Moderate-Intensity Physical Activity and Fasting Insulin Levels in Women

The Cross-Cultural Activity Participation Study

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OBJECTIVE — The purpose of this study was to determine the association between moderate-intensity physical activity (PA) and fasting insulin levels among African-American (n = 47), Native American (n = 46), and Caucasian women (n = 49), aged 40–83 years, enrolled in the Cross-Cultural Activity Participation Study. Associations by race/ethnicity, levels of central obesity, and cardiorespiratory fitness were also examined.

RESEARCH DESIGN AND METHODS — Physical activity scores were obtained from detailed PA records that included all PA performed during two consecutive 4-day periods scheduled 1 month apart. Using MET intensity (the associated metabolic rate for a specific activity divided by a standard resting metabolic rate), PA was expressed as MET-min (the product of the minutes for each activity times the MET intensity level) per day of energy expended in moderate (3–6 METs) and moderate/vigorous (≥3 METs) PA. Fasting insulin levels were determined by radioimmunoassay. Data were analyzed by multiple linear regression analysis.

RESULTS — After adjusting for race/ethnicity, age, educational attainment, and site, an increase of 30 min of moderate-intensity PA was associated with a 6.6% lower fasting insulin level ($P < 0.05$). The association was similar among races/ethnicities, centrally lean and centrally obese women, and women with low and high cardiorespiratory fitness levels.

CONCLUSIONS — These findings lend support to the 1995 Centers for Disease Control and Prevention and American College of Sports Medicine recommendations for an accumulation of 30 min/day in moderate-intensity PA. They also contribute to the growing literature suggesting that moderate amounts of PA have a significant role in reducing the burden of hyperinsulinemia and diabetes among ethnic populations at highest risk for these conditions.

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Physical activity (PA) has a beneficial effect in reducing plasma insulin levels among people with and without type 2 diabetes (1–3). Much of the evidence for this effect is from estimates of total daily PA and participation in vigorous PA. Few studies have reported an effect of moderate-intensity PA on insulin levels. In the Insulin Resistance Atherosclerosis Study, Mayer-Davis et al. (2) showed a significant association between moderate- and vigorous-intensity PA and insulin sensitivity among people with and without type 2 diabetes ($P < 0.05$). In the San Luis Valley Study, Regensteiner et al. (3) showed an inverse association between PA and fasting insulin levels ($P < 0.05$).

The mechanisms by which PA decreases insulin resistance and hyperinsulinemia are not yet fully understood. PA directly reduces insulin resistance and hyperinsulinemia by increasing the number and activity of glucose transporters (especially the GLUT4 isoform), in both muscle and adipose tissue (1,4). In addition, PA may indirectly reduce insulin resistance and hyperinsulinemia by promoting fat loss and preservation of lean body mass (1).

Whereas most studies generally show that vigorous PA may reduce insulin concentrations, these results are not directly applicable to most women who do not regularly perform such vigorous PA. In 1995, the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) released a statement recommending that all U.S. adults accumulate at least 30 min of moderate-intensity PA on most, if not all, days of the week (5). This moderate-intensity recommendation differs from previous recommendations suggesting that adults should exercise vigorously for at least 20 min three times per week (6). Few studies have examined the association between moderate-intensity PA, at levels recommended by the CDC and ACSM, and fasting insulin levels.

It is important to examine the association between PA and fasting insulin by levels of central obesity and cardiorespiratory fitness. Centrally obese individuals are at increased risk for insulin resistance and may be more likely to decrease their risk through increased PA (7), and moderate-intensity PA is relatively more strenuous for an individual with a low cardiorespiratory fitness level than an individual with a high cardiorespiratory fitness level. The purpose of this study was to determine the association between moderate-intensity PA and fasting insulin levels and to examine possible differences in this association by race/ethnicity, central obesity, and cardiorespiratory fitness level.

