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Walking for exercise—does three times per week influence risk factors in type 2 diabetes?

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Abstract

In order to assess the effects of regular walking on metabolic control and cardiovascular risk factors in type 2 diabetes 26 patients from one primary care clinic, aged 60.0 ± 7.3 years, participated in a walking program during 4 months. Prescribed exercise was walking for 45–60 min three times weekly. A control group of 26 patients from a neighboring primary care clinic, aged 59.3 ± 6.2 years, received no exercise instructions. Thus, randomization was not performed.

There were no improvements of blood pressure, body mass index, physical fitness, glycated hemoglobin A1c, fasting plasma glucose or insulin by intention-to-treat analysis. Seventeen patients in the intervention group increased their physical activity and improved systolic blood pressure; −7.6 mmHg (−15 to −0.2), diastolic blood pressure; −4.3 mmHg (−7.4 to −1.2), body mass index; −0.6 kg/m^2 (−1.1 to −0.1) and total plasma cholesterol; −0.6 mmol/l (−0.9 to −0.3), (mean difference, with 95% CI). We could observe no effects on glucose metabolism in either group.

Our results suggest that an increase of regular physical activity equivalent to 45 min of walking 3 days/week may suffice to improve systolic and diastolic blood pressure, lipid metabolism and BMI in patients with type 2 diabetes.
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Keywords: Type 2 diabetes; Exercise; Risk factors

1. Introduction

Cardiovascular morbidity is the major contributory factor to mortality in type 2 diabetes. In the United Kingdom Prospective Diabetes Study (UKPDS) systolic hypertension, dyslipidaemia and hyperglycaemia were significantly associated with coronary artery disease [1] and pharmacological treatment of hypertension was demonstrated to reduce cardiovascular mortality and morbidity [2]. Furthermore, UKPDS results show that glycaemic control is more crucial to the risk of developing micro vascular complications of type 2 diabetes, i.e. retinopathy and nephropathy, than macro vascular complications, i.e. stroke and coronary heart disease [3]. A subgroup analysis of the Scandinavian Simvastatin Survival Study (4S) suggests

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that the improvement of blood lipid levels was beneficial also to patients with type 2 diabetes, with respect to coronary heart events [4].

Impaired insulin sensitivity is a central metabolic disturbance in type 2 diabetes with its strongest expression in skeletal muscle. Physical exercise is known to enhance insulin sensitivity and is therefore regarded as a cornerstone in the management of type 2 diabetes [5].

A meta-analysis of 14 controlled trials of physical exercise concluded that post-intervention HbA1c levels were lower in the exercise groups compared with the control groups [6]. Other studies have indicated that regular walking [7] or more strenuous exercise programs [8] are beneficial to insulin sensitivity in type 2 diabetes. Regular exercise, combined with dietary restrictions, has also been shown to prevent the development of impaired glucose tolerance into overt type 2 diabetes [9,10]. Improved glycaemic control, blood pressure, cholesterol levels and body weight have been demonstrated in patients with type 2 diabetes after a lifestyle modification program [11].

Several authors have reported discouraging difficulties in implementing long-term exercise programs for patients with type 2 diabetes 60 years or older [12–14]. Many patients are unaccustomed to exercising [15] and attempts at introducing habits of regular physical activities may also be limited by other co-existing ailments. Contrary to this a high attendance to a long-term exercise program was observed in younger persons with type 2 diabetes or impaired glucose tolerance [16].

Current research thus indicates that physical exercise is associated with improved glycaemic control, blood pressure and blood lipid levels in type 2 diabetes, as well as a reduced risk of developing this disease in persons with impaired glucose tolerance.

In Sweden most patients with type 2 diabetes are cared for in primary health care and one central aspect of diabetes care ought to concern matters of lifestyle. There is a need for more detailed knowledge of the effects of various lifestyle interventions to be utilized in individual counseling and goal setting in diabetes care.

The aim of this study was to describe the effects on metabolic control and cardiovascular risk factors in type 2 diabetes after a period of a low intensity exercise program feasible to most patients and to the resources of a primary health care center.

