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Effects of acute exercise on postprandial triglyceride response after a high fat meal in overweight black and white adolescents

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Abstract

Objective—We examined the effects of acute exercise on postprandial triglyceride (TG) metabolism following a high fat meal in overweight black vs. white adolescents.

Design and Subjects—Twenty-one black and 17 white adolescents (12–18 yrs, BMI >85th percentile) were evaluated twice, during control versus exercise trials, 1–4 weeks apart, in a counterbalanced randomized design. In the control trial, participants performed no exercise on day 1. In the exercise trial, participants performed a single bout of 60 min exercise (50% VO_{2peak}) on a cycle ergometer on day 1. On day 2 of both trials, participants consumed a high-fat breakfast (70% calories from fat) and blood was sampled for TG concentration in the fasted state and for 6 hrs postprandially.

Results—There was a significant main effect of condition on postprandial peak TG concentration ($P=0.01$) and TG-area under the curve (AUC) ($P=0.003$), suggesting that independent of race, peak TG and TG-AUC was lower in the exercise trial vs. control trial. Including Tanner stage, gender, total fat (kg) and VAT as independent variables, stepwise multiple regression analyses revealed that in whites, VAT was the strongest ($P<0.05$) predictor of postprandial TG-AUC explaining 56% and 25% of the variances in TG-AUC in the control and exercise trials, respectively. In blacks, VAT was not associated with postprandial TG-AUC independent of trial.

Conclusion—A single bout of aerobic exercise preceding a high fat meal is beneficial to reduce postprandial TG concentrations in overweight white adolescents to a greater extent than black adolescents, particularly those with increased visceral adiposity.

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Keywords

postprandial triglyceride; acute exercise; race; visceral fat; adolescents

INTRODUCTION

Postprandial hyperlipemia is characterized by a rise in plasma triglyceride (TG)-rich lipoprotein levels following the intake of a high-fat diet ¹. In adults, evidence suggests that high levels of postprandial TG are associated with endothelial dysfunction ², incident cardiovascular events, and insulin resistance ^{3,4}. Conversely, it has been shown that in adults, a single bout of moderate-intensity exercise performed ~24 h prior to a high-fat meal is beneficial to reduce postprandial TG responses ⁵. Similarly, in normal-weight healthy adolescent boys acute exercise resulted in a 26% reduction in postprandial TG responses ⁶. It is currently unknown whether racial differences exist in postprandial TG responses between black and white adolescents given the lower TG concentration in blacks and the racial disparities in cardiometabolic risks ^{7,8}. Further, given the increasing trends in abdominal obesity in children and adolescents ^{9,10}, it remains to be determined if increased visceral adiposity modulates postprandial TG metabolism.

Therefore, we examined the effect of a single bout of aerobic exercise on postprandial TG responses after a high-fat meal in overweight black and white adolescents, and assessed the role of visceral adipose tissue (VAT) in modulating postprandial TG concentrations in youth.

MATERIALS AND METHODS

Subjects

Subjects were overweight otherwise healthy (BMI >85 percentile for age and gender) black ($n = 21$) and white ($n = 17$) boys and girls. Subjects were recruited via flyers posted in the city public transportation, posters placed on campus, and in the Weight Management and Wellness Center at Children's Hospital of Pittsburgh (CHP) of UPMC. The investigation was approved by the University of Pittsburgh Institutional Review Board. Parental informed consent and child assent were obtained from all participants. Inclusion criteria required that the subjects be 12-18 years of age in Tanner II-V, healthy (no syndromic obesity, no chronic medical conditions), non-smokers and physically inactive (no structured physical activity >2 times per week) in the preceding month. Subjects were excluded if they had asthma and had been dieting or had experienced significant weight loss in the preceding month. Girls with oral or injectable contraceptives were excluded. None of the subjects were taking medications known to affect body composition, glucose or fat metabolism. Racial background was verified by self-identity in three generations on both sides of the parents. Pubertal development was assessed according to Tanner criteria (genital development and pubic hair) by a certified nurse practitioner. All participants underwent a complete health history, physical examination and routine hematological and biochemical tests at the Pediatric Clinical and Translational Research Center (PCTRC) at CHP.

