Relationship Between Habitual Physical Activity and Insulin Levels Among Nondiabetic Men and Women

San Luis Valley Diabetes Study

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Objective: To determine whether higher levels of physical activity would be associated with lower fasting insulin and C-peptide levels in a free-living nondiabetic population. Research Design and Methods: A cross-sectional study was conducted with a Hispanic and non-Hispanic white population of 442 men and 489 women with normal glucose tolerance (by World Health Organization criteria) in two rural Colorado counties. Total physical activity was assessed by a 7-day physical activity recall from which metabolic equivalents were estimated. Relationships between metabolic equivalents and fasting insulin and C-peptide were assessed while considering obesity, age, and other risk factors known to influence fasting insulin levels. Results: Among all subjects, univariate analyses showed that higher activity levels were associated with lower mean fasting insulin and C-peptide levels ($P \leq 0.05$). Multiple linear regression showed that higher activity was significantly associated with lower values of log fasting insulin and C-peptide levels in men only ($P < 0.001$) independent of obesity, fat distribution, and age. Men in the highest tertile of activity had an adjusted mean fasting insulin level of 59.2 pM and fasting C-peptide level of 0.5 nM compared with a fasting insulin level of 72.7 pM and fasting C-peptide level of 0.6 nM for men in the lowest tertile of activity. The magnitude of the inverse association between activity and insulin was greatest in older rather than younger men. Physical activity was not associated with fasting insulin or C-peptide levels in women in the multivariate analyses. Conclusions: Based on cross-sectional data, we conclude that higher levels of habitual physical activity are associated with lower fasting insulin and C-peptide levels in Hispanic and non-Hispanic white men. *Diabetes Care* 14:1066–74, 1991

Endurance exercise training in the laboratory setting has been shown to have beneficial effects on certain markers of insulin action in both nondiabetic and non-insulin-dependent diabetic (NIDDM) subjects (1–7). However, much less is known about the effects of habitual physical activity on measures of insulin action in individuals with NIDDM or among nondiabetic free-living subjects. This is because there have been few population-based studies examining the effects of habitual physical activity on insulin action. In one South Pacific population, King et al. (8) found that sedentary women had a higher prevalence of NIDDM than nonsedentary women. Other studies have not shown a relationship between physical activity and development of diabetes (9–10). Studies conducted in normoglycemic subjects have generally shown that higher levels of physical activity are associated with better glucose tolerance and insulin resistance (11–13). Because there have been few such studies and because results have varied in the different reports, the relationship between physical activity and markers of insulin action, both in nondiabetic and diabetic populations, requires further study.

Therefore, we investigated the hypothesis that in nondiabetic subjects higher levels of habitual physical activity would be associated with lower fasting levels of insulin and C-peptide. We focused specifically on two markers of fasting insulin metabolism, fasting insulin level, which is highly correlated with insulin resistance

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(14), and fasting C-peptide level, which is an indirect marker of insulin secretion (15). We interviewed 931 Hispanic and non-Hispanic white men and women in two counties in the rural San Luis Valley, Colorado, with a 7-day physical activity recall (PAR). These subjects were all confirmed as having normal glucose tolerance. Because obesity increases insulin resistance (16), we adjusted for its effect and accounted for differences in fat patterning, age, and other risk factors for NIDDM. Understanding the impact of physical activity on markers of fasting insulin is important, because hyperinsulinemia has been found to be a risk factor for NIDDM (17–19) and cardiovascular disease (20–22).

RESEARCH DESIGN AND METHODS

The San Luis Valley Diabetes Study (SLVDS) has the purpose of characterized and related etiologic and prognostic factors associated with NIDDM in Hispanic and non-Hispanic white men and women. Data analyzed in this study were collected between 1984 and 1988. Detailed methods for the entire SLVDS have been reported elsewhere and only a summary is included herein (23). The nondiabetic control subset of the population was identified as follows. All occupied household structures in two counties (Alamosa and Conejos) in rural southern Colorado were identified (n = 6277), and an unduplicated random sample of 57.1% of the structures was drawn. A door-to-door enumeration of the occupants of the sampled structures was completed, and the enumeration interview was completed on 95.8% of the households.