2. Materials and methods

2.1. Patients

Patients with type 2 diabetes were enrolled from two different primary care practices in two well-defined suburban communities outside Stockholm, Sweden. Exclusion criteria were severe angina pectoris or other severe disability and insulin treatment. Public meetings, advertised in the local press, were arranged in the two communities and attendants were invited to participate. In addition, 67 patients with type 2 diabetes were invited to participate when visiting their physician and 100 by a personal letter of invitation.

Twenty-seven patients consented to participate in the intervention group and 31 in the control group. One patient in each group declined further participation shortly after inclusion in the study. Four patients in the control group were lost to follow-up despite repeated reminders. Thus, the intervention group and the control group both consisted of 26 patients.

We chose to invite the patients to the two groups from different communities in order to diminish the possibility that the control group patients would start exercising as they learned about the activities in the intervention group. This was therefore not a randomized study.

2.2. Study design

The patients in the intervention group were instructed to increase their exercise by 45 min of brisk walking, three times weekly, during 4 months. We expected this to be achievable to most patients. Four months was considered to be a sufficient period to allow for changes of the parameters under study. Walking groups were provided four times per week and the patients were asked to register every walk in a diary, whether they were taken in a supervised group or individually. No recommendations were given concerning changes of dietary habits and medication remained unaltered in both groups. The patients in the control group were informed that their results were to be used as reference values for diabetes patients over a period of 4 months when no alterations of life style or medication were undertaken.

2.3. Methods

At the time of inclusion and after 4 months resting systolic (SBP) and diastolic (DBP) blood pressure in the supine position and body mass index (BMI) were assessed. Since the patients were examined at two different primary care units different blood pressure tonometers were used (Speidel and Keller™). There were no differences in the blood pressures recorded with the four different tonometers that were used, when tested on the same patient for control.

Blood samples, obtained in the fasting state were analyzed for plasma glucose, insulin, glycated hemoglobin (HbA1c), and lipid levels (total cholesterol, HDL and LDL cholesterol and triglycerides). According to Swedish national diabetes guidelines HbA1c $< 6.5\%$ is regarded as good control.

Insulin resistance was obtained as HOMA2-IR (Homeostasis Model Assessment) from fasting serum insulin and plasma glucose levels by the use of the computerized HOMA calculator as described by Wallace et al. [17]. Serum insulin levels were analyzed at a central hospital laboratory using the Auto DELFIA method (Perkin-Elmer™).

Blood samples and measurements of other variables in this study were obtained within 24–48 h after the last exercise walk.

Age adjusted physical fitness was determined by bicycle ergometry as a submaximal exercise test. The patients performed six minutes of cycling at a resistance (50–150 W) that resulted in a steady heart rate. The patient's heart rate, sex and age were used in the Åstrand nomogram to calculate the predicted maximum oxygen uptake ($VO_{2\ max}$). A Monark 839E ergometer cycle was used for the exercise tests (MONARK EXERCISE AB™).

The patients answered a questionnaire that focused on daily physical activity. The questionnaires and walking diaries made it possible to identify those individuals in the intervention group who did increase their actual level of exercise.

2.4. Statistics

Paired t-tests were used to analyze differences within the intervention group and the control group, respectively. For analysis of differences between groups two-sided *t*-tests were used.

The ethics committee of Karolinska Institutet, Stockholm, approved this study.

3. Results

Baseline characteristics and results after 4 months are shown in Table 1. The exercise group increased their total amount of weekly exercise according to walking diaries and exercise questionnaires. However, only 17 patients attained 80% or more of the stipulated 3 min $\times$ 45 min increment. The predominant mode of exercise reported was walking. Aerobics, swimming, cycling, gardening, golfing and weight lifting were activities reported by few patients in each group. At baseline 11 patients in the intervention group and 15 in the control group reported habitual exercise exceeding 3 $\times$ 45 min of walking.

There were no significant effects on parameters reflecting glucose metabolism, i.e. HbA1c, plasma glucose and plasma insulin levels. HDL and LDL cholesterol levels were improved in both groups. In the intervention group there was a tendency towards a decrease in systolic and diastolic blood pressure. In the control group the tendency was towards a rise in systolic as well as diastolic blood pressure. Physical fitness when measured as predicted $VO_{2\ max}$ was average to low in both groups and did not improve during the study.