Study design

Each subject completed two 2-day trials (control trial vs. exercise trial) separated by 1-4 weeks in a counterbalanced randomized design. All subjects were admitted and stayed overnight twice (once for the control trial and the other for the exercise trial, in random order) at CHP for the evaluations listed below. For 48 hours preceding each trial participants were asked to refrain from physical activity other than activities of daily living.

Day 1: on day 1 of the first trial, subjects arrived at the PCTRC at 0800h after an overnight fast (minimum 8 hours) for a 2-hour oral glucose tolerance test (1.75 g/kg, max 75 g) to assess their glucose tolerance status. In the control trial, subjects performed no exercise and rested in the hospital room for the remainder of the day. In the exercise trial, subjects completed 60 minutes exercise on a cycle ergometer starting at 1700h. During the control and exercise admissions participants received standardized mixed meals (lunch and dinner) containing ~30% fat, ~55% carbohydrate and ~15% protein.

Day 2: on day 2 of each trial, participants consumed a high-fat breakfast (70% calories from fat) at 0800h and blood samples were obtained in the fasted state and thereafter for 6 h postprandially.

Anthropometric measurements

Body weight was measured on a balanced scale to the nearest 0.1 kg, and height was measured to the nearest 0.1 cm using a stadiometer. The Centers for Disease Control and Prevention Growth Charts were used to calculate sex-and age-specific BMI percentiles ¹¹.

Body composition

Total fat and fat free mass was assessed using Lunar iDXA (GE Healthcare, Madison, WI, USA) and analyzed with software enCORE 2007 version 11.40.004 (GE, Madison, WI, USA). A single axial image of the abdomen (L4-L5) was obtained using computed tomography to measure VAT.

Peak oxygen uptake

Peak oxygen uptake was determined using a graded incremental test on a cycle ergometer (Monark, Ergomedic 828E) with the use of standard open-circuit spirometry techniques (AEI Technologies, Pittsburgh, PA, USA). Participants cycled at an initial workload of 25 watts and the workload was increased by 50 watts every three minutes until volitional fatigue. Heart rate was monitored throughout using a Polar heart rate monitor (Polar Oy, Kempele, Finland). Data from the peak oxygen uptake were used to determine the exercise intensity and energy expenditure during 60-minute cycling exercise.

60-minute cycling exercise (day 1 of the randomized exercise trial)

In the late afternoon (1700h) of day 1 of the exercise trial, participants completed 60-minutes cycling on a cycle ergometer (Monark, Ergomedic 828E) at a resistance equivalent to 50% of their peak oxygen uptake. Subjects were instructed to maintain a target cadence of 60 rpm. One female subject performed 60 minutes of moderate-intensity walking on a treadmill due to seat discomfort. Heart rate was monitored throughout the test and ratings of

perceived exertion were taken every 15 minutes using the OMNI scale ¹². We chose the duration and intensity of this exercise bout since the current public health guidelines recommend that children and adolescents, regardless of weight status, should engage in at least 60 minutes of moderate-high intensity physical activity on most days of the week ¹³. In a review on the effect of exercise on postprandial TG concentrations, this exercise duration and intensity is suggested to provide moderately-large decreases in postprandial lipemia in adults ⁵.

Measurement of postprandial triglyceride concentrations (on day 2 of each trial)

A venous catheter was placed into a heated hand vein at 0700h. Fasting blood samples were taken from 0730h onwards at -30, -15 and 0 minutes prior to the ingestion of the meal. At 0800h participants consumed a high-fat breakfast test meal (70% calories from fat), which consisted of sausage links and hash browns fried in oil. The test meal was prescribed according to body surface area ¹⁴. Subjects were asked to consume each meal within 20 min with water (20 fl oz). The time taken to consume each meal and the volume of water ingested was recorded and replicated in subsequent trials.

