienced a reduction in BMI that was different from that seen in Whites. Furthermore, resistance training in African Americans also resulted in a greater reduction in BMI than did aerobic training. These results suggest that with respect to exercise-induced changes in body weight over an eight-week training period, African Americans benefit to a greater extent from resistance training compared to aerobic training and that the magnitude of change from resistance training would be greater than that expected in White patients. Although we used the standard method of body composition analysis (DEXA), we did not detect significant racial differences in body fat loss after exercise training. However, changes in BMI, body fat percentage, and WHR followed the same pattern, with African Americans responding more favorably to resistance training and no racial difference seen in response to aerobic training.

In addition to changes in anthropometric measurements, we also examined changes in glucose metabolism in response to exercise in African Americans and Whites. Because of previous research that suggested that African Americans are more insulin resistant than are Whites,[9–12] we hypothesized that this racial difference in glucose metabolism would persist in response to exercise training. However, in the present study, we did not observe baseline differences in HOMA-IR across race; in fact, we observed a greater improvement in insulin sensitivity rather than a reduced response in African Americans performing resistance training compared to Whites. Inasmuch as racial differences in insulin sensitivity exist,[5,9,22–24] in the setting of type 2 diabetes, our cohort did not reflect this difference. In addition, the observed changes in insulin sensitivity were consistent with changes in BMI and body composition, further supporting our experimental data, and indicating that racial differences in response to resistance training exist.

Pancreatic α-cell function was also examined with the HOMA-B model, a method demonstrated to be appropriate for those with type 2 diabetes.[25] In the present study, we observed that in response to resistance training, African Americans demonstrated a trend toward differential improvement in pancreatic â-cell function compared to Whites, indicating improved insulin secretion. These data, in combination with the observed greater improvement in insulin sensitivity and BMI in African Americans, underscore the significant effect of resistance training on glucose metabolism in African Americans with type 2 diabetes.

In summary, we have shown that although eight weeks of either resistance or aerobic exercise training do not result in significant differences in body fat changes between races, differences in anthropometric measures and glucose metabolism in response to resistance training exist between African Americans and Whites. Therefore, we suggest that from a clinical perspective, when designing an exercise program for a patient with type 2 diabetes, race should be taken into consideration, and that resistance training for African Americans may lead to greater weight loss and improved insulin sensitivity compared to aerobic exercise training. Future studies to confirm our findings should include larger samples and investigate mitigating factors such as caloric intake and resting energy expenditure that may contribute to such changes.

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Statistical expertise: Winnick
Acquisition of funding: Schuster
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