Physical Activity and NIDDM in African-Americans

The Pitt County Study

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OBJECTIVE— Studies directly examining the association between physical activity and NIDDM in African-Americans are rare. Consequently, the strength of this association in this ethnic minority group remains unclear. The current study broadly characterizes the types of physical activity engaged in by a community sample of working-class African-Americans and then quantifies the association between physical activity and NIDDM risk in this population.

RESEARCH DESIGN AND METHODS— During the 1993 reexamination of participants in the Pitt County Study in North Carolina, data on NIDDM history, current use of insulin or oral hypoglycemic drugs, and ~12-h overnight fasting blood glucose (FBG) were obtained from 598 women and 318 men, ages 30–55 years. The presence of NIDDM was determined by current insulin or medication use and FBG ≥ 140 mg/dl. Study participants were assigned to one of four categories of physical activity: strenuous, moderate, low, or inactive.

RESULTS— The weighted prevalence of NIDDM in the sample was 7.1%. After adjustment was made for age, sex, education, BMI, and waist-to-hip ratio, NIDDM risk for moderately active subjects was one-third that for the physically inactive subjects (odds ratio [OR], 0.35; 95% CI, 0.12–0.98). The ORs for low (OR, 0.51; 95% CI, 0.20–1.29) and strenuous (OR, 0.65; 95% CI, 0.26–1.63) activity also tended to be lower. A summary OR that contrasted any activity versus no activity was 0.51 (95% CI, 0.23–1.13).

CONCLUSIONS— Moderate physical activity was strongly associated with reduced risk for NIDDM in this sample. While replication of these findings is needed, public health interventions designed to increase moderate (leisure-time) physical activity in black adults should be strongly encouraged.

In recent decades, NIDDM has emerged as a major public health problem in the U.S. (1), and although all subgroups of the U.S. population have been affected to some extent, evidence suggests that racial and ethnic minorities have been more affected by these secular trends than non-Hispanic whites (2–7). Currently, for example, the age-adjusted prevalence of NIDDM among African-Americans is ~50–70% higher than it is for non-Hispanic whites (3), which is quite different from the nearly equal prevalence values reported in the 1960s (4). The factors responsible for these diverging racial/ethnic trends in NIDDM risk have not been identified, but black/white differences in obesity (8), especially among women, and in physical activity (9) are believed to play a key role (2,4,7).

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Abbreviations: CHS, Current Health Score; dBP, diastolic blood pressure; FBG, fasting blood glucose; OR, odds ratio.

The contribution of excess body weight and of body fat distribution to NIDDM risk in African-Americans has been well documented (2,3,6,7). Few studies, however, have directly examined the influence of physical inactivity on NIDDM risk in African-Americans. Beyond its beneficial effects on weight control, regular physical activity may lower NIDDM risk through enhancing insulin sensitivity and glucose metabolism (10); therefore, more studies focused on populations at increased risk for NIDDM, such as African-Americans, are needed.

Table 1 summarizes published studies (11–34) on the relationship between physical activity and NIDDM risk. Using both nonprospective and prospective study designs, the studies focused on various racial/ethnic populations and used diverse approaches to measuring both physical activity and NIDDM status. Variations in findings by sex and age are apparent, but overall, the studies suggest that regular work or leisure-time physical activity protects against increased risk for NIDDM.

We encountered only two studies that provided data on the relationship between physical activity and NIDDM risk in African-Americans. The first (21), a cross-sectional study of interethnic differences in lifestyle correlates of NIDDM among Mexican-Americans, Puerto Ricans, and Cubans in the Hispanic Health and Nutrition Examination Survey (HANES), and among non-Hispanic whites and blacks in the Second National Health and Nutrition Examination Survey (NHANES II), reported an inverse association involving work-related physical activity only for Mexican-Americans. Leisure-time activity was not related to risk in any group (21). The second study (30) investigated diabetes incidence over 16 years (1971–1987) among participants in the National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up Study. Low baseline physical activity was significantly associated with increased risk for NIDDM for the sample as a whole (30). Subgroup analyses revealed a significant association for white women and trends in the expected direction for the

Table 1—*Non-prospective and prospective studies of physical activity (PA) and diabetes*