Upon completion of the meal subjects rested in their bed for the remainder of the test period. Blood samples were taken at 30 min, 45 min and 1 hour after a high-fat breakfast and then hourly for 6 hours for measurements of TG, glucose, insulin and C-peptide. After the meal, participants were not allowed to eat or drink for 6 hours, except for ice chips, until the blood sampling was over.

Biochemical measurements

Plasma glucose was measured by the glucose oxidase method with a glucose analyzer (YSI, Inc., Yellow Springs, OH, USA) and the insulin concentration was determined by radioimmunoassay ¹⁵. C-peptide was measured by double-antibody RIA (Siemens Health Care Diagnostics, formerly Diagnostic Products Corp., Tarrytown, NY, USA), which is 100% specific for C-peptide ¹⁶. Plasma lipid levels were measured in the Nutrition Laboratory of the University of Pittsburgh Graduate School of Public Health, certified by the Centers for Disease Control and Prevention, National Heart, Lung, and Blood Institute standardization program as shown previously ¹⁶.

Statistical analysis

Statistical procedures were performed using SPSS (Version 18; SPSS, Inc., Chicago, IL, USA) and SAS 9.3. Independent *t*-tests were used to compare racial differences in subject characteristics. A chi-square test was used to compare gender and Tanner distribution between black and white adolescents. Repeated measures modeling (proc mixed) was used to evaluate main effects (condition, race, and time) and group interactions (condition x race, condition x time, time x race and condition x time x race) for TG, glucose, insulin and C-peptide. In instances where significant interaction effects are observed, the analyses were stratified by condition and/or race where appropriate. Group differences were assessed with least squared means. Area under the curve (AUC) for blood samples were calculated using the trapezoidal method.

To examine the influence of VAT on postprandial TG concentrations, subjects were categorized as low (blacks: $<39.4 \text{ cm}^2$ and whites: $<62.3 \text{ cm}^2$), moderate (blacks: $39.4 \text{ cm}^2 - 48.6 \text{ cm}^2$ and white: $62.3 \text{ cm}^2 - 75.6 \text{ cm}^2$) or high (blacks: $>48.6 \text{ cm}^2$ and whites: $>75.6 \text{ cm}^2$) VAT groups using the tertiles of VAT derived within each race. Then, the lower two tertiles of VAT groups were combined and referred as the low VAT group for the analyses. Stepwise multiple regression analyses were performed to determine the independent associations between Tanner, gender, total fat (kg) and VAT with postprandial TG-AUC (dependent variable). Further, repeated measures modeling was used to examine VAT specific condition, race and time effects (main effects and 4-way interaction) for TG, glucose, insulin and c-peptide.

RESULTS

The subject characteristics are shown in Table 1. Despite similar age, BMI and total fat, black adolescents had lower ($P<0.05$) VAT, fasting glucose, total cholesterol, TG, LDL and VLDL compared with white adolescents.

High-fat test meal and 60 min exercise summary

There were no differences in total energy intake (kcal) and energy content of the meals between black and white adolescents on day 2 of the trials (Table 2). During the 60-minute cycling exercise on day 1 of the exercise trial, exercise intensity, heart rate and energy expenditure were similar between races (Table 2).

Plasma concentration in the fasting period

Fasting TG and metabolic variables prior to the ingestion of a high-fat meal are shown in Table 3. There was a significant ($P<0.05$) main effect of condition and race, and interaction (condition X race) effect on fasting TG, suggesting that 1) fasting TG concentration was significantly lower in the exercise trial vs. control trial (condition effect, $P<0.001$), 2) fasting TG was higher in white compared with black adolescents (race effect, $P=0.034$), and 3) the magnitude of difference in fasting TG concentration between the control vs. exercise trials was significantly greater in white than in black adolescents (interaction effect, $P=0.007$). Regardless of the trials, black adolescents had lower ($P=0.034$) fasting TG compared with their white peers. No significant ($P>0.1$) main or interaction effects were observed with respect to fasting glucose, insulin and C-peptide concentrations.

