Habitual Physical Activity and Glucose Tolerance

Males Age 16-64 in a Total Community

Henry J. Montoye, Ph.D., Walter D. Block, Ph.D., Helen Metzner, M.A.,* and Jacob B. Keller, M.P.H.,* Knoxville, Tenn., and Ann Arbor, Mich.*

SUMMARY

The data being reported are part of an epidemiologic study of health and disease in an entire community, Tecumseh, Michigan. Approximately 1,300 males age 16-65 were classified into three groups on the basis of their habitual leisure and occupational physical activity. A blood sample was drawn one hour after a glucose challenge and analyzed for glucose concentration. A measure of body fatness (sum of four skinfolds) was also available on the men. Glucose concentration of the three physical activity groups was compared by analyses of variance within narrow age groups. There was no significant relationship between glucose tolerance and habitual physical activity. There was a slight, but in some age groups significant, relationship between glucose tolerance and body fatness. The population was then divided within each age group into subgroups (thirds) by sum of skinfolds. The analysis was repeated in each age-fatness group. Glucose tolerance was better in the active men but only among the leanest subgroup of subjects. DIABETES *26*:172-76, March, 1977.

Gabriele and Marble[1] concluded more than 25 years ago that the increased physical activity in a summer camp improved control of diabetic children. Furthermore, as far back as in 1945, Blotner[2] reported that physical inactivity (bed rest) resulted in diminished sugar tolerance in nondiabetic patients. Since that time there have been other studies that supported these conclusions and other investigations that have not. In no large study has there been an attempt to study the relationship of physical activity to glucose tolerance in nondiabetic subjects while controlling body fatness or other confounding factors. Fortunately in the Tecumseh Community Health Study, a measure of body fatness was available on the male participants, as well as an estimate of habitual physical activity. It is the purpose of the present report to describe the relationship of habitual physical activity to glucose tolerance and to make observations of the possible influence of body fatness on the relationships.

From the School of Health, Physical Education and Recreation, University of Tennessee, Knoxville, TN.

*Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI.

Accepted for publication September 9, 1976.

METHODS

The Tecumseh Health Study has been described in detail elsewhere.[3,4] Briefly, it is an ecologic study of an entire community of about 10,000 persons. One of the purposes of the study is to identify the factors or constellation of factors that are important in the maintenance of health or the development of disease. Approximately 82 per cent of all the residents of Tecumseh, Michigan, and its rural fringe participated in the second series of examinations (1962-1965). Body fatness and glucose tolerance were measured in most of these subjects, but habitual physical activity was estimated only in males 16-64 years of age. The physical activity, blood glucose, and body-fatness relationships were studied in this male population (1962-1965 examinations) but known diabetics were excluded.

Glucose Tolerance

The respondents came to the clinic, usually in family groups, at which time skinfolds were measured. At this time, participants four years of age and over were given 100 gm. of glucose. The time of ingestion was recorded. One hour after glucose challenge venous blood was drawn. The examining physician noted the time of venipuncture and obtained a history of recent meals and snacks, specifying the time and amount of each item of food taken in the four hours preceding arrival at the clinic. The amount of carbohydrate consumed in each of the last four hours was estimated from these records by a dietitian using standard tables. Blood glucose concentrations were determined by the modified Hoffman method employing the AutoAnalyzer. The glucose concentration was then corrected for sex, age, and length of time since last meal by regression analyses. The resulting "glucose scores" have a mean of 10 and a standard deviation of 1. Details of these procedures have been published.[5,6]

Body Fatness

Skinfolds were measured at four sites: triceps, subscapula, suprailium, and area adjacent to the umbilicus. The measurements were taken with a Lange caliper calibrated by means of small springs of known force-compression curves. The measure of body fatness was simply the sum of the four skinfolds.