In a separate analysis of the 17 patients in the exercise group that achieved 80% or more of the prescribed increment of exercise systolic and diastolic blood pressure, BMI and total plasma cholesterol were significantly reduced.

Nine patients in the intervention group did not alter their exercise habits. Six of them remained on a low level of physical activity and three maintained their previous level of exercise, which was higher than what was stipulated for the study.

A number of patients experienced ailments that limited their participation in physical activities to some degree. In the intervention group 12/26 and in the control group 9/26 patients reported such physical obstacles in the physical activity questionnaire.

4. Discussion

The main results of this study indicate that brisk walking for 45 min 3 days/week may not provide a

Table 1
Basic characteristics (T0) and differences at 4 months (dT4) for type 2 diabetes patients

	I ($n = 26$)		C ($n = 26$)		Incr ($n = 17$)	
	T0	dT4	T0	dT4	T0	dT4
Age (years)	60.0 ± 7,3		59.3 ± 6.2		60.4 ± 8.5	
Sex M/F	11/15		15/11		8/9	
Diabetes duration (years)	5.2 ± 4.3		5.8 ± 4.2		5.2 ± 3.5	
Glucose lowering treatment Diet/Tablets	11/15	11/15	14/12	14/12	8/9	8/9
Antihypertensive treatment	19	19	13	13	11	11
Lipid-lowering treatment	8	8	9	9	6	6
Exercise (h/week)	2.5 ± 1.6	1,2 (0.7 to 1.7)*	3.3 ± 2.1	0.2 (−0.6 to 1.0)	2.6 ± 1.8	2.6 (1.9 to 3.3)*
Systolic BP (mmHg)	146.9 ± 13.5	−4.3 (−9.6 to 1.0)	154.8 ± 18.6	2.6 (−4.7 to 9.9)	146.2 ± 12.2	−7.6 (−15.0 to −0.2)*
Diastolic BP (mmHg)	85.2 ± 5.3	−2.6 (−5.3 to 0.1)	85.0 ± 8.9	1.4 (−1.8 to 5.0)	85.2 ± 5.6	−4.3 (−7.4 to −1.2)*
BMI (kg/m^2)	32.2 ± 5.0	−0.3 (−0.8 to 0.2)	30.9 ± 5.4	0.1 (−0.1 to 0.3)	31.8 ± 5.2	−0.6 (−1.1 to −0.1)*
HbA1c (%)	6.3 ± 0.9	0,0 (−0.2 to 0.2)	6.0 ± 0.7	0.1 (−0.1 to 0.3)	6.3 ± 0.9	−0.1 (−0.4 to 0.2)
Fasting glucose (mmol/l)	9.0 ± 2.6	0.2 (−0.3 to 0.7)	8.2 ± 1.8	−0.2 (−0.7 to 0.3)	9.2 ± 2.8	0.0 (−0.7 to 0.7)
Fasting insulin (pmol/l)	99.6 ± 61.2	−6.4 (−23.1 to 10.3)	79.5 ± 50.9	−4.2 (−20.9 to 12.5)	98.2 ±69.1	−15.1 (−38.4 to 8.2)
HOMA2-IR	1.2 ± 0.4	0.0 (−0.1 to 0.1)	1.0 ± 0.3	0.0 (−0.1 to 0.1)	1.2 ± 0.5	0.0 (−0.04 to 0.04)
Total cholesterol (mmol/l)	5.5 ± 1.0	−0.3 (−0.6 to 0.0)	5.6 ± 1.1	−0.3 (−0.6 to 0.0)	5.7 ± 1.1	−0.6 (−0.9 to −0.3)*
HDL cholesterol (mmol/l)	1.15 ± 0.32	0.14 (0.10 to 0.18)*	1.19 ± 0.33	0.14 (0.10 to 0.18)*	1.14 ± 0.31	0.15 (0.09 to 0.21)*
LDL cholesterol (mmol/l)	3.3 ± 1.1	−0.4 (−0.7 to −0.1)*	3.4 ± 1.0	−0.4 (−0.7 to −0.1)*	3.4 ± 1.2	−0.6 (−1.0 to −0.2)*
Triglycerides (mmol/l)	2.4 ± 1.2	−0.1 (−0.5 to 0.3)	2.2 ± 1.1	0.0 (−0.3 to 0.3)	2.5 ± 1.2	−0.3 (−0.7 to 0.1)
$VO_{2\ max}$ (l/min)	2.0 ± 0.5	0.0 (−0.1 to 0.1)	2.0 ± 0.5	0.0 (−0.1 to 0.1)	2.0 ± 0.6	0.0 (−0.2 to 0.2)