Plasma concentration in the postprandial period

Figure 1 shows postprandial TG response between control vs. exercise trial stratified by race (significant race x condition interaction, $P=0.03$). Although TG increased over time in both races (main effect of time: $P<0.0001$), the reductions in TG concentrations in response to acute exercise was only significant in white adolescents (main effect of exercise; $P=0.0005$). In black adolescents (Figure 1A), there was no main effect of exercise ($P=0.17$).

There was a rise in insulin and c-peptide over time (main effect, $P<0.05$), but no significant racial or exercise differences were observed (no significant interactions or main effects; data not shown). For glucose, there was also the expected rise in glucose over time (main effect,

$P<0.0001$), but with a significant main effect of race, wherein whites had a higher glucose than blacks ($P=0.005$).

There was a significant main effect of condition on postprandial peak TG concentration ($P=0.01$) and TG-area under the curve (AUC) ($P=0.003$), suggesting that independent of race, peak TG and TG-AUC was lower in the exercise trial vs. control trial (Table 4). Further, regardless of the trials, black adolescents have lower peak TG ($P=0.05$) and TG-AUC ($P=0.04$) compared with their white peers. No significant ($P>0.1$) main or interaction effects were observed in postprandial glucose-AUC, insulin-AUC and C-peptide AUC.

Influence of VAT on fasting and postprandial TG concentrations

To further examine the influence of VAT on postprandial TG responses, subjects were categorized into the low VAT [black ($n=14$, mean $\pm$ SEM): $37.7 \pm 2.3 \text{ cm}^2$; white ($n=10$): $60.3 \pm 3.8 \text{ cm}^2$] and high VAT groups [black ($n=7$): $74.7 \pm 4.4 \text{ cm}^2$; white ($n=6$): $127.9 \pm 16.9 \text{ cm}^2$] based on the cutoffs derived within each race. In blacks, total fat (kg) and % body fat was significantly ($P<0.05$) lower in the low VAT group (5 boys, 9 girls) vs. high VAT (4 boys, 3 girls) group. In whites, although both total fat (kg) and % body fat tended to be lower in the low VAT group (7 boys, 3 girls) vs. high VAT (5 boys, 1 girl) group, these did not reach statistical significance ($P>0.05$ for both).

In black adolescents, there was a significant postprandial TG response (main effect of time: $P<0.001$) with no significant ($P>0.05$) effects of VAT or exercise (Figure 2A). Conversely, the postprandial TG response in whites was higher in the high VAT group and control conditions (Figure 2B), wherein the high VAT groups had a greater postprandial TG increase over time and a greater difference between the control and exercise conditions (interaction of VAT x time and VAT x exercise: $P<0.05$). Thus, in white adolescents, postprandial TG-AUC was significantly ($P<0.05$) higher in the high VAT (control trial: $1527.3 \pm 208.9 \text{ mg/dl}$; exercise trial: $1184.8 \pm 153.8 \text{ mg/dl}$) compared to the low VAT (control trial: $796.2 \pm 53.2 \text{ mg/dl}$; exercise trial: $687.8 \pm 42.5 \text{ mg/dl}$) groups in both control and exercise trials. Including Tanner, gender, total fat (kg) and VAT as independent variables, stepwise multiple regression analyses revealed that in white adolescents, VAT was the strongest ($P<0.05$) predictor of postprandial TG-AUC and explained 56% and 25% of the variances in postprandial TG-AUC in the control and exercise trial, respectively. In blacks, none of the independent variables (Tanner, gender, total fat and VAT) were significantly ($P>0.1$) associated with postprandial TGAUC in both trials.

When considering VAT category, race x VAT interaction effects on glucose, insulin and c-peptide response were observed. In only those with high VAT, whites had a significantly high postprandial glucose than blacks with a high VAT (main effect: $P=0.001$), with no differences between those with low VAT. For insulin, whites with low VAT had a lower postprandial insulin response than blacks with low VAT (main effect of race: $P<0.0001$), whereas the reverse was observed in the high VAT group ($P=0.015$). For c-peptide, whites with a low VAT had a significantly lower c-peptide at 45 minutes and 1 hour than blacks with a low VAT. However, in those with high VAT, whites consistently had significantly higher postprandial c-peptide than blacks with high VAT (main effect of race, $P=0.001$).