Assessment of Habitual Physical Activity

An activity-recall questionnaire and interview was employed during the second and third examinations to collect habitual physical activity data on males 16 years of age and over who were not attending school. The professional interviewer, at first contact, gave a self-administered questionnaire to the respondent. In the questionnaire, inquiries were made about occupation(s), transportation to and from work, leisure time activities, such as doing major home repairs and maintenance, gardening, and sports participation. At next contact, the interviewer spent from 30 to 60 minutes with each respondent, completing supplementary questionnaire forms designed to probe for details on each activity. The questionnaire and interview forms were designed to allow an estimate of physical activity during the preceding year. In only one general occupation, farming, were the tasks too varied to permit an analysis and quantitative score. For men in this occupation, the interviewer simply determined that the respondent actually worked the farm and these subjects were then grouped in a separate category as farmers.

For the present analysis, data from the following subjects were excluded: (a) males over age 64, because there were too few of them and because many of these were retired, (b) respondents who were employed less than 10 hours per week at the time of the interview, (c) men for whom no information was available on their occupations, and (d) those for whom there were no blood values.

The energy cost of each of the 34 leisure activities and of various occupation activities was estimated. This estimate was expressed as a ratio of the work metabolic rate divided by the basal metabolic rate (work-to-basal ratio) and is abbreviated as WMR/BMR. For example, a score of 3.0 for bowling indicates that the energy expenditure for bowling is estimated at three times the basal metabolic rate. More strenuous activities were given higher ratios; e.g., the ratio for handball is 12. This method of scoring was used to avoid considering the subject's body weight and converting work to calories. It is assumed that a task performed by a heavy person raises his metabolism by proportionately the same amount as for a person weighing less, even though the caloric expenditure may be different. Since the activities generally entailed moving one's own body weight, errors in making this assumption are probably not serious. A detailed description of the questionnaire, a complete table of the metabolic costs, and the coding system for the various occupation and leisure activities have been published elsewhere.[7] An index of habitual physical activity was then calculated for each subject, consisting of the weighted mean work-to-basal ratio utilizing the WMR/BMR associated with each of the subject's occupational and leisure time activities, weighted by the number of hours spent at each. This reflects the average 24-hour energy expenditure.

For purposes of the analyses, the respondents were grouped by decade of age. Distributions for each of the age groups were examined, and within each age decade the respondents who were in the lowest 20 per cent were classified as least active (sedentary), the middle 60 per cent as intermediate, and the upper 20 per cent as most active.

The statistical analysis employed for glucose score was a two-way analysis of variance comparing the mean glucose score of each of the three activity groups (least active, intermediate, and most active) with age groups as the second classification. Data on farmers were not included in the statistical analysis because it was not possible to calculate physical activity indices for this group.

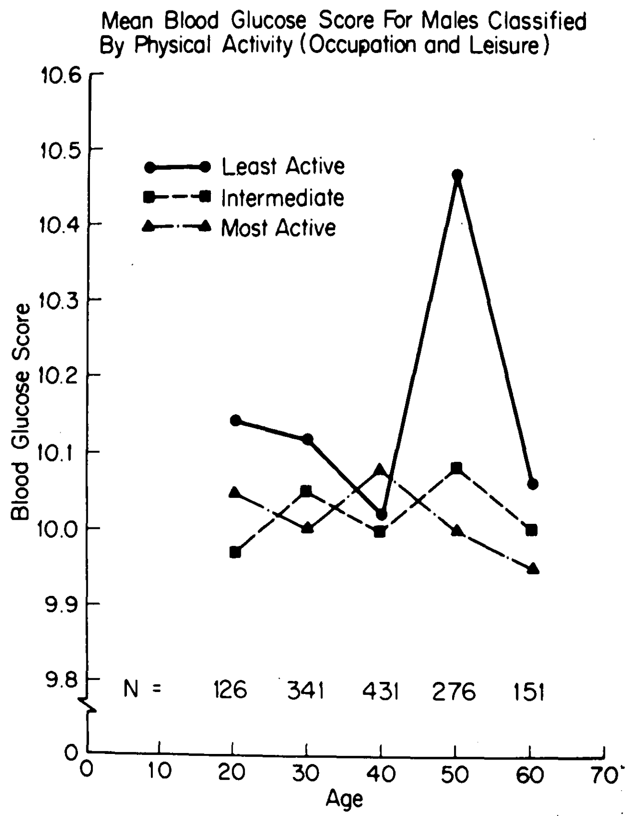

FIG. 1. Relationship of blood glucose score and habitual physical activity including both occupation and leisure time. Analysis of variance revealed no statistically significant differences among the three activity groups in glucose score.