Those enumerated individuals between the ages of 20 and 75 yr who were of Hispanic or non-Hispanic white ethnicity were selected for the second stage of control selection. In this stage, subjects were randomly selected by age, sex, and ethnic and county strata that reflected the older age and ethnic distribution of diabetic subjects. Eligible control subjects were residents of the study area, not living in an institutional setting, judged mentally competent by the interviewers, spoke English or Spanish, and had never been told by a physician that they had diabetes. Of 2192 sampled control subjects, 201 (9.2%) were subsequently found to be ineligible, most of whom had moved from the study area at the time of the invitation to the clinic. Of the remaining 1991 subjects, 1351 (67.9%) completed clinic visits. Of these 640 subjects refusing clinic visits, 499 (78%) completed a refusal interview. Older subjects and Hispanic men had a lower response overall, whereas married individuals, those with more education, and those who had a family history of diabetes were somewhat more likely to attend the clinic in the control group.

Blood was drawn from subjects after at least an 8-h fast to obtain values for fasting insulin and C-peptide levels. Fasting serum insulin levels were determined with double-antibody radioimmunoassay techniques by the University of Colorado Health Sciences Center General Clinical Research Center laboratory (24). Fasting glucose was measured with the glucose oxidase method also at the University of Colorado (25). Fasting plasma C-peptide levels were measured by radioimmunoassay at the University of Chicago (26).

Results of a glucose tolerance test performed after at least an 8-h fast were used to classify the diabetes status of all subjects by oral glucose tolerance test (according to World Health Organization [WHO] criteria) (27). Of this group, 931 subjects had both PAR data and fasting insulin or C-peptide data and were included in the analyses of this study.

Description of variables. Assessment of physical activity was obtained with PAR (28,29). PAR was modified for use in the SLVDS by dividing the week into work versus nonwork (leisure) time rather than into weekdays versus weekends. This was done to better quantitate activity levels of subjects who worked on weekends (such as farmers and homemakers). PAR required subjects to recall the time spent in activities that were included in three categories of activity intensity (active, very active, and extremely active) as well as in time spent sleeping. The remaining time was assumed to have been spent in somewhat active activities. Each of the five possible categories was assigned an average metabolic equivalent MET level, where 1 MET = 1 kcal/kg · body wt^{-1} · hr^{-1}. The MET values were 1 (sleep), 1.5 (somewhat active), 4 (active), 6 (very active), and 9 (extremely active). This information enabled estimation of energy expenditure for the prior week. MET values for selected activities are shown in Appendix 1.

Subjects were first asked to recall work activities and then nonwork activities. Work activities generally included activities necessary for the support of the household, whether paid or unpaid (as with full-time homemakers, some retired individuals, or ranchers). Classification of activities into work or nonwork categories was determined by the respondent with the assistance of the interviewers. Activities not considered to be specifically work related were classified as nonwork by default. Further details of physical activity assessment in the SLVDS have been reported elsewhere (29).

To more fully examine the relationship between physical activity and fasting insulin and C-peptide levels, we evaluated the role of potential confounders. These included ethnicity, age, fasting glucose, obesity, fat distribution pattern, smoking, peripheral arterial disease (PAD), or angina and hypertension. Confounders were chosen because they were risk factors associated with hyperinsulinemia or diabetes, e.g., obesity, or because they were potentially associated with physical activity level, e.g., peripheral arterial disease.

Of the potential confounders, age, fasting glucose, mean arterial blood pressure, and measures of obesity and fat distribution were treated as continuous variables. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. The waist-to-hip ratio was determined by dividing waist circum-

TABLE 1
Characteristics of control subjects with normal glucose tolerance in San Luis Valley diabetes study (1984–1988)

	Men (n = 442)*	Women (n = 489)†
Age (yr)	52 (24–75)	52 (21–75)
Body mass index (kg/m^2)	26 (16–42)	25 (15–43)
Subscapular skin fold (mm)	19.4 (3.8–53.3)	22.5 (3.3–59.8)
Waist-to-hip ratio	0.99 (0.87–1.11)	0.88 (0.66–1.13)
Fasting insulin (pM)	73 (18–276)	72 (6–558)
Fasting C-peptide (nM)	0.62 (0.01–1.80)	0.58 (0.02–1.95)
Fasting glucose	98 (79–131)	93 (68–126)
Total metabolic equivalents	299 (220–713)	267 (218–465)
Mean arterial blood pressure	93 (70–143)	88 (65–128)
Peripheral arterial disease/angina (% with condition)	13.1	14.5
Smoking (% smokers)	28.3	22.1