I: the intervention group; C: the control group; and Incr: the patients in the intervention group that achieved 80% or more of the increment of exercise postulated in the study (walking 3 × 45 min weekly during 4 months). Data are means ± S.D. or means (95%CI). HOMA2-IR: computerized homeostasis model assessment of insulin resistance.

* $P < 0.05$.

sufficient increase of physical activity to improve the degree of glycaemic control, lipid homeostasis or blood pressure in patients with type 2 diabetes.

Various factors in our study might account for the absence of improved glycaemic control. The degree of physical activity obtained by the patients may have been insufficient. Our patients were in comparatively good glycaemic control when included in the study. This implies that the participating patients might have been a highly motivated group. Other investigators have demonstrated that diabetes patients with higher HbA1c levels respond with a more pronounced decrease in this respect following regular exercise [11]. With increasing age the glucose metabolism may react less favourably to physical activity. This may account for the lack of effect on glucose metabolism in our study. Furthermore, the number of patients in our study may have been too small to detect minor effects on glucose metabolic control in patients who already had a relatively good metabolic control.

A comparison of our results to those of another study comprising a similar number of patients with comparable degree of blood glucose control may be justified. Yamanouchi et al. [7] studied two groups of patients with type 2 diabetes, aged 23–59 years. A "diet and exercise" group (DE) walked ~13.5 km daily and a "diet only" group (D) walked ~3.2 km daily during a 6–8 weeks period of hospitalization, according to pedometer readings. In the DE group ($n = 14$) fasting blood glucose improved (6.1–5.2 mmol/l) as well as insulin sensitivity (euglycaemic insulin clamp). In the D group ($n = 10$) fasting blood glucose improved to a similar degree (5.9–5.1 mmol/l) whereas insulin sensitivity was not significantly altered. The dietary restrictions (reduction of daily caloric intake by 1000 kcal from the patient's ordinary intake) may explain the improved glycaemic control of both groups and the exercise may explain the improved insulin sensitivity of the DE group. The authors do not specify the actual increase of walking in the DE group but a reasonable assumption is that it amounted to approximately 10.3 km daily, i.e. the difference between the two groups. This comparison implies that the relatively small amount of exercise, rather than the small number of patients or their degree of glycaemic control, accounts for the absence of effects on glycaemic variables in our study. It deserves mention that the patients studied by Yamanouchi et al. were hospitalized during the study. The amount of walking applied in our study may better reflect the amount of exercise feasible in everyday life and especially in an elderly diabetes population.

Few studies have described the effects of exercise in type 2 diabetes patients over 55 years of age. Zierath and Wallberg-Henriksson conclude in a review article that there is "a difference in the metabolic response to regular exercise between younger and older type II diabetic patients ... none of the older patient groups (57–61 years) respond to exercise training with improved HbA1c levels." [18]

The absence of metabolic response to exercise in elderly type 2 diabetes patients may be due to concomitant ailments that prevent more vigorous exercise. If an age-dependant "exercise resistance factor" should exist, this would diminish the value of recommending exercise to elderly patients. At the same time it seems likely that such an age-dependant decrement of response to exercise would be subject to individual variations.

The age of the patients in this study is well representative of the age of diabetes patients listed to Swedish primary health care. According to current data from the National Diabetes Registry of Sweden 23% of the 65,000 patients registered in primary health care are aged 30–59 years and 77% are 60 years or older.

$VO_{2\,max}$ did not change in any of our groups. Walker et al. have reported improved fitness, expressed as estimated $VO_{2\,max}$, following a period of walking for 1 h/day on 5 days weekly during 12 weeks, in postmenopausal women with and without type 2 diabetes [19]. The amount of exercise, in our study, may have been insufficient for increasing respiratory fitness. The exercise levels required to improve glycaemic control may be lower than those required for improved respiratory fitness. This does not necessarily exclude the possibility of improved glycaemic control even though respiratory fitness did not improve.