First author	Year	Sample	Exposure	Outcome	Findings
Non-prospective studies					
Lindgarde (11)	1981	107 normoglycemic men, age 48 years, Malmö, Sweden	4 categories of work and leisure-time PA	IGT prevalence	Prevalence higher for inactive subjects during leisure time
Taylor (12)	1983	538 Polynesian men and women, age ≥20 years	4 categories of work PA	Diabetes prevalence	Prevalence marginally higher with sedentary/light/moderate versus heavy PA levels
Taylor (13)	1984	1,235 Fiji Melanesian and Indian men, age ≥20 years	4 categories of work PA	Diabetes prevalence	Prevalence higher with sedentary/light/moderate versus heavy PA levels
King (14)	1984	5,519 Melanesians and Indians in Fiji and Micronesians in Kiribati, age ≥20 years	2 categories of work and leisure-time PA	Diabetes prevalence	Prevalence higher for active versus inactive subjects
Annuzzi (15)	1985	65 IGT subjects and 125 non-IGT subjects, ages 40–59 years, Italy	2 categories of work and leisure-time PA	IGT status	Leisure-time PA levels lower among IGT subjects
Cederholm (16)	1985	797 nondiabetic men and women, ages 47–54 years, Uppsala, Sweden	2 categories of work and leisure-time PA	Blood glucose levels 2 h after 75-g glucose load	Blood glucose levels after glucose load higher for subjects with low leisure-time PA levels
Chen (17)	1986	8,305 men and women, NHANES I, U.S.	2 categories of PA	Diabetes prevalence	Prevalence higher for inactive subjects (older adults only)
Frisch (18)	1986	5,398 alumnae of 10 colleges/universities, ages 21–80 years, U.S.	Ex-athlete (yes/no)	Diabetes prevalence	Prevalence lower in ex-athletes
Jarrett (19)	1986	6,672 male civil servants, ages 40–64 years, Whitehall Study, U.K.	3 categories of leisure-time PA	Blood glucose levels 2 h after 50-g glucose load	No association
Dowse (20)	1991	5,080 Mauritians, ages 25–74 years	2 categories of work and leisure-time PA	IGT and NIDDM prevalence	Prevalence higher for inactive subjects (except Chinese females)
Harris (21)	1991	6,581 Mexican-Americans, Puerto Ricans, and Cubans; Hispanic HANES; 15,364 whites and blacks, ages 20–74 years, U.S.	Work and leisure-time PA	Prevalence of IGT, diagnosed and undiagnosed NIDDM	NIDDM prevalence decreased with increased work PA levels (Mexican-American men only)
Ramaiya (22)	1991	1,147 Hindu Indian migrants, age ≥15 years, Tanzania	2 categories of PA	Prevalence of IGT and NIDDM	Prevalence lower for higher PA levels
Rajala (23)	1995	345 men and 435 women, age 55 years, Oulu, Finland	PA (yes/no)	Prevalence of diagnosed and undiagnosed diabetes	Prevalence of undiagnosed diabetes higher for inactive subjects
Regensteiner (24)	1995	219 IGT Hispanic and non-Hispanic whites, ages 31–76 years, San Luis Valley, CO	Total MET hours per week; work and nonwork PA	Insulin area (marker of insulin action) and fasting insulin	Lower values of insulin areas associated with higher PA levels; no association with fasting insulin levels
Schulz (25)	1995	101 Mixtec Indians, age ≥20 years, Oaxaca, Mexico	Total MET hours per week; leisure-time and work PA	Prevalence of IGT and diabetes	No association
Sowers (26)	1995	1,965 men and women, ages 35–64 years, Mexico City	Total MET hours per week	Fasting insulin, 2-h insulin, and insulin sensitivity	PA associated with higher fasting insulin, 2-h insulin, and insulin sensitivity (women only)