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Abbreviations: ACSM, American College of Sports Medicine; CDC, Centers for Disease Control and Prevention; ECG, electrocardiogram; MET intensity, the associated metabolic rate for a specific activity divided by a standard resting metabolic rate; MET-min, the product of the minutes for each activity times the MET intensity level; PA, physical activity.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Physiological and demographic characteristics of study participants*

	African-Americans	Native Americans	Caucasians	All
n	47	46	49	142
Age (years)	57.0 ± 10.4	51.4 ± 10.1	55.7 ± 11.3	54.8 ± 10.8
Education (years)	15.1 ± 2.7	14.9 ± 2.3	16.0 ± 2.7	15.4 ± 2.6
Weight (kg)	82.8 ± 16.8	71.0 ± 14.3	68.8 ± 13.7	74.2 ± 16.1
Height (cm)	163.3 ± 5.8	157.7 ± 6.6	165.2 ± 5.9	162.1 ± 6.8
BMI (kg/m^2)	31.1 ± 6.1	28.6 ± 5.7	25.2 ± 4.7	28.2 ± 6.0
Waist circumference (cm)	89.2 ± 13.0	88.7 ± 11.4	78.4 ± 10.9	85.3 ± 12.7
Systolic blood pressure (mmHg)	129.5 ± 18.5	118.9 ± 13.5	117.6 ± 19.3	122.2 ± 18.0
Diastolic blood pressure (mmHg)	79.2 ± 8.7	76.7 ± 9.2	76.2 ± 9.3	77.4 ± 9.1
Overall obese (%)*	53	33	12	32
Adjusted centrally obese (%)†	43	72	39	51
Unadjusted centrally obese (%)‡	53	46	16	38
Cardiorespiratory fit (%)§	26	57	65	49
Diabetic (%)	13	15	2	10

Data are *n*, means ± SD, or %. *BMI ≥30; †residual values ≥0 for regression of waist circumference on BMI; ‡waist circumference ≥88 cm (11); §maximal treadmill time ≥16 min if <50 years of age or ≥14 min if ≥50 years of age (12).

RESEARCH DESIGN AND METHODS

Subjects

This study is a part of the Cross-Cultural Activity Participation Study, a 5-year community study affiliated with the Women's Health Initiative community studies (8). Subjects who enrolled in the study for 6 weeks included 57 African-American women residing in South Carolina, 50 Native American women residing in Pueblo and Navajo reservations in New Mexico, and 53 Caucasian women residing in South Carolina (*n* = 28) and New Mexico (*n* = 25). Subjects were recruited through advertisements placed in newsletters, fliers posted in community centers, radio advertisements, and personal conversations. Before study enrollment, subjects were screened during a telephone call for inclusion criteria of *1*) age ≥40 years; *2*) self-identified race/ethnicity as African-American, non-Hispanic Caucasian, or at least 50% Native American; *3*) absence of physical illnesses or disabilities that would limit daily physical activities such as walking; and *4*) the ability to read and write well enough to record daily physical activities in a record book. Subjects gave written informed consent for participation in research as approved by the University of South Carolina's and the University of New Mexico's Institutional Review Boards. Subjects were given $50 for successful completion of the study.

Among the 160 women enrolled in the study, 8 withdrew due to time demands, 5 had health problems that limited their study activities, 2 were noncompliant with the study protocol, 2 failed to complete all study forms as required, and 1 was taking insulin medication. After excluding these 18 subjects, 142 women were eligible for the present analyses.

Study design

Surveys for physical activity, health history, and demographic data were completed in subjects' homes or worksites in New Mexico and South Carolina during five study visits. Cardiorespiratory fitness, body composition, and blood lipids were obtained during visits to the Exercise Testing Laboratories at the University of New Mexico and the University of South Carolina. Data collection and testing procedures were standardized through preliminary training sessions for all field and laboratory staff. The same study procedures and models of laboratory equipment were used at each site to obtain study data. All data were entered and analyzed at the University of South Carolina.

Study data

Interviewer-administered surveys designed to obtain demographic and health behavior information were administered to each subject. Race/ethnicity was obtained from the demographic survey and reported as 100% African-American, 100% non-Hispanic Caucasian, or at least 50% Native American.