Most walks were not supervised and the patients recorded only the time spent on each exercise session, not the intensity. This lack of exactness concerning exercise intensity is a weakness of our study. At the same time it reflects the conditions and resources available in primary health care, where most Swedish type 2 diabetes patients receive counseling on lifestyle matters.

HDL and LDL cholesterol were equally improved in the exercise group and in the control group. This could not be explained by alterations in medication. Some factor, other than exercise, probably accounts for this improvement. Our study was conducted between April–September and the improved HDL and LDL cholesterol levels may have been a result of a seasonal change. Other authors have reported improved lipid levels during the summer months [20].

The SBP difference between the exercise and the control groups on inclusion in the study raised the question whether this difference was a reflection of differing traditions of treatment for hypertension between the two primary care practices where the patients were listed. A survey of the records of 280 and 290 patients, respectively at the two primary care practices, revealed no significant differences in blood pressure levels between the two. Mean SBP ($\pm$S.D.) were 148.6 (19.9) and 146.3 (19.0), respectively (unpublished data).

The nine patients in the intervention group who did not increase their level of physical activity probably illustrate the difficulties of obtaining adherence to exercise programs pointed out by other authors [12–14]. To three of those patients three walks per week was less exercise than they did before the study started and they had not altered their exercise habits after 4 months. They could therefore not be expected to improve their risk factors in this study. Thus, 6 out of 26 patients did not reach the relatively modest exercise goal of this study, which was conducted in a primary care setting at short distances from the homes of the patients. No special utensils were required for exercising. We believe that exercise alternatives that are easily available would provide the best opportunities for the establishment of regular exercise habits.

A separate analysis of the 17 patients in the intervention group who increased their amount of exercise seems justified. It resembles a clinical situation where some patients manage to adhere to lifestyle recommendations and some do not. No improvement of glucose control could be discerned in this group, as was also the case for the entire intervention group. However, systolic and diastolic blood pressures and BMI were decreased to statistically significant degrees.

The United States Centers for Disease Control and Prevention recommend every US adult to accumulate the equivalent of 30 min of brisk walking on most, preferably all, days of the week [21]. Further studies are needed to elucidate whether or not this recommendation is consistent with improved glucose metabolism in patients with type 2 diabetes.

The intensity and frequency of exercise, at which effects on diabetes risk factors can be discerned, may not be possible to define in terms of absolute threshold values. It is also likely that the effect of increased regular exercise depends on previous exercise habits. The necessary amount of exercise can be expected to differ between individuals and to appear on a sliding scale between ‘‘no effect’’ and ‘‘maximum effect’’. Mortality studies have demonstrated that great health benefits can be achieved if unfit persons can improve their degree of fitness by participating in moderately vigorous exercise programs [22,23]. A sedentary person that starts exercising can be expected to improve his/her risk factors relatively more than a well-trained person who makes a corresponding increment in exercise intensity.

Motivation plays a central role in any medical consultation concerning lifestyle alterations. This is particularly true for the question of exercise in type 2 diabetes. The acute blood glucose reduction following a 30 min walk, demonstrated in a previous study [24], might provide motivational information to diabetes patients, many of whom may not be accustomed to exercising at all. When counseling a person with type 2 diabetes it may be tempting to suggest low intensity exercise for psychological reasons. It might be relevant to argue that ‘‘a little exercise is better than none and more is better than a little’’. At the same time it is important to provide the patient with such substantial information that he or she can set realistic goals for sustainable exercise habits.

Our results suggest that different levels of physical activity may be required for the improvement of the various risk factors in type 2 diabetes. Thus, in the patients who increased their exercise levels a significant decrease of SBP and DBP as well as BMI and total plasma cholesterol levels occurred, without a corresponding improvement of glycaemic control. More detailed knowledge of the specific effects on diabetes risk factors that can be obtained from regular physical activities adds to the credibility of clinical advice concerning the role of regular physical training as an important part of the management of type 2 diabetes.

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