Values are given as mean with ranges in parentheses.
*Two hundred fifty-three (57%) non-Hispanic whites and 189 (43%) Hispanics.
†Two hundred eighty-nine (59%) non-Hispanic whites and 200 (41%) Hispanics.

ference (measured in cm at the bottom of the 10th rib at midrespiration) by hip circumference (measured at the most lateral tip of the superior iliac crest). The subscapular skin-fold thickness measurements were made at the lower angle of the right scapula with Lange calipers, and the average of 2 values within 0.5 mm of each other was used. Mean arterial pressure was defined as one-third the pulse pressure added to diastolic pressure. A second variable, which categorized subjects as hypertensive if diastolic pressure was >90 mmHg or if they were on antihypertensive medication, did not change the relationship between physical activity and insulin or C-peptides in earlier modeling. Therefore, only mean arterial pressure was retained in the final model.

Other potential confounders or risk factors for NIDDM were treated as categorical variables. Ethnicity was defined by self-report of subjects to the question "Are you of Spanish or Hispanic origin or descent?" (30). A current smoker was defined as one who had smoked at least 100 cigarettes in his/her lifetime and who was currently smoking. PAD and angina were defined according to previously established criteria (31,32).

Data analysis. Univariate analyses were completed with Spearman's rank-correlation coefficient (r_s) (33) and t tests (34). Multiple linear regression was used to determine whether there was an independent association of physical activity (entered into the models as a continuous variable) with fasting insulin and fasting C-peptide levels, adjusted for potentially confounding variables. Although physical activity is presented in models as a continuous variable, models with activity categorized into tertiles produced similar conclusions and were used for descriptive purposes in the study. Sex-specific regression models were created for fasting insulin and C-peptide levels separately, with the general linear models procedure of the SAS statistical package (35). Because both fasting insulin and C-peptide levels were highly skewed, the natural log transformation was used to achieve a better approximation to the normal distribution for these two outcome variables. Interaction terms were evaluated to assess possible differences in the effect of activity on fasting insulin or C-peptide levels in different ethnic, age, and BMI groups. Although regression models were presented with all variables entered, backward stepwise removal of variables and influence diagnostics were used to confirm the stability of the parameter estimates.

RESULTS

We interviewed 442 men and 489 women 20–75 yr of age who had laboratory measures of fasting insulin and C-peptide levels available. Characteristics of these subjects are shown in Table 1.

TABLE 2
Univariate correlation coefficients between fasting insulin and C-peptide levels with continuous variables in San Luis Valley diabetes study (1984–1988)

	Men		Women	
	Fasting insulin (pM)	Fasting C-peptide (nM)	Fasting insulin (pM)	Fasting C-peptide (nM)
Age (yr)	−0.006	0.149*	0.063	0.188*
Body mass index (kg/m^2)	0.514*	0.529*	0.564*	0.611*
Subscapular skin fold (cm)	0.424*	0.453*	0.550*	0.560*
Waist-to-hip ratio	−0.038	−0.037	0.035	0.039
Fasting glucose	0.333*	0.381*	0.367*	0.434*
Total metabolic equivalents	−0.229*	−0.267*	−0.089†	−0.116*
Mean arterial blood pressure	0.166*	0.194*	0.172*	0.192*

Values were computed with Spearman's rank-correlation coefficients (r_s).
*$P < 0.005$, †$P < 0.05$.