PA records were used to obtain a detailed account of all PA performed during two consecutive 4-day periods, scheduled 1 month apart. PA recordings began when subjects awoke in the morning and ended when they went to bed in the evening. For each activity performed, subjects recorded the time they began an activity, the purpose and type of activity, and the perceived intensity of the activity in the PA record (see APPENDIX). Upon completion, PA records were edited for completeness and clarity by study staff in the presence of the subjects. The study staff assigned a 5-digit code obtained from the Compendium of Physical Activities (9) to the activities in the PA record that links the purpose, description, and MET intensity for each activity. The MET intensity reflects the associated metabolic rate for a specific activity divided by a standard resting metabolic rate. Individual differences that may alter the energy cost of movement (e.g., body mass) are not taken into account. Therefore, PA was measured in terms of absolute intensity rather than relative intensity.

PA data were summed as minutes per day and MET-minutes (the product of the minutes for each activity times the MET intensity level) per day. One MET-min is roughly equivalent to 1 kcal/min for a 60-kg person (10). Minutes per day and MET-min per day were sorted into intensity groups using the CDC-ACSM recommendations for activities of moderate (3–6 METs), moderate/vigorous (≥3 METs), and vigorous (>6 METs) intensity (5).

Overweight and obesity status were expressed using BMI, computed as weight in kilograms divided by height in meters squared. Body weight in kilograms was measured to the nearest 0.1 kg using a Seca Model 770 scale (Shorr Productions, Olney, MD). Height was measured to the nearest 0.1 inch using a stadiometer and converted to meters. Overall obesity was defined as a BMI ≥30 kg/m^2 (11).

Central obesity was measured by the waist circumference. A Gulick anthropometric tape measure (Creative Health Products, Plymouth, MI) was used to measure the waist circumference. The waist circumference was taken at the midpoint between the ribs and iliac crest, under clothing and next to the subject's skin. Waist circumference was measured twice to the nearest 0.1 cm at the end of exhalation with the average measurement recorded for data entry and analysis. To determine central adiposity, regression analysis was used to adjust waist circumference for BMI. The residual scores from the regression analysis were used to classify central obesity status,

Table 2—*Fasting insulin and glucose levels and PA levels by race/ethnicity*

	African-Americans	Native Americans	Caucasians	All
n	47	46	49	142
Fasting insulin (pmol/l)	64.6 (41.6–100.5)	49.1 (33.1–112.6)	35.2 (23.7–47.5)	46.0 (31.6–89.7)
Fasting glucose (mg/dl)	86.7 (78.5–100.4)	82.9 (77.6–95.3)	83.1 (76.8–94.1)	83.7 (77.6–95.3)
Moderate PA*				
Min/day	69 (52–88)	126 (88–180)	102 (70–141)	96 (65–148)
MET-min/day	282 (193–351)	499 (346–718)	418 (275–585)	366 (239–572)
Moderate/vigorous PA†				
Min/day	73 (54–92)	130 (88–189)	106 (84–146)	98 (68–149)
MET-min/day	287 (196–374)	528 (346–796)	461 (328–623)	377 (263–615)
Vigorous PA‡				
Min/day	6 (4–8)	4 (2–19)	10 (5–16)	7 (4–16)
MET-min/day	45 (26–62)	30 (15–137)	73 (35–123)	54 (26–132)
Cardiorespiratory fitness				
Minutes on treadmill	10 (8–13)	14 (11–17)	15 (12–18)	13 (10–16)
METs§	8 (7–9)	9 (8–11)	10 (9–12)	9 (8–10)

Data are *n* or medians (25th and 75th percentiles). *3–6 METs; †≥3 METs; ‡>6 METs (sample sizes for the women reporting any vigorous PA: African-Americans, *n* = 11; Native Americans, *n* = 19; Caucasians, *n* = 24); §maximal METs achieved on treadmill.

with residual scores <0 classified as centrally lean and residual scores ≥0 classified as centrally obese.