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Table 1—*Continued*

First author	Year	Sample	Exposure	Outcome	Findings
Prospective studies					
Manson (27)	1991	87,253 nondiabetic women, ages 34–59 years, Nurses' Health Study, U.S.	Vigorous PA (at least weekly)	NIDDM incidence	Incidence lower for vigorous exercise versus sedentary subjects
Schranz (28)	1991	338 normal subjects, age ≥15 years, Malta	3 categories of work and leisure-time PA	2-h postchallenge glucose	PA inversely associated with baseline blood glucose only
Manson (29)	1992	21,271 men, ages 40–84 years, Physicians' Health Study, U.S.	Frequency of vigorous exercise	NIDDM incidence	Decreased incidence with increased frequency of vigorous exercise
Lipton (30)	1993	9,531 whites and 1,566 blacks, ages 25–70 years, NHANES I Epidemiologic Follow-up Study, U.S.	3 categories of work and leisure-time PA	NIDDM incidence	Inactivity associated with increased incidence (white women only)
Helmrich (31)	1994	5,990 men, ages 39–68 years, University of Pennsylvania alumni, U.S.	Total leisure-time energy expenditure	NIDDM incidence	Incidence inversely associated with energy expenditure
Burchfiel (32)	1995	6,815 Japanese American men, ages 45–68 years, Honolulu Heart Program, Oahu, HI	5-level PA index	NIDDM incidence	Incidence inversely associated with PA
Perry (33)	1995	7,735 men, ages 40–59 years, British Regional Heart Study, U.K.	6-category PA index	NIDDM incidence	Incidence inversely associated with PA
Monterrosa (34)	1995	353 Mexican-American men and 491 Mexican-American women, ages 25–64 years, San Antonio, TX	Leisure-time PA (at least weekly)	NIDDM incidence	Incidence inversely associated with PA (men only)

IGT, impaired glucose tolerance; MET, metabolic equivalent; PA, physical activity.

smaller samples of white men, black men, and black women (30). In sum, while most studies suggest that regular physical activity is associated with reduced risk for NIDDM in a variety of populations, the strength of this association in African-Americans is not clear. We attempt to help clarify this issue in the current report.

RESEARCH DESIGN AND METHODS

Study population

Data for this study were collected during the 5-year (1988–1993) follow-up examination of participants in the Pitt County Study (35), a prospective investigation of social, behavioral, and anthropometric predictors of hypertension in African-Americans aged 25–50 years in 1988. Housing units for the baseline survey were identified through an area probability sample, with probabilities proportional to the expected number of black households in a given area. Of the 2,225 race and age-eligible individuals identified, 1,784 (80%) agreed to be interviewed. More details on the baseline survey methodology are available elsewhere (36,37).

Respondents were eligible for the 1993 follow-up study if their mean, untreated diastolic blood pressure (dBP) at baseline was <95 mmHg. Of the 1,407 individuals (900 women and 507 men) who met this criterion, 780 (87%) women and 415 (82%) men were reexamined in 1993. Of these 1,195 individuals, 613 (79%) women and 323 (78%) men consented to having their blood drawn after ~12-h overnight fasting. Of the 936 individuals who underwent venisection, 9 women were excluded from the analysis sample because they reported being pregnant, and 11 individuals (6 women, 5 men) were excluded because of missing values on one or more key study variables. These exclusions resulted in an analysis sample of 916 participants: 598 women and 318 men.

Study protocol

A standardized protocol was used by trained interviewers to assess demographic, socioeconomic, behavioral, and health characteristics of the study population (36). Physical measurements included height (in inches), weight (in pounds), waist and hip circumferences (in inches), and three consecutive measurements of sitting blood pressure (in millimeters of mercury) taken with a mercury sphygmomanometer 10–15 min into the interview. Study participants who gave written informed consent for an early-morning blood sampling were scheduled for a separate follow-up home visit by trained phlebotomists. Blood samples were obtained in the respondents' homes, except for 15 samples obtained in the Clinical Laboratory at East Carolina University School of Medicine under the supervision of one of our coauthors (P.G.K.).

Blood samples obtained during home visits were drawn into Vacutainer tubes and within 2 h were transported in coolers at 4°C to the clinical laboratory mentioned above. The blood samples were centrifuged immediately, blood glucose was analyzed, and frozen serum aliquots were stored at −70°C for repeated analyses, if needed.