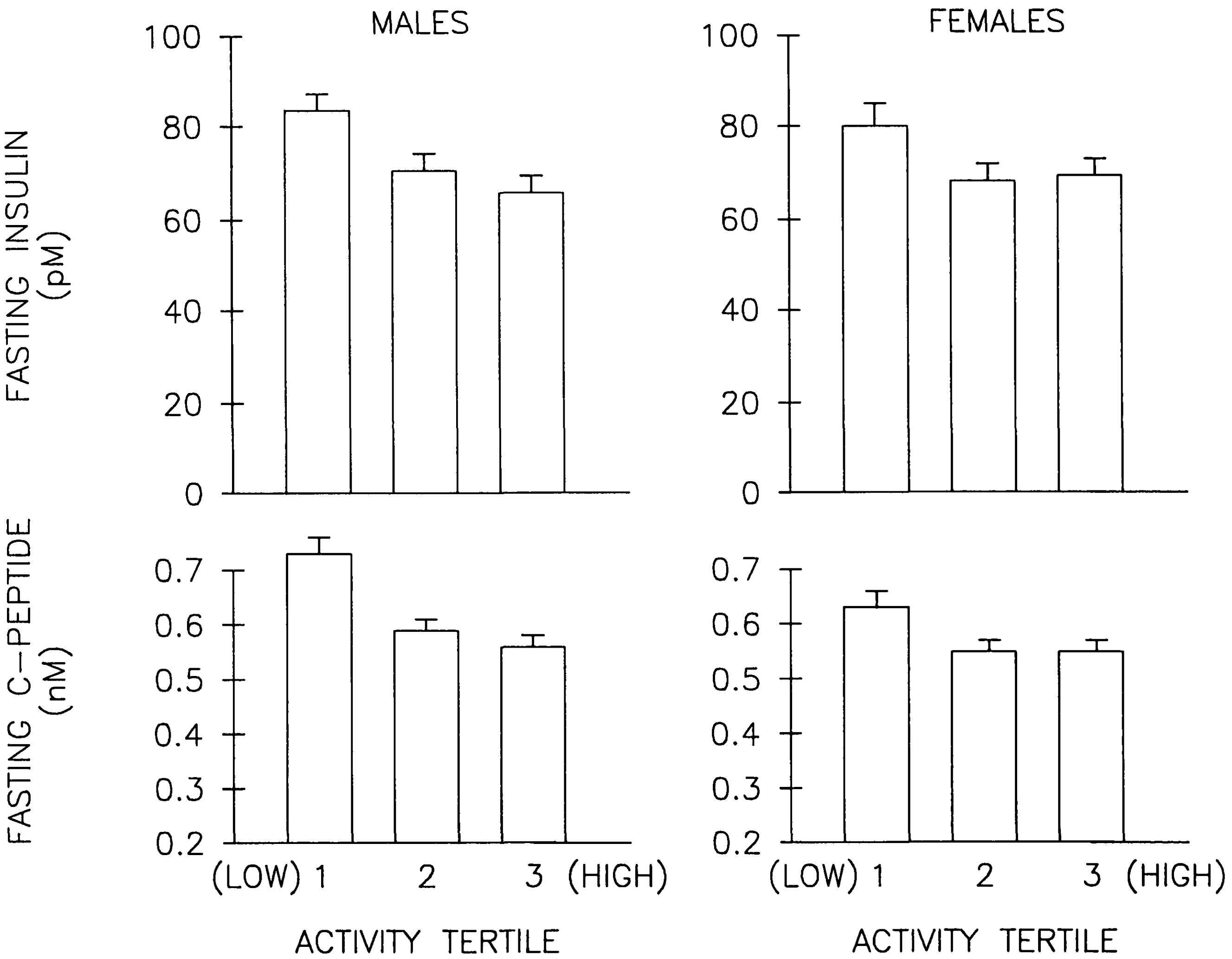

FIG. 1 Fasting insulin and C-peptide levels by physical activity tertiles for men and women. Physical activity in metabolic equivalents was divided into low, medium, and high tertiles.

Univariate analyses in both men and women showed that fasting insulin was inversely related to total METs (Table 2, Fig. 1) and positively related to BMI, subscapular skin fold, fasting glucose, and mean arterial pressure (Table 2). Fasting insulin levels in men were not significantly related to ethnicity, age, PAD or an-

TABLE 3
Relationship between fasting insulin and fasting C-peptide levels with categorical variables (San Luis Valley, Colorado, 1984–1988)

	Men		Women	
	Fasting insulin (pM)	Fasting C-peptide (nM)	Fasting insulin (pM)	Fasting C-peptide (nM)
Ethnicity				
Non-hispanic white	71.4 ± 39.6	0.62 ± 0.28	66.0 ± 47.4	0.54 ± 0.24
Hispanic	76.2 ± 43.2	0.63 ± 0.30	82.2 ± 49.8*	0.64 ± 0.31*
Presence of peripheral arterial disease or angina				
No	72.6 ± 40.2	0.61 ± 0.27	72.0 ± 49.2	0.57 ± 0.27
Yes	80.4 ± 46.8	0.73 ± 0.34*	75.6 ± 47.4	0.63 ± 0.31
Smoking				
No	75.0 ± 42.6	0.63 ± 0.29	72.6 ± 45.6	0.57 ± 0.28
Yes	70.8 ± 36.6	0.61 ± 0.28	72.0 ± 58.8	0.59 ± 0.27