RESULTS

A comparison of mean glucose scores for the three physical activity groups at each age is shown in figure 1. The least active subjects tend to have higher glucose scores, but the difference among the three groups over all ages was not significant ($P < 0.05$).

The msot sedentary men in this population are fatter than the more active respondents.[3] One may raise the question whether glucose score is also related to body fatness. Correlation coefficients expressing the relationship of glucose scores and sum of skinfolds are shown in table 1. Although three of the six coefficients are statistically significant, the numerical values are not impressive. Others[8,9] have reported similar low correlation between blood glucose and an estimate of body fatness in nondiabetic men. In an effort to eliminate any effect of body fatness, the distributions of men within age decades were divided into thirds on the basis of the sum of four skinfolds. A comparison in glucose scores was then made among the three physical activity groups within each of the body-fatness subgroups. The results are shown in figure 2. Glucose scores were higher among the least active subjects in the leanest third subgroup. A two-way analysis of variance indicated these differences were statistically significant. However, among the other two fatness subgroups, physical activity was not related to glucose score.

DISCUSSION

The importance of exercise in the treatment of diabetes has been stressed for a number of years.[10,11] There is reason to think that exercise results in increased entry of glucose into cells. It has long been known that prolonged exercise, as in marathon running, results in a decrease in blood sugar.[12-15] Cross-transfusion studies[16] have demonstrated that the blood or lymph from normal exercising dogs causes hypoglycemia in resting normal dogs. The same thing happens when the blood or lymph of exercising diabetic (depancreatized) dogs is circulated through resting diabetic dogs.

Blotner,[2] 30 years ago, reported diminished sugar tolerance in nondiabetic patients who had been confined to bed for from one month to 13 years. The study can be criticized in that the controls were 21 healthy and physically active subjects. However, in more recent studies normal subjects showed decreased glucose tolerance after bed rest of one to three weeks,[17] 12 days[18] and even as short a period as 72 hours.[19] If the subjects exercised in bed in the latter study, glucose tolerance was improved. This finding plus the fact that immobilized monkeys showed decreased glucose tolerance prompted the authors in that study[19] to conclude that inactivity rather than decreased effect of gravity was responsible for the diminished glucose tolerance. However, bed rest is a severe degree of inactivity and may not be comparable to the differences between the sedentary and relatively active subjects in the present study.

TABLE 1

Correlation coefficients: blood glucose vs. sum of four skinfolds

Age group	r	N
16-19	0.06	316
20-24	0.10	236
25-34	0.15*	525
35-44	0.11*	626
45-54	−0.01	415
55-64	0.15†	251

*Statistically significant, $p < 0.01$.
†Statistically significant, $p < 0.05$.