Table 2—*Description of physical activity categories in the Pitt County study*

Physical activity categories	Strenuous exercise or work?	For at least 20 min, 3 times per week?	Nonstrenuous walking at least 15 min at a time?	Nonstrenuous home maintenance or gardening?
Strenuous	Yes	Yes		
Moderate	Yes	No		
	No		Yes	Yes
Low	No		Yes	No
	No		No	Yes
Inactive	No		No	No

Measurement of NIDDM status

Glucose was measured by the hexokinase method using an Abbott Spectrum Analyzer (Abbott, Diagnostic Division, Abbott Park, IL). Individuals were considered to have diabetes if they reported a medical history of diabetes and were using insulin or hypoglycemic medications or if their fasting blood glucose (FBG) was ≥140 mg/dl. Forty-five individuals reported a medical history of NIDDM. While all of these subjects reported taking insulin or oral hypoglycemic agents, 38 had FBG values ≥140 mg/dl and 7 had FBG values <140 mg/dl. Thirty-three individuals reported no medical history of diabetes but their FBG was ≥140 mg/dl. All individuals in this latter group were recontacted by the research team, and their NIDDM status was confirmed by a second elevated FBG level or by new evidence of physician-diagnosed NIDDM. Hence, in this sample, a total of 78 individuals were classified as having diabetes and 838 were classified as being nondiabetic.

Measurement of physical activity

Study participants were assigned to four mutually exclusive categories of physical activity based on their answers to four questions (Table 2). Individuals were assigned to the "strenuous" activity category if they answered "yes" to the following two questions (38): *1*) Do you engage in exercise or work that makes you breathe hard and sweat, even when the weather is not hot? *2*) Do you engage in this activity for at least 20 min, three times per week? Individuals were classified as moderately active if they answered "yes" to the first question but "no" to the second question. Individuals who responded "no" to both questions could also be classified as moderately active if they regularly walked (for at least 15 min at a time) and engaged in home maintenance or gardening. Walking and home maintenance or gardening were considered nonstrenuous activities. Subjects reporting no strenuous activity and only one nonstrenuous activity (either walking or home maintenance/gardening) were assigned to the "low" activity group. Finally, individuals who participated in none of the above activities were considered inactive.

Covariates

Potential control variables included age (years), sex, education (less than high school versus other), job status (blue-collar versus other), employment and labor force participation status, BMI, the ratio of the waist (measured at the umbilicus) to hips (greatest diameter of the gluteal muscles), cigarette smoking (yes/no), alcohol consumption (yes/no), and Current Health Score (CHS), a nine-item measure (39) of subjective well-being in which higher scores indicate better health.

Data analysis

Multiple logistic regression was used to estimate associations between physical activity and diabetes. Age, education, BMI, and waist-to-hip ratio were retained as covariates in the final regression model because each was associated in univariate analyses with both physical activity and NIDDM. On the other hand, employment and labor force participation, and blue-collar job status, were not associated with NIDDM; hence, they were not retained in the final model. The CHS, although associated with both physical activity and NIDDM, was also excluded from the final model because of evidence that it mediated the relationship between physical activity and NIDDM.

Because of the small number ($n = 78$) of diabetic subjects, sex-specific analyses were not feasible. The data for men and women were thus pooled, and a dummy variable for sex (female = 1, male = 0) was included in the final regression model. Parameters for the regression models were estimated by the maximum-likelihood method. Means and percentages of selected sociodemographic, behavioral, and health characteristics were obtained for diabetic and nondiabetic subjects. Weighted analyses were performed to account for the complex survey design and nonresponse; Gauss statistical software (40) was used for these analyses.

RESULTS

— Selected (unadjusted) demographic, behavioral, and health correlates of NIDDM status are shown in Table 3. Of the 916 respondents, 78 (weighted percentage, 7.1%) met the study criteria for NIDDM. On average, diabetic subjects were older and had higher BMI values and waist-to-hip ratios than nondiabetic subjects. The proportion of females among diabetic and nondiabetic subjects did not differ significantly. While diabetic subjects were twice as likely as nondiabetic subjects to be non–high school graduates, the proportions of diabetic and nondiabetic subjects with blue-collar jobs were comparable. Unemployment as well as nonparticipation in the labor force (i.e., unemployed, not looking for work) were more common among diabetic subjects. Cigarette smoking and alcohol consumption did not differ between the two groups; however, diabetic subjects reported lower mean CHSs. Diabetic subjects were also nearly 50% more likely to be hypertensive than nondiabetic subjects. Finally, diabetic subjects were less likely than nondiabetic subjects to engage in moderate physical activity, and they were more likely to be physically inactive.