Values are means ± SD.
*$P < 0.05$ fasting insulin or C-peptide level in presence vs. absence of variable (sex specific).

gina, waist-to-hip ratio, or smoking (Tables 2 and 3). In women, fasting insulin level was not related to age, PAD or angina, waist-to-hip ratio, or smoking but was related to ethnicity. Relationships between fasting C-peptide levels and these variables were similar except that age was positively related to fasting C-peptide levels in both men and women, and PAD or angina was positively related to fasting C-peptide levels in only men (Tables 2 and 3).

In the multivariate models, fasting insulin and C-peptide levels were log transformed to better approximate a normal distribution. We retained all variables in presenting the models, not because they were all true confounders, but to evaluate whether even with all possible confounders considered, physical activity would still be significantly related to fasting insulin and C-peptide levels. For women, there was no significant relationship between physical activity and fasting insulin or C-peptide levels in the multivariate analysis (Table 4), although the regression coefficients were in the direction consistent with an inverse relationship between insulin levels and physical activity. For men, even with all potential confounders included (including such strong predictors as BMI or fasting glucose), there was still a significant inverse relationship between physical activity and fasting insulin concentration (Table 5).

The parameter estimate for the relationship between fasting insulin and physical activity (−0.0008, *P* = 0.0027; Table 5) shows that there is an inverse relationship between levels of physical activity and fasting insulin, such that lower levels of activity were associated with higher levels of fasting insulin. The parameter estimate appears small because it represents the effect of a 1-U change in METs/wk on the log-transformed fasting insulin level. However, when we compared the lowest and the middle tertiles of activity as an example, this change represented ~9-pM decrease in fasting insulin concentration for a 70-kg man who spends ~1 h and 15 min/day 7 days/wk performing active activities such as brisk walking on level ground and feeding livestock (Appendix 1). The significant inverse relationship between physical activity and fasting C-peptide level was also maintained in the full model for men (Table 5).

TABLE 4
Full regression model for women (San Luis Valley, Colorado, 1984–1988)

	Fasting Insulin		Fasting C-Peptide	
	Parameter estimate	*P*	Parameter estimate	*P*
Total metabolic equivalents	−0.0003	0.6027	−0.0001	0.8365
Body mass index	0.0305	0.0001	0.0362	0.0001
Fasting glucose	0.0147	0.0001	0.0143	0.0001
Subscapular skinfold	0.0126	0.0001	0.0079	0.0037
Waist-to-hip ratio	−0.0614	0.8199	0.0358	0.8788
Ethnicity	0.1225	0.0028	0.0854	0.0166
Age	−0.0023	0.1979	0.0039	0.0121
Mean arterial blood pressure	0.0021	0.3474	−0.0007	0.7123
Presence of peripheral arterial disease or angina	0.0136	0.8051	0.0059	0.9021
Smoking	0.0226	0.6377	0.1026	0.0148

R^2 = 0.39 for fasting insulin, R^2 = 0.43 for fasting C-peptides. All variables were in model simultaneously.

TABLE 5
Full regression model for men (San Luis Valley, Colorado, 1984–1988)

	Fasting Insulin		Fasting C-Peptide	
	Parameter estimate	*P*	Parameter estimate	*P*
Total metabolic equivalents	−0.0008	0.0027	−0.0005	0.0196
Body mass index	0.0482	0.0001	0.0399	0.0001
Fasting glucose	0.0151	0.0001	0.0158	0.0001
Subscapular skinfold	0.0092	0.0184	0.0112	0.0014
Waist-to-hip ratio	0.2069	0.7050	0.3874	0.4271
Ethnicity	0.0865	0.0396	0.0083	0.8247
Age	−0.0012	0.5127	0.0051	0.0014
Mean arterial blood pressure	0.0023	0.2726	0.0022	0.2460
Presence of peripheral arterial disease or angina	0.1004	0.0984	0.1830	0.0008
Smoking	−0.0136	0.7735	0.0162	0.7019

R^2 = 0.35 for fasting insulin, R^2 = 0.40 for fasting C-peptides. All variables were in model simultaneously.

