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Original Article

Association of Physical Activity with Risk of Type 2 Diabetes

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Abstract

Background: Physical activity has shown to prevent type diabetes 2. However, the type, intensity and amount of effective physical activity as well as individuals' needs according to level of their risk for type 2 diabetes have not been clarified comprehensively. This study investigated a relation between moderate aerobic physical activity ≥150 minuets/week with decreased risk of type 2 diabetes among obese and non-obese residents of south of Tehran, Iran.

Methods: This study, which was a part of the Cardiovascular Risk Factors Survey in Tehran population Lab region, was designed and conducted based on MONICA/WHO project. Totally, 1552 adult inhabitants of 17th district of Tehran were enrolled in this cross-sectional study. Physical activity was assessed by MONICA Optional Study of Physical Activity questionnaire. Diabetes was defined as a history of a prior diagnosis of diabetes or fasting serum glucose ≥126 mg/dl. All data analyses were conducted using SPSS 17 software for Windows

Results: In a multivariate model, moderate aerobic physical activity ≥150 minuets/week was significantly associated with decreased risk of type 2 diabetes in all and non-obese subjects [OR= 0.56; 95%CI: 0.35-0.91 and OR= 0.50; 95%CI: 0.26-0.94, respectively]. There was no significant relation between the physical activity and type 2 diabetes risk in obese subjects [OR=0.64; 95%CI: 0.30-1.39].

Conclusion: Moderate aerobic physical activity ≥150 minuets/week was significantly associated with decreased risk of type 2 diabetes in non-obese people and could be an acceptable exercise goal for these individuals. However, obese people should be investigated more to produce a tailored exercise guideline to this population at high risk of type 2 diabetes.

Keywords: *Physical activity, Diabetes mellitus, Iran*

Introduction

Type 2 diabetes is the common type of diabetes. In the United States, it has reached epidemic levels with affected 20.6 million people (1, 2). The prevalence of diabetes has been estimated at 8.7% in the Iranian population aged 15-64 yr (3). Increased number of newly diagnosed type 2 diabetics along with its complications has made a major public health concern in industrialized and developing countries (4–8). Genetic susceptibility, environmental and lifestyle factors like obesity, central adiposity, unhealthy diet, and physical inactivity are risk factors of type 2 diabetes (9, 10).

There is evidence that in spite of national educational efforts to decrease sedentary behavior, 24% of American adults do not participate in leisure-time activity (11). Results from cross-sectional studies have shown an inverse relation between moderately intense physical activity and type 2 diabetes (12, 13). Prospective studies have also found that moderate to high level physical activity can prevent type 2 diabetes (14-19). In addition, some clinical trials have shown that lifestyle modifications such as increase in physical activity, weight reduction, and balanced diet can prevent type 2 diabetes (20-23). In total, evidence confirms an effective role for physical activity in prevention of type 2 diabetes. Nevertheless, several main issues remain to be resolved. The type, intensity, and amount of physical activity that can be efficient should be verified. Another point is that whether physical activity alone can prevent

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diabetes. In addition, it should be considered whether an individuals' susceptibility for developing type 2 diabetes can determine their requirements for physical activity. Various studies have shown that aerobic physical activity reduces the risk of developing type 2 diabetes (20, 21, 23-27). In a systematic review, it was found that moderate intensity physical activity was associated with reduced risk of diabetes even after adjustment for body mass index (BMI); although this relation was attenuated (28). Some interventional trials have shown that 150 min moderate physical activity per week could decrease risk of progression to diabetes in adults with impaired glucose tolerance or at high risk of cardiovascular disease independent of weight loss, although this level of activity did not preclude development of diabetes in all cases (29). Therefore, it seems higher levels of physical activity are needed to maximize diabetes risk reduction in high-risk subjects such as the obese, those with positive family history of diabetes, and those with impaired glucose tolerance.

We aimed to determine whether ≥150 min moderate aerobic physical activity per week could decrease risk of type 2 diabetes among obese and non-obese adult Inhabitants of 17th District of Tehran.

Materials and Methods

Subjects

This study, which was a part of the Cardiovascular Risk Factors Survey in the population Lab region affiliated to Tehran University of Medical Sciences, was designed and conducted based on MONICA/WHO project.