Selected (unadjusted) correlates of physical activity are presented in Table 4. The top row shows the number of individuals in each of the four physical activity categories; the weighted percentages corresponding to these numbers are 11.1% (inactive), 29.3% (low), 26.7% (moderate), and 32.9% (strenuous). Means for age, BMI, and waist-to-hip ratio did not differ across physical activity categories. Females were overrepresented in the inactive category and underrepresented in the moderate and strenuous categories. Non–high school graduates, unemployed subjects, and those not in the labor force were also overrepresented among physically inactive subjects. Membership in the strenuous activity category was strongly associated with blue-collar employment. Cigarette smoking did not

Table 3—*Selected demographic, behavioral, and health correlates of NIDDM status in the Pitt County Study*

Correlates	NIDDM status: Diabetic	Nondiabetic
n	78	838
Age (years)	44.5 ± 6.4†	39.0 ± 6.9
BMI	30.4 ± 6.5†	28.9 ± 6.2
Waist-to-hip ratio	0.89 ± 0.06*	0.85
Females (%)	58.7	54.7
Less than high school education (%)	56.5*	27.6
Blue-collar employment (%)	44.8	44.3
Unemployed (%)	24.3	16.9
Not in labor force (%)	24.0*	13.7
Cigarette smoking (%)	32.3	37.7
Alcohol consumption (%)	33.2	37.3
CHS	29.2 ± 7.8*	33.3 ± 8.2
Hypertension (%)	42.5*	28.6
Physical activity (%)		
Strenuous	33.2	32.9
Moderate	16.5†	27.5
Low	29.8	29.3
Inactive	20.5*	10.3

Data are means ± SE or %. Values are weighted for differential selection and nonresponse. "Not in labor force" refers to subjects who were unemployed and not looking for work. CHS consists of nine items, with possible score range of 9–45 points. Hypertension was determined by blood pressure ≥140/90 mmHg or current use of antihypertensive medication. $*P \leq 0.05$, $†P \leq 0.10$.

differ across activity categories, but the strenuously active were more likely than the inactive to consume alcohol. Mean CHSs were lowest among physically inactive individuals. Finally, while hypertension status did not vary by activity level, diabetes was more common among the physically inactive compared with the moderately active.

Table 5 summarizes the covariate-adjusted relationships between physical activity and NIDDM in three weighted logistic regression models. The physical inactivity category was the referent in all models. Model 1 presents the unadjusted odds ratio (OR) and 95% CI for physical activity. Although strenuous, moderate, and low levels of physical activity were all associated with a lower risk for diabetes compared with inactivity, only the contrast for moderate physical activity versus inactivity (OR, 0.30, 95% CI, 0.11–0.86) was statistically significant. These results changed only slightly after adjustment in model 2 for sex and age.

Model 3 was adjusted for age, sex, education, BMI, and waist-to-hip ratio. The statistically significant association for moderate physical activity persisted; the OR was 0.35 (95% CI, 0.12–0.98). Non–high school graduates were twice as likely (OR, 2.0; 95% CI, 1.02–3.83) to be classified as having diabetes than individuals with at least a high school education. Increasing age was strongly related to increased risk for NIDDM. For example, the OR contrasting risk for 40-year-old versus 30-year-old subjects was 2.36 (95% CI, 1.45–3.84). A nonstatistically significant excess risk was observed for women compared with men. Higher waist-to-hip ratios were also strongly associated with increased NIDDM risk. For example, individuals with a waist-to-hip ratio of 0.95 were twice as likely (OR, 2.03; 95% CI, 1.29–3.22) to be classified as having diabetes than individuals with a waist-to-hip ratio of 0.85. After adjusting for all other variables in the model, BMI was not significantly associated with NIDDM risk; the OR for a difference in BMI of 5 kg/m^2 was 1.01 (95% CI, 0.79–1.30).

Finally, to assess whether participation in any type of activity was associated with reduced risk for NIDDM, the strenuous, moderate, and low physical activity groups were combined into a single category labeled "active." After we adjusted for age, sex, education, BMI, and waist-to-hip ratio, the OR comparing NIDDM risk for active versus inactive subjects was 0.51 (95% CI, 0.23–1.13).