Cardiorespiratory fitness was determined from the subject's time to exhaustion on a treadmill graded exercise test. The graded exercise test was performed under physician supervision using a Quinton treadmill with a 3-channel electrocardiogram (ECG) monitor. A treadmill protocol designed for this study was pilot-tested to assure that all study subjects could reach volitional fatigue within 26 min. The treadmill protocol started at 2.0 mph and 0% grade (2.5 METs) and increased every 2 min to 3.7 mph and 21% grade (14.5 METs). Exercise test endpoints were exhaustion, dyspnea, ECG abnormalities, or equipment technical problems (6). Cardiorespiratory fitness levels were determined by dividing subjects into two categories based on their age-specific maximal treadmill durations. Among subjects <50 years old, a maximal treadmill duration >16 min was classified as high fitness and ≤16 min as low fitness. Among subjects ≥50 years old, a maximal treadmill duration >14 min was classified as high fitness and ≤14 min as low fitness. The speed and grade of the treadmill at a duration of 16 and 14 min are equivalent to 10 and 9 METs, respectively, which correspond with the cut points of fair and below-average fitness levels versus good and above-average fitness levels based on the American Heart Association's fitness recommendation (12).

After a 12-h fast, blood samples were collected at rest from the antecubital vein using standard venipuncture methods. Insulin was measured by radioimmunoassay using the Coat-A-Count Insulin procedure (Diagnostic Products, Los Angeles, CA) (13). Ten percent of the subjects at each site returned to the laboratory 1 week after their initial blood collection, for a 2nd blood collection to determine subject repeatability ($r = 0.94$) and intra-assay variation (coefficient of variability 2.6%).

Fasting glucose levels were determined using enzymatic kits from Sigma Diagnostics (St. Louis, MO). Subjects taking insulin medication were excluded from the study ($n = 1$). A subject was classified as having type 2 diabetes if her blood glucose value was ≥126 mg/dl or she had physician-diagnosed diabetes (14).

Statistical analyses

All data were analyzed using PC-SAS (Cary, NC). Log transformations for insulin and glucose were used to normalize skewed data. Adjusted regression analyses were performed to estimate the linear association between physical activity and fasting insulin levels. Analyses were conducted in the full sample and, to focus specifically on the potential association between moderate-intensity PA and fasting insulin levels, analyses were repeated among the subset of women who reported no time spent in vigorous activities. Regression model results are presented in terms of the predicted change in the log of fasting insulin with an increase in physical activity of 90 MET-min/day, which is equivalent to 30 min of PA per day at a 3 MET intensity level (5). Covariates individually included in the regression analysis were race/ethnicity, age, educational attainment, site, fasting glucose levels, central obesity, BMI, and maximal treadmill time. Effect modification for the PA–fasting insulin association was tested using the product of PA and race/ethnicity, PA and cardiorespiratory fitness, and PA and central obesity in separate regression analysis models.

RESULTS

Characteristics of the study sample are presented in Table 1. African-Americans were older and had a higher body weight than Native Americans and Caucasians. The proportion of women with diabetes was higher in African-American and Native American women than in Caucasian women.

Table 2 shows the median and 25th and 75th percentiles for fasting insulin, glucose, and PA levels by race/ethnicity. Comparison of the PA levels by race/ethnicity showed lower energy expenditures among African-Americans than among the other races/ethnicities. Thirty-eight percent of the sample reported participation in vigorous PA. There were no differences in the median time spent in vigorous PA among the three races/ethnicities.

Table 3 shows unadjusted medians and 25th and 75th percentiles for log fasting insulin levels by quartiles of moderate/vigorous PA. The median values for log fasting insulin levels decreased with an increase in PA levels.

Table 4 shows the percentage change in fasting insulin levels associated with a 90 MET-min/day unit increase of moderate/vigorous and moderate PA. Each higher increment of 90 MET-min/day of moder-

Table 3—*Moderate/vigorous PA (≥3 METs) and fasting insulin levels by quartiles of PA*

	Moderate/vigorous PA (MET-min/day)			
	<263	263–377	378–614	>614
n	35	36	35	36
Moderate/vigorous PA (MET-min/day)	196 (126, 233)	333 (284, 354)	482 (413, 532)	858 (684, 1,068)
Log insulin (pmol/l)	4.27 (3.60, 4.68)	4.13 (3.75, 4.53)	3.58 (3.17, 4.35)	3.57 (3.16, 3.92)