Totally, 1552 subjects aged 25-64 yr from inhabitants of 17th district of Tehran were enrolled in this cross-sectional study. Subjects were randomly selected by one stage cluster sampling. Each of clusters size was equal. The units of sampling were defined based on geographic location and city blocks of 17th zone of Tehran. Exclusion criteria were diseases or disabilities imposing limitations on physical activity. The research ethics committee of the Tehran University of Medical Sciences approved the study and written informed consent was obtained from each subject before entry into the study.

Data collection

Information based on demographic characteristics including age, sex, education level, smoking status and history of a prior diagnosis of hypertension, diabetes, taking antihypertensive and/or hypoglycemic drugs including insulin therapy as well as family history of diabetes was collected by a trained nurse using a standard questionnaire. Anthropometric measurements were performed by trained nurses using standard protocols and technique. Weight and height were measured in light clothing without shoes. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). According to their BMI, subjects were divided into 2 groups, non-obese (BMI <30) and obese (BMI ≥30). Waist circumference was measured at the umbilical level to the nearest centimeter at minimal inspiration. Blood pressure measurements were performed according to guidelines of The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII) with the participant in a recumbent position after 5 min rest by trained nurses and the average of 3 measurements were recorded. Participants were recommended to avoid alcohol, cigarette smoking, caffeinated beverages, and exercise for at least 30 min before their blood pressure measurement. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg and/or current use of antihypertensive drugs. Twelve-hour overnight fasting blood samples were collected to determine serum glucose and total cholesterol levels and were stored at -80° C until performing laboratory assays. Serum glucose and total cholesterol were measured using enzymatic-calorimetric method (Hitachi 902-Boehringer Manneheim). Diabetes was defined as a self-reported history of a prior diagnosis of diabetes or fasting serum glucose ≥126 mg/dl. Hypercholesterolemia was defined as a serum total cholesterol ≥200 mg/dl.

The physical activity questionnaire used for this study was the MONICA Optional Study of Physical Activity (MOSPA) questionnaire developed by the Centers for Disease Control and Prevention, USA (CDC) (30). Participants were asked to report the time usually spent on physical activity during work, transportation to work, household, and leisure time during a normal week. Moderate physical activity was defined as requiring a metabolic equivalent (MET) score of 3–6 (31). Some common aerobic activities of moderate intensity included walking at a moderate intensity, cycling, swimming, jogging, skiing, and ball games. Devoted minutes to moderate aerobic physical activity per week were calculated for each subject.

Statistical Analyses

Continuous variables were expressed as mean± standard deviation (SD) and were compared using the *t*-test. Categorical variables are expressed as percentages and were compared using the χ^2 test. According to their physical activity level, Subjects were divided into 3 groups including: group 1 or inactive, group 2 with physical activity <150 minuets/week, and group 3 with physical activity ≥150 min/wk. Linear and logistic regressions were used to determine the association of physical activity (total MET) with BMI and obesity, respectively. The relation between physical activity and type 2 diabetes was investigated with multiple logistic regression models, using inactive as the reference category in all, obese and non-obese subjects. In the first model, analyses were adjusted for age and sex; then in the second model, education and smoking status were added. Finally, in the third model, analyses were also adjusted for BMI, waist circumference, hypercholesterolemia, hypertension, and family history of Diabetes. In case of obese and non-obese subjects, all the mentioned covariates were added to analyses in the third model except for BMI. All data analyses were conducted using SPSS 17 software for Windows. $P \leq 0.05$ were considered statistically significant.

Results

A total of 944 (60.8%) participants were women. Mean age of the participants was 41.78±12.30 yr. Mean weight and BMI±SD were 72.37±14.60 kg and 27.78±5.48 kg/m^2, respectively. Age-adjusted prevalence of type 2 diabetes was 11.4%. Characteristics of participants also categorized according to their obesity status are depicted in Table 1. Prevalence of Diabetes, hypertension and hypercholesterolemia was significantly higher in obese than non-obese group ($P< 0.000$). There was no significant difference in family history of diabetes between obese and non-obese groups (30.2 vs. 27.7, $P>0.05$) (Table1).

After dividing subjects into 3 groups, inactive (group 1), with physical activity <150 min/wk (group 2), and with physical activity ≥150 min/wk (group 3), physical activity ≥150 min/wk was independently associated with decreased risk of type 2 diabetes in all subjects in a multivariate model and compared with inactivity (OR= 0.56; 95% CI: 0.35-0.91) (Table 2).