CONCLUSIONS

— In this study, NIDDM risk among African-Americans engaging in moderate physical activity was ~65% lower than that of their physically inactive counterparts. This protective effect of moderate activity was independent of age, sex, education, BMI, and waist-to-hip ratio, all established risk factors for NIDDM (2,7,21). Low and strenuous physical activ-

Table 4—*Selected correlates of physical activity in the Pitt County Study*

Correlates	Physical activity level: Inactive	Low	Moderate	Strenuous
n	100	287	245	284
Age (years)	39.8 ± 7.1	40.7 ± 7.3	39.0 ± 6.9	38.5 ± 6.5
BMI	28.7 ± 6.9	29.2 ± 6.3	28.8 ± 6.2	29.1 ± 6.0
Waist-to-hip ratio	0.85 ± 0.09	0.85 ± 0.07	0.85 ± 0.07	0.86 ± 0.08
Females (%)	67.1	64.2	51.1*	45.6*
Less than high school education (%)	44.5	27.7*	27.1*	28.4*
Blue-collar employment (%)	36.8	37.4	43.7	53.5*
Unemployed (%)	34.0	22.9†	14.8*	8.9*
Not in labor force (%)	31.6	17.6*	14.6*	5.7*
Cigarette smoking (%)	34.6	39.5	32.4	40.2
Alcohol consumption (%)	25.9	35.4	33.6	44.8*
CHS	30.6 ± 9.9	32.0 ± 8.2	35.0 ± 6.8*	33.0 ± 8.3*
Hypertension (%)	24.1	33.1	28.4	29.4
Diabetes (%)	13.1	7.2	4.4*	7.1

Data are means ± SD or %. Values are weighted for differential selection and nonresponse. "Not in labor force" refers to subjects who were unemployed and not looking for work. CHS consists of nine items, with possible score range of 9–45 points. Hypertension was determined by blood pressure ≥140/90 mmHg or current use of antihypertensive medication $*P \leq 0.05$ vs. inactive group; $†P \leq 0.10$ vs. inactive group.

Table 5—*Relative odds of NIDDM by level of physical activity, the Pitt County Study*

Predictor (contrast)	Model 1	Model 2	Model 3
Physical activity			
Low/inactive	0.51 (0.21–1.25)	0.43 (0.18–1.06)	0.51 (0.20–1.28)
Moderate/inactive	0.30 (0.11–0.86)	0.32 (0.11–0.89)	0.35 (0.12–0.98)
Strenuous/inactive	0.51 (0.21–1.28)	0.60 (0.25–1.46)	0.65 (0.26–1.63)
Sex (F/M)		1.17 (0.60–2.27)	1.76 (0.80–3.88)
Age (10 years)		2.94 (1.86–4.64)	2.36 (1.45–3.84)
Education (less than high school/high school or greater)			1.98 (1.02, 3.82)
BMI (5 kg/m^2)			1.01 (0.79–1.30)
Waist-to-hip ratio (0.10)			2.03 (1.27–3.22)

Data are ORs (95% CI). Values are weighted for differential selection probability and nonresponse. Model 1, unadjusted; Model 2, adjusted for age and sex; Model 3, adjusted for age, sex, education, BMI, and waist-to-hip ratio.

ity also tended to be associated with reduced NIDDM risk (~49% and ~35%, respectively). An important finding was that analyses pooling data for individuals who regularly participated in any kind of physical activity suggested a risk reduction of ~50% compared with subjects reporting no activity. We reiterate, however, that only the ORs for comparisons involving moderate activity versus inactivity were statistically significant. Nevertheless, considered as a whole, these study findings add to the growing body of population-based evidence (11–18,20–24,26–34) supporting the hypothesis that regular work or leisure-time physical activity reduces risk for NIDDM. The current study suggests that for middle-aged African-Americans, this reduction in risk could be appreciable.

Inconsistencies in findings across studies assessing the strength of the relationship between physical activity and risk for NIDDM could be due to differences in study design or in methods of measurement of physical activity and diabetes, or a combination of these factors (Table 1). Although each of these considerations deserves attention, the manner in which the physical activity measure is defined (i.e., its ability to accurately reflect the lifestyle of the study population) may be especially important in studies of racial or ethnic minorities (41–43).