Data are *n* or unadjusted medians (25th and 75th percentiles).

ate/vigorous and moderate PA was associated with 6.7 and 6.6% lower fasting insulin levels, adjusted for race/ethnicity, age, educational attainment, and site ($P < 0.05$). When further adjusted for fasting glucose levels, central obesity, BMI, and maximal treadmill duration, each higher increment of 90 MET-min/day of moderate/vigorous and moderate PA was associated with 3.4 and 5.2% lower fasting insulin levels ($P < 0.05$). The associations of fasting insulin and PA were similar across race/ethnicity, cardiorespiratory fitness, and central obesity status groups, consistent with the lack of statistical interaction ($P > 0.20$) (Table 5).

CONCLUSIONS

The results of this study indicate that an increment of 30 min/day of physical activity performed at a moderate intensity was associated with a 6.6% lower fasting insulin level among African-American, Native American, and Caucasian women enrolled in the Cross-Cultural Activity Participation Study. The association between PA and fasting insulin levels was present after adjustment for potential confounding variables of race/ethnicity, age, educational attainment, and site. When further adjusted for fasting glucose levels, central obesity, BMI, and maximal treadmill duration, an increment of 30 min/day of moderate-intensity PA was associated with a 5.2% lower fasting insulin level. The findings were also consistent among women of different races/ethnicities and levels of cardiorespiratory fitness and central obesity.

An inverse association between PA and fasting insulin levels is clinically relevant, since fasting insulin levels are a strong predictor of type 2 diabetes (4,15). The prevalence of diabetes is high among ethnic minorities in the U.S. (16,17), especially among Native Americans (16). The estimated prevalence of diabetes among Native American women living in New Mexico is 31% (16), compared with 12% among Caucasian women and 19% among African-American women (17). The potential impact of increased physical activity on diabetes risk in women and ethnic minorities is substantial. In studies with Pima Indians, a population with a prevalence of diabetes of 70% (18), Kriska et al. (19) have shown that leisure PA is inversely related with fasting and 2-h plasma glucose concentrations among individuals aged 15 to 59 years. Among the 1,054 Pima Indians who reported >2.5 h per week of leisure PA in the previous year, the prevalence of diabetes was reduced by 32% compared with those reporting less activity. Manson et al. (20) also showed that vigorous PA was associated with a lower risk for diabetes among Caucasian women. In their sample of 87,253 women aged 34–59 years enrolled in the Nurses Health Study, those who engaged in vigorous physical activity at least once per week had a 33% reduced risk for diabetes compared with women who did not exercise weekly. Further analysis of the Nurses Health Study suggests that, after adjusting for BMI and other covariates, brisk walking was independently associated with a 51% reduced risk for diabetes compared with easy, casual walking (21).

The findings in the present study are also consistent with those reported by Mayer-Davis et al. (2), who showed that both nonvigorous and vigorous PA was associated with higher insulin sensitivity among 1,467 African-American, Hispanic, and non-Hispanic white men and women enrolled in the Insulin Resistance Atherosclerosis Study. A 1-year recall of PA was used to determine the association between PA and insulin sensitivity measured directly by a intravenous glucose tolerance test. The investigators showed that 200 kcal/day in PA was associated with a 2.68% increase in insulin sensitivity. This amount of PA is equivalent to walking 2 miles at 3.0–3.5 mph (6). However, when results were adjusted for obesity and fat distribution, the association between PA and insulin sensitivity was attenuated. The attenuation suggests that obesity and fat distribution may confound the observed association between PA and insulin sensitivity.

In the present study, the association between moderate-intensity PA and fasting insulin levels remained significant after adjusting for potential covariates such as race/ethnicity, age, education, fasting glucose levels, cardiorespiratory fitness levels, central obesity, and BMI. Cardiorespiratory fitness and obesity may not necessarily be confounding variables but may be in the PA–fasting insulin causal pathway. However, the association between PA and insulin was not modified by central obesity or cardiorespiratory fitness levels ($P > 0.20$).