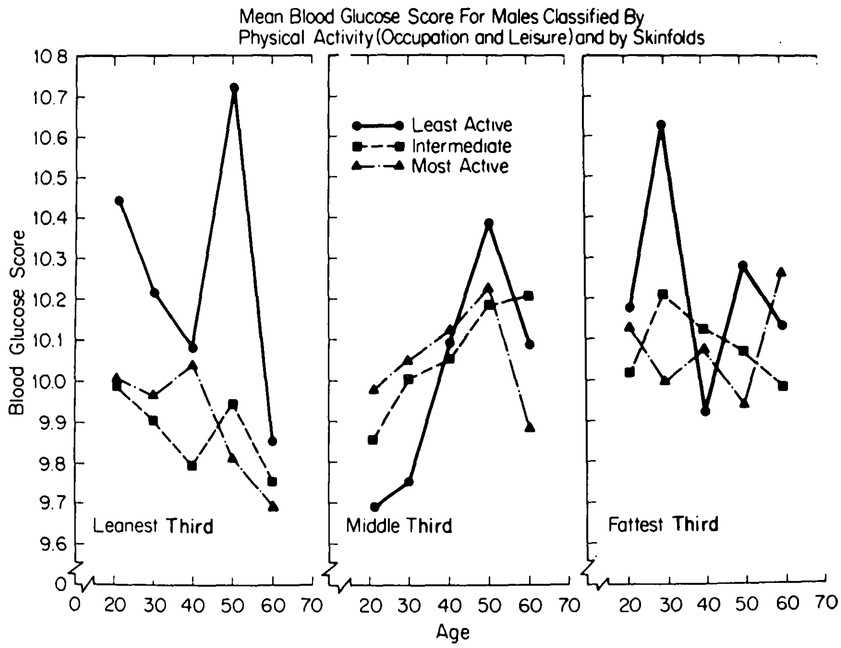

FIGURE 2

Blood glucose score for males classified by age, body fatness, and habitual physical activity. Analysis of variance indicated a significant difference in glucose score among activity groups in the leanest subjects (left panel). The differences in glucose score among the physical activity groups were not significant in the intermediate group (middle panel) or the fattest subjects (right panel).

There have been investigations in which the effects of physical training on blood glucose or glucose tolerance in normal subjects have been studied. The results are not consistent. In one study[20,21] with 12 males, glucose tolerance improved after six weeks of training. However, this training was followed by four weeks of detraining without the glucose tolerance reverting to the pre-training values. In two other training studies in nondiabetic subjects, there was no change in glucose tolerance.[25,26,28] One of these studies[25,26] involved fairly large numbers, 62 in the experimental group and 28 in the control group. In one investigation[27] the effects of physical training on glucose tolerance were inconclusive, and in one, using only five normal subjects, glucose actually became poorer after training.[23] When post-cardiac-infarct patients were put on an exercise program for nine months, no significant improvement in glucose tolerance occurred.[31] Blood concentration of glucose also did not change significantly in normal sedentary subjects who embarked on a physical training program.[24,29,30] It seems quite clear from these studies that a physical conditioning program does not have any profound effect on blood glucose or glucose tolerance in nondiabetic subjects.

Another approach in studying the effect of regular exercise on blood sugar concentration or glucose tolerance is to compare these measurements in subjects of different habitual physical activity, as was done in the present investigation. In only one other study known to the present authors has glucose tolerance been compared. This was an investigation by Bjorntrop[35] in which 15 trained runners and skiers age 52-56 were compared with 45 untrained men of the same age. Glucose tolerance was better and plasma insulin and body fatness lower in the trained men. The numbers in that investigation were small and intensity of exercise in the trained group was greater than in our "most active" group.

Resting—i.e. preëxercise—concentration of glucose in the blood has been compared in active and sedentary subjects in several studies,[8,23,29,32,34] and in no case was there a statistically significant difference. No attempt was made to eliminate the influence of possible confounding variables in these studies. In the present investigation there also was no relationship between habitual physical activity in males of average and above-average fatness. In lean males, however, active men showed improved glucose tolerance. Why this is so is not clear. Perhaps in fatter subjects the additional adiposity masks the effect of physical activity on glucose tolerance.

In summary, it appears that the acute effect of exercise is to reduce blood glucose, possibly because glucose penetration is enhanced. Physical activity has continued to be used in the treatment of diabetics, apparently with success. Decreased insulin requirement in juvenile diabetes has been observed by a number of investigators during summer camp, but whether this is due to increased physical activity is not known.

Although bed rest decreases glucose tolerance in nondiabetic subjects, physical training has little effect on glucose tolerance or blood glucose. When habitually active normal subjects are compared with other normal but sedentary men, the differences in blood glucose or glucose tolerance are also not impressive.

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