The physical activity measure used in the current study categorized individuals on the basis of their regular participation in strenuous or nonstrenuous activities. In this sample of Southern, largely working-class, African-American adults, we expected strenuous physical activity to be closely associated with occupational exertion and nonstrenuous activity to more strongly reflect leisure-time activity. In developing questionnaire items for the latter, we emphasized "low-impact," low-cost activities such as walking, home maintenance, and gardening (Table 2).

Data in Table 4 document the expected close relationship between participation in strenuous physical activity and employment, especially blue-collar employment. Among moderately active subjects, blue-collar employment was somewhat less common. In contrast to the strenuously active subjects, those who were moderately active participated in a variety of low to moderately intense activities (Table 2). The cumulative physiological benefits, including enhanced insulin sensitivity and glucose tolerance (10), derived from regular participation in a more varied set of activities of low or moderate intensity may have been responsible for the somewhat larger reduction in NIDDM risk noted for this group. This interpretation is consistent with the conclusions and recommendations reached by national consensus panels (41,42) regarding the potential broad health benefits of low or moderately intense levels of physical activity.

Several limitations of the current study should be acknowledged. First, because data on physical activity and NIDDM status were collected with reference to the individual's current status, we do not know whether physical inactivity preceded or followed the occurrence of diabetes. Slightly more than half of the individuals classified as having NIDDM in this study (38 of 78 subjects) reported taking medication for diabetes. If some subjects decided to become physically inactive because of their diabetes, the observed ORs (which indicated positive benefits of physical activity) may be overestimates of the true associations. However, because physicians presumably try to encourage their diabetic patients to engage in physical activity, "reverse causation" of this type is an unlikely alternative explanation of the study findings. Nevertheless, only a longitudinal study design can adequately clarify this issue.

Second, an unknown number of diabetic subjects were probably excluded from the 1993 follow-up study, along with hypertensive subjects (dBP ≥95 mmHg or medically treated hypertension). Hence, the weighted NIDDM prevalence of 7.1% reported in this study is almost certainly an underestimate of the actual prevalence of diabetes in the larger population of 30- to 55-year-old black adults in Pitt County. Moreover, because of the eligibility criterion regarding blood pressure, study findings can be generalized to only the 1,407 individuals (78.9% of the total sample) judged by survey criteria in 1988 to be normotensive. Incidentally, this limitation imposed by the study design raises the possibility that the protective associations reported for physical activity in this study could be underestimates of the true associations if physical inactivity was especially common among individuals with both hypertension and diabetes in 1988.

A third and related source of bias concerns the potential effects of selective participation in the blood-sampling portion of the 1993 follow-up study. Specifically, the OR associated with any one of the three physical activity categories would be artificially high (i.e., biased toward the null) if nonparticipants in the blood-sampling portion were more likely than participants to be both physically inactive and diabetic. Conversely, the ORs would be artificially low (i.e., biased away from the null) if nonparticipants were less likely to be both inactive and diabetic. To the extent that selection bias of this kind exists in the current study, it is probably not large, because the associations between a number of well-established risk factors for diabetes, such as sex, education, and waist-to-hip ratio, are all consistent with findings from other studies that involve African-American populations (7,21,30).

Finally, data on family history of diabetes, a risk factor of demonstrated importance for African-Americans (21), were not collected in this study. The reported ORs would be overestimates of the association between physical inactivity and NIDDM risk if individuals with a family history of diabetes were also more likely to be physically inactive. This limitation of the study should be addressed in future research; however, it is worth noting that in at least one study (31), physical activity was still associated with a lower incidence of NIDDM after adjustment was made for family history of diabetes. Moreover, the protective effect of physical activity was strongest among people with one or more established risk factors, including a family history of diabetes.

In conclusion, findings from this study suggest that regular physical activity (especially moderate activity) may be associated with a 50–60% reduction in risk for NIDDM in middle-aged African-Americans. Studies using larger samples of African-Americans that allow for sex-specific analyses, and using measures of physical activity appropriate for the geographical setting, are needed to replicate these findings. Longitudinal studies would be especially valuable, as would cost-effective community- based interventions designed to increase moderately intense leisure-time physical activity in middle-aged black adults (9,43).

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