DISCUSSION

We examined the effect of a single bout of aerobic exercise on postprandial TG responses after a high-fat meal in overweight black and white adolescents. The primary findings of the present study are that although acute exercise attenuates postprandial TG concentrations in both overweight black and white youth, the reductions in postprandial TG after exercise are more pronounced in white adolescents (–19%) to a greater extent than black adolescents (–8%). Furthermore, increased visceral fat appears to be a major contributor to the higher postprandial TG responses in white but not black youth. However, our finding that acute exercise is effective in reducing the exaggerated TG concentrations after a high-fat meal to a greater extent in overweight white than black adolescents suggests that 60 min of moderate intensity aerobic exercise is beneficial to reduce postprandial triglyceridemia in overweight youth, particularly in white adolescents with increased visceral adiposity.

Similar to adult observations⁵, a growing body of evidence in adolescents demonstrates that postprandial TG may be attenuated by a single bout of exercise performed up to ~24h before the ingestion of high-fat meal. Barrett et al.⁶ have shown that a single bout of both continuous walking (–14%) and intermittent physical activity (–26%) is effective in reducing postprandial TG levels in normal-weight adolescent boys. The same group¹⁷ subsequently demonstrated that aerobic exercise performed at either moderate (53% VO₂ peak) or vigorous intensity (75% VO₂ peak) before the consumption of a high fat meal is similarly effective in reducing postprandial TG [–24% (moderate intensity) and –21% (vigorous intensity)] in normal-weight adolescent boys ($n=8$). Recently, MacEneaney et al.¹ reported that acute exercise prior to a fatty meal reduced postprandial TG in both lean and overweight boys to a similar degree (~20%). Our findings in a biracial sample of overweight black and white adolescents extend the previous observation in youth^{1, 6, 17} and suggest that 60 min of moderate-intensity aerobic exercise (energy expenditure 450-500 kcal) is effective in reducing postprandial TG responses to a greater degree in overweight white adolescents than in black adolescents.

To our knowledge, this is the first study to examine the influence of visceral fat on postprandial lipemia in youth. Our findings that white adolescents with high VAT have greater postprandial TG responses as compared with adolescents with low VAT are consistent with previous adult studies reporting that increased VAT is associated with delayed postprandial TG concentrations in total as well as large, medium and small TG-rich lipoprotein responses in middle-aged men with¹⁸ and without impaired glucose tolerance¹⁹. Similar findings have been noted in women that postprandial lipidemic concentration to a high-fat meal was exacerbated in obese women with increased abdominal obesity compared with women with lower-body obesity, despite similar BMI and fasting plasma TG concentration²⁰. Together, these findings suggest that VAT is an important contributor to the deteriorations of the postprandial TG metabolism independent of age. Further, our findings that the significant reduction in postprandial TG after an acute exercise bout in adolescents with high VAT supports the importance of engaging in regular physical activity to lower postprandial lipemia and associated CVD risk factors. This appears especially true in overweight white adolescents with increased visceral fat.

It appears that racial differences in CVD risk factors begin during childhood. We ^{7, 8} and others ²¹ have shown that black children and adolescents have lower visceral adiposity and more favorable lipid profiles and atherogenic risk factors than their white peers. Therefore, it is plausible that the significantly lower fasting TG concentration in overweight black adolescents as compared with white adolescents observed in this study may have limited the beneficial effect of exercise on postprandial TG concentration in black adolescents.