PA levels among the women in this study were higher than reported in U.S. surveillance system surveys. The higher PA level estimates are likely a function of the PA records used, which included household and occupational activities, compared

Table 4—*Percentage difference in fasting insulin levels associated with an estimated energy expenditure of 30 min of PA per day*

		Decrease in fasting insulin levels	
	n	Adjusted for covariates*	Adjusted for covariates and possible mediators†
Moderate/vigorous PA‡	142	6.7 (3.1–9.7)	3.4 (1.1–6.8)
Moderate PA§	88	6.6 (3.0–11.0)	5.2 (1.2–9.0)

Data are *n* or % (95% CI). The unit of change is set to 90 MET-min/day, equivalent to 30 min of PA at a moderate intensity (3 METs). *Adjusted for ethnicity, age, educational attainment, and site; †adjusted for ethnicity, age, educational attainment, site, fasting glucose levels, central obesity, BMI, and fitness; ‡≥3.0 METs; §3–6 METs, excluding women who reported any vigorous PA.

Table 5—*Percentage difference in fasting insulin levels associated with an estimated energy expenditure of 30 min of PA per day stratified by ethnicity fitness level, and central obesity*

	Decrease in fasting insulin levels					
	Moderate/vigorous PA (n = 142)*			Moderate PA (n = 88)†		
	n	Adjusted for covariates‡	Adjusted for covariates and possible mediators§	n	Adjusted for covariates‡	Adjusted for covariates and possible mediators§
Ethnicity						
African-Americans	47	3.2 (−4.0 to 9.8)	1.5 (−2.0 to 10.8)	36	9.6 (−3.2 to 12.1)	6.8 (−2.8 to 11.4)
Native Americans	46	9.1 (3.5 to 14.5)	5.6 (0.5 to 15.2)	27	5.3 (−2.2 to 12.3)	4.3 (−1.1 to 14.4)
Caucasians	49	5.9 (0.3 to 11.3)	0.3 (−3.2 to 12.6)	25	6.1 (−1.8 to 13.1)	1.5 (−2.3 to 12.9)
Cardiorespiratory fitness‖						
Low	72	8.4 (4.0 to 12.6)	6.3 (2.1 to 10.4)	59	7.6 (3.1 to 11.2)	6.1 (1.8 to 13.4)
High	70	3.7 (−1.5 to 8.7)	2.0 (−2.5 to 6.3)	29	6.0 (−1.9 to 7.7)	0.3 (−2.6 to 9.1)
Adjusted central obesity						
Centrally lean	70	7.9 (2.6 to 12.9)	3.1 (−0.5 to 12.6)	42	8.1 (−0.2 to 11.6)	7.3 (1.9 to 13.3)
Centrally obese	72	6.1 (1.5 to 10.5)	4.0 (−1.2 to 11.6)	46	6.0 (0.1 to 12.1)	3.8 (−1.4 to 11.6)

Data are n or % (95% CI). The unit of change is set to 90 MET-min/day, equivalent to 30 min of PA at a moderate intensity (3 METs). *≥3.0 METs; †3–6 METs, excluding women who reported any vigorous PA; ‡adjusted for age, educational attainment, site, and ethnicity (only in cardiorespiratory fitness and central obesity models); §adjusted for fasting glucose levels, BMI, central obesity (only in ethnicity and fitness models), and maximal treadmill duration (only in ethnicity and central obesity models); ‖low fitness is maximal treadmill time of <16 min if <50 years of age or <14 min if ≥50 years of age (18).

with studies that use a questionnaire and only include the traditional sports and recreational activities. The current CDC-ACSM recommendation is for 30 min of moderate- or moderate/vigorous-intensity PA performed on most, if not all, days of the week (5). Thirty minutes of moderate-intensity PA is equivalent to walking at 3.0–3.5 mph, working in the garden, or doing vigorous housework. The median time spent in moderate/vigorous PA among women in this study was 98 min/day in the form of household, lawn and garden, child care, walking, and occupational activities (22). Less than 1% of the activities recorded by participants in their PA records were vigorous sports and conditioning activities.