The association of physical activity with BMI and with obesity was not significant [P=0.37 and P= 0.43, respectively; (linear and logistic regression)]. After categorized according to obesity and compared with inactive group, the multivariate-adjusted odds ratio for diabetes in obese group with physical activity ≥150 min/wk was 0.64 (95% CI: 0.30-1.39), whereas in non-obese subjects, physical activity ≥150 min/wk was significantly associated with decreased risk of type 2 diabetes by 50% (OR= 0.50; 95% CI: 0.26-0.94) (Table3).

Discussion

We found that moderate aerobic physical activity ≥150 min/wk was significantly associated with reduced risk of type 2 diabetes in all and non-obese subjects. However, in obese participants physical activity did not reduce risk of type 2 diabetes.

Table 1: Baseline characteristics of the subjects[1]

Characteristic	All (n=1552)	Non-Obese (n=1079)	Obese (n=473)	*P*-value
Female (%)	60.8	54.1	76.1	0.000
Age (y)	41.78 ± 12.30	40.49 ± 12.55	44.70 ± 11.17	0.000
Education (y)	6.65 ± 5.17	7.26 ± 5.27	5.24 ± 4.64	0.000
Smokers (%)	15.2	17.4	10.4	0.001
Weight (kg)	72.37 ± 14.60	66.52 ± 10.81	85.74± 13.28	0.000
BMI (kg/m^2)	27.78 ± 5.48	24.98 ± 3.31	34.17 ± 3.87	0.000
Waist circumference (cm)	90.14 ± 12.85	85.40 ± 10.78	100.93 ± 10.45	0.000
Hypercholesterolemia (%)	41	34.6	55.4	0.000
Hypertension (%)	42.8	35.2	60.3	0.000
Family history of DM (%)	28.5	27.7	30.2	0.31
Diabetes (%)	11.4	9.1	16.7	0.000

[1]All values are expressed as mean and standard deviation and or percentage.
BMI= Body Mass Index, DM = Diabetes Mellitus

Table 2: Association between physical activity and risk of type2 diabetes in all subjects[1]

Physical Activity	Adjusted for age and sex	adjusted for education and smoking status	adjusted for BMI, waist circumference, hypercholesterolemia, hypertension and family history of DM
Inactivity	1	1	1
Physical Activity <150 minuets/week	0.63 (0.40-0.99)	0.63 (0.40-0.99)	0.72 (0.45-1.15)
Physical Activity ≥150 minuets/week	0.50 (0.31-0.80)	0.51 (0.32-0.81)	0.56 (0.35-0.91)

[1]n=1552
BMI = Body Mass Index, DM = Diabetes Mellitus

Table 3: Association between physical activity and Risk of type2 diabetes in obese and non obese subjects

Physical Activity	Adjusted for age and sex	adjusted for education and smoking status	adjusted for waist circumference hypercholesterolemia, hypertension and family history of DM
Non-Obese			
Inactivity	1	1	1
Physical Activity <150 minuets/week	0.55 (0.30-1.02)	0.55 (0.30-1.01)	0.59 (0.32-1.11)
Physical Activity ≥150 minuets/week	0.46 (0.25-0.86)	0.47 (0.25-0.86)	0.50 (0.26-0.94)
Obese			
Inactivity	1	1	1
Physical Activity <150 minuets/week	0.72 (0.36-1.43)	0.72 (0.36-1.44)	0.90 (0.44-1.85)
Physical Activity ≥150 minuets/week	0.55 (0.26-1.13)	0.56 (0.27-1.17)	0.64 (0.30-1.39)

DM = Diabetes Mellitus

Results of Prospective studies (14-19) have found an effective role for physical activity in prevention of type 2 diabetes. In addition, several clinical trials showed that lifestyle interventions that included physical activity were successful in prevention of type 2 diabetes (20-23). However, the type, intensity, and duration of beneficial physical activity associated with decreased risk of type 2 diabetes have not been clarified completely. In addition, there is controversy that whether physical activity can prevent diabetes independent of BMI and body fatness. Finally, the minimal physical activity level to preclude development of type 2 diabetes based on each individual's susceptibility to become diabetic is a critical issue, which needs further investigation.