Currently, the mechanisms by which acute exercise is associated with reductions in postprandial TG responses are unclear. It has been suggested that reductions in postprandial lipemia in response to acute exercise may be due to an improved clearance of TG by skeletal muscle and adipose tissue, a reduced hepatic production of VLDL particles or both ²². Indeed, lipoprotein lipase activity in muscle has been shown to have a delayed increase in mRNA activity up to ~48 hours after the last exercise bout ^{23, 24}. It is unclear whether our findings would remain true in response to regular exercise training in youth. Further, it is also unknown whether an equivalent energy intake deficit would result in similar reductions in postprandial TG response in children and adolescents. In adults, Gill and Hardman ²⁵ have shown that the exercise induced reduction in postprandial TG response was almost 3 times as great as the reduction due to a similar diet induced energy deficit (2.14 mmol· h/L vs. 0.79 mmol· h/L) in postmenopausal women.

The limitations of this study warrant mention. Although this is the first study in adolescents to examine the effects of race, acute exercise and visceral adiposity on postprandial TG metabolism during two overnight inpatient admissions, our observations are based on healthy pubertal overweight adolescent boys and girls, who were of African-American and Caucasian ethnicities. Whether our findings would remain true in other ethnic groups or pre-pubertal children is unknown. Due to our small sample, we could not examine gender influences on postprandial TG concentrations in this study. In this study, we did not employ multiple CT scans to quantify total VAT volume due to an increased radiation exposure. Currently, no studies are available regarding the effects of different exercise modalities on postprandial TG metabolism in youth.

In conclusion, we observed that 60 min of moderate-intensity aerobic exercise, in line with public health recommendations, is effective in reducing fasting and postprandial TG in both overweight white and black adolescents. Increased visceral adiposity appears to be a major contributor to the higher postprandial TG concentrations in white but not black youth. However, aerobic exercise is effective in attenuating the exaggerated TG responses to feeding to a greater extent in overweight white than black adolescents. Studies are needed to examine if reductions in visceral adiposity with exercise intervention further reduce postprandial TG in overweight youth.

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critical revision of the manuscript. Lee is the guarantor of this work, had full access to all the data and takes full responsibility for the integrity of data and the accuracy of data analysis.

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FIGURE 1.

Fasting and postprandial TG concentration between control vs. exercise trials. Data are mean $\pm$ SEM.

* Different from time -15 and 0 minutes within that condition ($P < 0.05$).

† Different from previous time point within that condition ($P < 0.05$).

FIGURE 2.

Fasting and postprandial TG concentration between low vs. high VAT group within each race. Data are mean $\pm$ SEM.

* Different from time -15 and 0 minutes within that condition and VAT group ($P < 0.05$).

† Different from previous time point within that condition and VAT group ($P < 0.05$).

TABLE 1

Subject characteristics

	Black (n=21)	White (n=17)	P
Male/Female (n)	9/12	12/5	NS
Tanner stage, II-III/ IV-V (n)	1/20	4/13	NS
Age (yrs)	15.4 ± 0.3	14.5 ± 0.3	NS
Body weight (kg)	93.5 ± 5.4	96.1 ± 5.4	NS
BMI (kg/m ²)	34.2 ± 1.5	33.4 ± 1.7	NS
<i>Body composition</i>			
Percent body fat (%)	40.5 ± 1.3	40.9 ± 1.9	NS
Total body fat (kg)	38.2 ± 3.4	38.1 ± 3.5	NS
Fat free mass (kg)	53.9 ± 2.3	53.8 ± 2.8	NS
VAT (cm ²) *	50.1 ± 4.4	85.6 ± 10.6	0.002
Subcutaneous AT (cm ²) *	493.9 ± 44.9	461.1 ± 46.8	NS
<i>Metabolic</i>			
NGT/IFG/IGT (n)	14/2/5	14/1/2	0.546
Total cholesterol (mg/dl)	137.5 ± 5.0	172.2 ± 10.8	0.004
TG (mg/dl)	64.2 ± 4.0	99.5 ± 8.3	<0.001
HDL (mg/dl)	44.6 ± 1.7	44.9 ± 2.0	NS
LDL (mg/dl)	80.2 ± 4.6	107.5 ± 9.9	0.011
VLDL (mg/dl)	12.8 ± 0.8	19.9 ± 1.7	<0.001
VO ₂ peak (ml/kg/min)	26.1 ± 1.3	28.5 ± 1.7	NS

Mean ± SEM. NS, $P > 0.05$.