Next, we examined multiple interaction terms to test whether the association between physical activity and fasting insulin and C-peptide levels was consistent across ethnicity, BMI, and age strata. Of these factors, only age was found to interact with physical activity and this was true only for fasting insulin level but not for fasting C-peptide level. The results suggest that the association between physical activity and insulin level was greatest in older compared with younger men. Among people with low physical activity levels, insulin concentrations were higher at older ages. Among men who were more physically active no increase with age was apparent.

CONCLUSIONS

The main finding of this study was that with higher levels of physical activity, fasting insulin and C-peptide levels were lower in men. In addition, the relationships between physical activity and fasting insulin and C-peptide levels were present even after adjustment for potential confounding variables including obesity and glucose level. Therefore, based on cross-sectional data, we concluded that higher levels of habitual physical activity are associated with lower concentrations of fasting insulin and C-peptide levels in Hispanic and non-Hispanic white men.

The fact that fasting C-peptide levels were highest in men with the lowest physical activity levels supports the findings observed with fasting insulin. A higher C-peptide level implies higher insulin secretion because C-peptide and insulin are secreted in equimolar amounts (15). Furthermore, fasting C-peptide levels are a potentially more reliable index of insulin secretion than fasting insulin level, because C-peptide is not cleared by the liver (15). The use of fasting insulin as a marker of insulin metabolism is also important, because fasting insulin levels are highly correlated with insulin resistance (14).

The SLVDS provides an opportunity to study the effects of habitual physical activity in a biethnic population. We recently reported significant ethnic differences in fasting and 2-h insulin levels (36). In this study, in a subset of the same population, when we adjusted for similar factors and then physical activity was added, Hispanic men still had higher fasting insulin levels than non-Hispanic white men. Thus, physical activity does not account for the ethnic differences in insulin levels observed previously (36,37).

In women, unlike men, we observed that the association between physical activity and fasting insulin and C-peptide levels seen in the univariate models was not maintained in the multivariate models. There are several possibilities why this might have occurred. There is evidence that there is less variability in activity in women compared with men in this study population (29). In addition, the lack of association in women may also reflect a decreased ability of the PAR to assess physical activity in women. These factors could have made the true effects of physical activity in women difficult to detect.

Although we did not observe a statistically significant relationship between physical activity and fasting insulin concentration in women in the complete analyses, when we further analyzed our data we found that similar to findings in men, restricting the regression models to women in the lower two-thirds of activity levels increased the negative direction of the parameter estimates for METs, although it remained nonsignificant. Paradoxically, the parameter estimates for METs in the subset of most active women also showed stronger negative associations when examined separately. The strengthening of effect in both subgroups was due to higher adjusted mean fasting insulin and C-peptide concentrations for the highest activity group. We were unable to explain these higher means by consideration of menstrual status, exogenous estrogen use, or dietary factors (data not shown). Although the higher insulin levels in most active women may still be due to an unidentified biological factor, they may also be due to the suggested inability of the PAR to properly assess activity in women.

In any study where questionnaire data are used for assessment of physical activity, questions arise about reliability and validity of the questionnaire. The modified PAR was chosen for use in this study because of previous validation in another population (38,39). We have reported that the PAR was consistent compared with other measures of activity for measuring work-related and total activity in the SLVDS study population (29). The benefits of the use of a questionnaire to measure physical activity are obvious for a population-based study. Energy expenditure may be precisely determined through direct or indirect calorimetry; however, these methods are not feasible for population-based studies. Thus, a questionnaire validated for use in a population study has great value.

Many laboratory studies have examined the relationship between physical activity and markers of glucose tolerance in both diabetic and nondiabetic men and women. Some reports have shown that endurance exercise has improved glucose tolerance in diabetic subjects (1,2,6,7), whereas in others, such benefits did not result (40–43). It has been hypothesized that exercise may be effective in normalizing glucose tolerance only in diabetic subjects who can adequately secrete insulin and therefore have impaired insulin resistance as a principal defect (6). Studies in normoglycemic subjects have generally shown that endurance exercise training reduces fasting and postglucose plasma insulin concentrations (3–5). However, although some authors have found that oral glucose tolerance is improved in trained subjects, others have reported unchanged or worsened glucose tolerance in trained compared with untrained subjects (44,45).