When PA levels were stratified by race/ethnicity, African-American women spent 73 min/day in moderate/vigorous PA, compared with Native American and Caucasian women, who were more active (130 and 106 min/day, respectively). These amounts of time spent in moderate/vigorous PA are equivalent to an energy expenditure of 287, 528, and 461 MET-min/day among African-Americans, Native Americans, and Caucasians, respectively. These findings are similar to estimates from PA time and motion studies that suggest women spend significant parts of their day in occupational, household, and family care activities and less time in recreational and conditioning activities (23). Data from the Third National Health and Nutrition Examination Survey also showed that only 3% of all women reported participation in vigorous physical activity (24), similar to our study.

The observation that African-American women expended about half the energy in moderate/vigorous PA compared with Caucasian women is consistent with studies that show African-American women are less physically active than Caucasian women (24). There are no published data that compare differences in moderate/vigorous PA between Caucasian and Native American women. Both Caucasian and Native American women spent more time in sports and conditioning activities than African-American women.

Several limitations should be considered when examining the results of this study. First, the cross-sectional design of this study precludes the assumption of temporality and that physical activity alone was associated with decreased fasting insulin levels. Second, fasting insulin was used as a surrogate of insulin sensitivity. Fasting insulin is a valid surrogate for insulin sensitivity as long as glucose levels are within normal limits (25). The possibility of having biased insulin results due to abnormal glucose levels is minimal in this study, since 88% of the sample had fasting glucose levels within the normal limits. Third, the sample size was small and may not be representative of the participants' respective ethnic groups.

A major strength of this study was the assessment of physical activity using PA records kept by the subjects for 8 days. PA records are a direct measure of physical activity and are often used as a tool to validate PA surveys and other indirect measures of physical activity. A total of 66,091 observations of daily physical activity were written into the PA records, averaging ~60 different activities per person per day. PA levels reported in this study are based on the most comprehensive recording of the subject's daily physical activity.

In conclusion, to decrease chronic disease morbidity and mortality rates, CDC-ACSM recommendations have encouraged all adults to obtain 30 min of moderate-intensity PA on most, if not all, days of the week. Thirty minutes of a moderate activity, such as brisk walking, was associated with a 6.6% reduction in fasting insulin levels independent of race/ethnicity, age, educational attainment, and site among African-American, Native American, and Caucasian women. The association between PA and fasting insulin was also similar among centrally lean and obese women and fit and unfit women. To encourage increased participation in moderate-intensity PA, it is necessary to intervene on activities in which women report participating. Future studies examining associations between PA and insulin levels among ethnically diverse women should attempt to measure household, lawn and garden, family care, walking, and occupational activities in addition to traditional sports and conditioning activities.

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Appendix—*Example of a Physical Activity Record*

Time began	Position (circle one)	Description (what are you doing?)	How hard? (circle one)	Activity group (circle one)
7:15	Recline	Dressing	Light	SC HH PAR
	Sit		Moderate	TRANS OCC
	Stand		Vigorous	WALK INAC
	Walk			LG EC MISC
7:25	Recline	Walking in the house	Light	SC HH PAR
	Sit		Moderate	TRANS OCC
	Stand		Vigorous	WALK INAC
	Walk			LG EC MISC
7:30	Recline	Walk for exercise	Light	SC HH PAR
	Sit		Moderate	TRANS OCC
	Stand		Vigorous	WALK INAC
	Walk			LG EC MISC
8:00	Recline	Watch TV news	Light	SC HH PAR
	Sit		Moderate	TRANS OCC
	Stand		Vigorous	WALK INAC
	Walk			LG EC MISC
8:10	Recline	Cook breakfast	Light	SC HH PAR
	Sit		Moderate	TRANS OCC
	Stand		Vigorous	WALK INAC
	Walk			LG EC MISC

EC, exercise/conditioning; HH, household; INAC, inactivity; LG, lawn and garden; MISC, miscellaneous; OCC, occupation; PAR, parenting; SC, self care; TRANS, transportation; WALK, walking.

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