* $n = 16$ in White (CT image lost during data transfer).

Based on the average of two fasting glucose measurements at the time of the OGTT (at -15 and 0 min) and plasma glucose at 2-hr OGTT, glucose tolerance status was determined as such. NGT (normal glucose tolerance), fasting plasma glucose <100 mg/dl and 2-h post-OGTT glucose of <140 mg/dl.

IFG (impaired fasting glucose), fasting plasma glucose (FPG) of 100–125 mg/dl

IGT (impaired glucose tolerance), 2-hr post-OGTT glucose of 140–199 mg/dl according to ADA criteria ²⁶.

TABLE 2

High-fat test meal parameters and 60-minute exercise summary

	Black (n=21)	White (n=17)	P
High-fat test meal			
Total energy (kcal)	824.5 ± 30.4	852.2 ± 29.7	NS
Protein (g)	20.1 ± 0.7	20.6 ± 0.7	NS
Carbohydrate (g)	43.8 ± 1.5	43.4 ± 1.5	NS
Fat (g)	64.1 ± 2.6	66.3 ± 2.3	NS
60-minute cycling			
Resistance (kg) *	1.3 ± 0.1	1.4 ± 0.1	NS
Workload (W) *	79.4 ± 4.6	84.4 ± 6.6	NS
Heart rate (bpm)	151.8 ± 3.1	154.5 ± 1.9	NS
Energy expenditure (kcal)	449.2 ± 26.5	495.9 ± 31.9	NS
RPE	5.9 ± 0.5	5.4 ± 0.3	NS

Mean ± SEM. NS, $P > 0.05$.* $n=20$ in Black (1 subject performed 60-min treadmill exercise due to seat discomfort).

RPE, rated perceived exertion scales.

TABLE 3

Fasting TG, glucose, insulin and C-peptide concentrations measured on day 2 of each trial before the intake of a high-fat breakfast test meal

Variables *	Black		White		Effect, <i>P</i>		
	Control	Exercise	Control	Exercise	Condition	Race	Interaction
TG (mg/dl)	69.1 ± 8.1	65.1 ± 7.9	106.4 ± 11.4	80.9 ± 8.2	<0.001	0.034	0.007
Glucose (mg/dl)	90.1 ± 1.2	89.5 ± 1.0	92.7 ± 1.3	92.1 ± 1.4	0.526	0.096	0.971
Insulin (μU/ml)	34.7 ± 3.2	35.6 ± 2.5	33.9 ± 4.0	31.5 ± 2.8	0.681	0.551	0.356
C-peptide (ng/ml)	2.9 ± 0.3	3.0 ± 0.2	3.2 ± 0.4	3.1 ± 0.3	0.777	0.577	0.456

Mean ± SEM.

* Measured at 15 minutes before a high-fat breakfast test meal

TABLE 4

Postprandial TG, glucose, insulin and C-peptide responses during the control versus exercise trial

	Black		White		Effect, <i>P</i>		
	Control	Exercise	Control	Exercise	Condition	Race	Interaction
Peak TG (mg/dl)	174.1 ± 18.3	160.0 ± 15.3	239.1 ± 24.5	197.5 ± 18.9	0.01	0.05	0.184
TG-AUC	731.2 ± 74.8	675.3 ± 61.8	1042.8 ± 117.8	846.5 ± 85.9	0.003	0.04	0.081
Glucose-AUC	540.8 ± 8.9	549.7 ± 8.3	562.9 ± 10.4	566.5 ± 9.0	0.321	0.097	0.669
Insulin-AUC	290.0 ± 25.0	301.0 ± 30.5	344.4 ± 45.6	312.3 ± 35.0	0.500	0.474	0.173
C-peptide-AUC	24.3 ± 1.3	26.1 ± 2.2	28.5 ± 3.4	26.4 ± 2.6	0.886	0.475	0.104

Mean ± SEM.