Far fewer studies have examined the relationship between physical activity and markers of insulin action in the population rather than in the laboratory setting. Results of this study were generally consistent with the few studies that have examined the relationship between markers of glucose tolerance or insulin action and habitual physical activity in large groups or populations. In a study conducted in the South Pacific, sedentary women, but not men, had a higher prevalence of NIDDM, independent of BMI (8). Physical activity was scored only as a dichotomous variable, perhaps contributing to the lack of findings in the men due to a narrow range of scoring. In the Tecumseh study, male subjects showed no relationship between glucose tolerance and physical activity (evaluated by extensive questionnaire) except in the leanest subgroup (13). In this study, glucose concentrations, not insulin concentrations, were measured. Zavaroni et al. (11), in a study of Italian factory workers, found that in both men and women fasting glucose and glucose tolerance were related to leisure (but not work) physical activity. However, physical activity was only assessed on a four-point scale. Finally, in a study conducted in Taiwan, male laborers had lower glucose and insulin responses to glucose and meal tolerance tests than office workers (12). The increase in glucose level with age appeared to be attenuated by physical activity. In this study, occupation was used as a surrogate for physical activity. Thus, these studies show general agreement with this study as to the beneficial effects of physical activity on glucose tolerance and insulin resistance, although they differ as to methods and degree of assessing physical activity.

We found that the greatest difference in insulin concentration occurred between the lowest and middle tertiles of physical activity. Thus, the difference between very low levels of activity and any higher amount of activity was associated with the greatest difference in insulin concentration. Performing moderate levels of a recreational activity such as brisk walking on level ground or an occupational task such as feeding livestock for >1 h/day total was associated with lower insulin levels in the SLVDS population. In the laboratory, exercise training sessions conducted 3 times/wk for ≤ 1 h were associated with decreases in insulin level so that relatively small increases in physical activity level have been seen to have a significant effect (46,47).

The mechanism by which endurance exercise decreases fasting insulin level have not been completely elucidated but may be related to an increased tissue sensitivity to insulin resulting from regular exercise (48,49). Studies have shown that insulin binding to monocytes (50,51) and erythrocytes (52) is increased by exercise training and decreases with inactivity. Alternatively or additionally, it is possible that exercise causes a diminished secretion of insulin by the pancreas in response to a particular glucose concentration (53). Recently, studies have suggested that exercise magnifies insulin-caused increases in the intrinsic activity of plasma membrane glucose transporters (54).

In conclusion, higher levels of habitual activity were similarly associated with lower insulin levels in both Hispanic and non-Hispanic white men, independent of level of obesity. These findings suggest that increased physical activity may prevent the development of hyperinsulinemia. Evidence from numerous epidemiological and physiological studies suggests that hyperinsulinemia is a risk factor for coronary heart disease and NIDDM (17–22,55,56). Although the less active subjects in this study may not have had high levels of insulin, it is possible that even small increases in insulin level, or relative hyperinsulinemia, add to the risk of developing coronary heart disease or NIDDM (21). This study suggests that strategies to prevent coronary heart disease and NIDDM by increasing habitual physical activity to lower insulin levels in the community setting may be useful. In many population settings, a formal exercise program may not be feasible. Therefore, strategies that call for an increase in the physical activity level associated with the daily routine may have potential to be both practical and even optimal methods to help in preserving good health. These interventions must be evaluated in rigorous clinical and community randomized trials before their efficacy will be known.

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APPENDIX 1

Examples of activity intensity categories from 7-day physical activity recall (San Luis Valley, Colorado, 1984–1986)

Intensity category	Metabolic equivalent level*	Examples
Sleep	1.0	Sleep
Somewhat active	1.5	Leisurely walking, standing, driving, light indoor painting, playing a musical instrument
Active	4.0	Brisk walking (level), gardening, sweeping, mopping, feeding livestock, leisurely cycling
Very active	6.0	Brisk walking (uphill), climbing stairs, stacking firewood, carrying a child, social dancing, shearing sheep
Extremely active	9.0	Running, aerobic exercise, digging ditches, shoveling heavy snow, cross-country skiing

*1 metabolic equivalent = 1 kcal energy expended/kg · body wt^{-1} · h^{-1}.

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