Studies have found that aerobic physical activity both greatly reduces type 2 diabetes risk and decreases the risk of progression from impaired glucose tolerance to type 2 diabetes (21,22). In a systematic review (28), results from cross-sectional and prospective studies were generally consistent with an inverse association between moderately intense physical activity and type 2 diabetes. In the meta-analysis of 10 prospective cohort studies, those who were regularly engaged in moderate intensity physical activity had 31% lower risk of type 2 diabetes compared with sedentary individuals (OR: 0.69; 95% CI 0.58–0.83). Even after adjustment for BMI, the reduction in diabetes risk remained substantial (17%) (28). In addition, review of six diabetes prevention trials showed that in adults with impaired glucose tolerance or at high risk of cardiovascular disease, increasing moderate physical activity level up to 150 min/wk was associated with lower risk of progression to diabetes independent of weigh loss (29).

In this study, ≥150 min of moderate aerobic physical activity per week was significantly associated with decreased risk of type 2 diabetes independent of BMI and waist circumference. In the Da Qing Study (20) which was designed to investigate the separate effects of physical activity, diet and combined effects of physical activity plus diet on development of diabetes, physical activity independently reduced risk of diabetes incidence. In fact, diabetes risk was reduced by 46% in the physical activity only intervention group without a substantial change in BMI (20). Some useful biological effects of physical activity on glucose metabolism and insulin sensitivity independent of body fatness are suggested; which include increased insulin-stimulated glycogen synthesis through enhancement of insulin-stimulated glucose transport rate by GLUT4 glucose transporters and increased glycogen synthase activity as well as accelerated capillary proliferation in muscles, increased muscle mass, and a higher ratio of more insulin-sensitive muscle fiber types (32, 33).

On the other hand, studies have also shown that 150 min/wk of moderate physical activity did not provide full protection against diabetes and annually 2-13% of subjects participating in the lifestyle intervention still develop diabetes (29). It seems that higher levels of physical activity may be needed to maximize reduction of diabetes risk in those at high risk of the disease such as people with high BMI, positive family history of diabetes and impaired glucose tolerance. Our results concurred with this point when the subjects were categorized into 2 groups of non-obese (BMI< 30 kg/m^2) and obese (BMI ≥30 kg/m^2) and moderate aerobic physical activity ≥150 min/wk reduced risk of type 2 diabetes only in non-obese subjects. However, there was no significant association between this level of physical activity and decreased risk of diabetes in obese participants. On the other hand in the Chinese Da Qing Impaired Glucose Tolerance and Diabetes Study (20), the decrease in diabetes risk in the physical activity intervention arm was evident in both initially lean (BMI <23) and overweight (BMI >23) subjects. In addition, in a recent prospective study, the inverse relationship of vigorous activity and brisk walking with diabetes risk was also present in all levels of BMI (19). Conversely, the US Diabetes Prevention Program (DPP) research group in their study of nondiabetic persons with elevated fasting and post-load plasma glucose concentrations showed that the impact of lifestyle in-

tervention was dependent on baseline BMI of the subjects. They found lifestyle intervention to be more effective than metformin in non-obese (BMI< 30 kg/m^2) participants, whereas there was no difference in their relative effect in subjects with BMI over 35 kg/m^2 (22). This evidence shows that the effect of diabetes prevention is not similar among different populations. Therefore physical activity guidelines for the prevention of type 2 diabetes should be adjusted according to the level of individual's risk for developing type 2 diabetes.

One limitation of this study was the cross-sectional design of study, which could not explain the cause and effect relation of diabetes and physical activity as clearly as longitudinal studies. Another limitation was measurement of Physical activity with self-reported questionnaire. Because subjective assessment of physical activity is difficult (34), this study and most of others had to focus on activities that are most easily recalled and that are most heterogeneous among individuals. Therefore, some recall bias could not be avoided.

In conclusion, with uprising incidence of obesity in modern societies, the prevalence of type 2 diabetes is growing. Unequivocal evidence has demonstrated that physical activity can prevent or delay the onset of diabetes. We found that ≥150 min per week of moderate intensity aerobic physical activity was significantly associated with decreased risk of type 2 diabetes in non-obese Iranian adults and it could be suggested as an acceptable exercise goal for them in prevention of type 2 diabetes. However, there was no significant association between this level of physical activity and decreased diabetes risk in obese participants. More studies should attempt to clarify particularly what type, intensity and duration of physical activity can be optimal for decreased risk of type 2 diabetes in obese Iranian adults. In addition, it is needed to provide exercise guidelines based on each subject's level of risk for developing diabetes, especially those with obesity, positive family history of diabetes mellitus, impaired glucose tolerance, and specific ethnic groups.

Ethical Considerations

Ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors.

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