Effect of aerobic exercise on glycosylated hemoglobin and VO2max values in patients with type 2 diabetes

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ABSTRACT

Background/aim: The changes of glycosylated hemoglobin Hb A1c and VO2max values have been considered as an important marker of glucose control over time. Exercise training intervention is underused in the management of type 2 diabetes mellitus in East Africa. The aim of this study was to investigate the influence of aerobic exercise program on HbA1c and VO2 max values in type 2 diabetic patients. Material and methods: 30 patients with type 2 diabetes, their ages range from 40 to 70 years old enrolled in the study were randomly assigned into 2 groups: control and study. HbA1c and VO2 max were measured for all participants pre and post treatment period. Results: There was a significant difference between the two groups in the HbA1c and VO2 max assessment after treatment. Conclusion: We suggest additional aerobic exercise training is a necessary adjunct to the treatments of type 2 diabetes to improve glycemic control and quality of life in patients with type 2 diabetes.

KEY WORDS: Exercise, Physical activity, Type 2 diabetes, Glycemic control.
INTRODUCTION

Diabetes mellitus is a metabolic disorder of multiple etiology characterized by chronic hyperglycemia with disturbances of carbohydrate, fat, and protein metabolism resulting from defects in insulin secretion, insulin action, or both (1). The estimated number of people with diabetes worldwide is expected to rise from 171 million in 2000 to 366 million in 2030 (2). Prevalence of diabetes in adults worldwide was estimated to be 4% in 1995 and to rise to 5.4% by 2025 (3). In addition, diabetes is associated with increased morbidity and premature death from cardiovascular disease, including stroke and myocardial infarction (4). The increasing rate of diabetes prevalence appears to be strongly related to lifestyle changes brought on by economic transition, industrialization, and globalization (5).

For many years, physical activity has been along with diet and medication considered fundamental in the treatment of diabetes (6), and based on a number of large randomized controlled trials, physical activity and exercise have recently been recommended to prevent and treat diabetes according to ADA (7) ACSM (8, 9) and other national guidelines (10).

Moreover, considering the potential adverse effects attributed to some drugs (11, 12), the clinical importance of physical activity, as well as that of therapeutic education (13) is even increasing.

However, the terms “physical activity” and “exercise” denote two different concepts (14). “Physical activity” refers to any bodily movement produced by skeletal muscles that results in an expenditure of energy (expressed in kilocalories) and includes a broad range of occupational, leisure and daily activities. “Exercise” refers to planned or structured physical activity. It involves repetitive bodily movements performed to improve or maintain one or more of the components of physical fitness: aerobic capacity (or endurance capacity), muscular strength, muscular endurance, flexibility and body composition. Thus, not only the role of physical activity, but in addition that of an exercise has long been recognized in the treatment regimen of type 2 diabetes patients, which results in a variety of physiological and metabolic adaptations (15).

A considerable amount of literature has been published recently to attempt to identify safe and effective exercise programs for this section of population. The most clinically relevant recent advances related to people with type 2 diabetes and the following recommendations were proposed in the last ADA statement (15). Summarizing the evidence from these reports relating to exercise recommendations, it appears that the most important factor is to design a program for individuals that will provide the proper amount of exercise to attain maximal benefit at the lowest risk.

In the past, there have been numerous minor studies on the effects of aerobic exercise on patients with type 2 diabetes and offering distinct findings. Exercise interventions were generally found to reduce glycated hemoglobin (HbA1c) even though more recently the effects on other parameters, such as carnitine, were investigated (16).

Some meta-analysis has been particularly useful in summarizing and analyzing prior research. In a meta-analysis, reviewing exercise intervention of at least 8 weeks of supervised exercise in type 2 diabetic individuals (17), regular aerobic exercise was seen to have a statistically and clinically significant effect on VO2max, and as reflected in HbA1c this kind of intervention improve glycemic control while having little effect on body weight, as shown in another meta-analysis on exercise interventions including 14 studies: 12 with aerobic exercise and 2 with resistance exercise as the form of intervention (18).

In a more recent meta-analysis (19) on seven studies using aerobic exercise as the form of intervention, the reduction in HbA1c was confirmed in conjunction with a statistically significant reduction of about 5% for LDL-C, whereas no statistically significant improvements were found for TC, HDL-C, TC/HDL-C or TG.

As seen from the aforementioned meta-analysis, we could say that the effects of aerobic exercise on HbA1c (the major marker of glycemic control), are well established. However, the most interesting question to be addressed, it is not the effect of aerobic exercise itself but the effects of exercise intensity, specifically, vigorous exercise versus moderate physical activity (typically walking).

The effect of exercise intensity was also recently evaluated on insulin sensitivity: three randomized controlled trials (20–21) and a review (22) compared the effects on insulin sensitivity of different intensities of aerobic exercise training with the same total energy expenditure on exercise. We can conclude by stating that interventions with more vigorous aerobic exercise programs resulted in greater reductions in HbA1c, greater increase in VO2max and greater increase in insulin sensitivity.

MATERIALS AND METHODS

30 patients between 40 and 70 years of age referred to the outpatient clinics, who were diagnosed with type 2 diabetes, were enrolled in the study. Patients with severe diseases and advanced diabetic complications such as neuropathy or retinopathy, history of cerebrovascular incidents, orthopedic problems, cancer, age >70, < 40 years, taking insulin, BMI > 35, A1c value >11, surgical interventions in the brain, upper or lower limbs were excluded from the study. Written informed consent was obtained from each patient.

Age, sex, weight, height, body mass index duration of disease and educational levels of the patients were recorded. The study was designed as a prospective randomised clinical trial.

Patients were randomized into 2 groups, each group consisting of 15 patients. In group 1 was the control group and was treated through diet control and medication and didn’t perform any exercise and group 2 was the study group and was treated through the same selected program of diet control and medication in addition to designed aerobic exercise training program.
All treatments were applied for 3 days a week, 40 min, at a moderate intensity and 50-80% of VO2max by 50% of maximum heart rate for 12 weeks by the same physician. HbA1c and VO2 max were recorded for all subjects at baseline and after 12 weeks.

Statistics

A statistical package program was used to evaluate the data obtained from the study. Descriptive statistical methods (frequency, proportion, mean, and standard deviation) were used in the evaluation of research data as well as the Kolmogorov–Smirnov distribution test for examining normal distribution. The Pearson chi-square test was used in comparing qualitative data. In comparing quantitative data, the unpaired samples t-test was used in intergroup comparison of parameters. The Paired samples t-test was used for intragroup comparisons. The results were calculated at the 95% confidence interval, $P < 0.05$ significance level and $P < 0.01$ advanced significance level.

RESULTS

No study participant left the research project for any reason. No side effects or complications were observed during the treatment. Baseline characteristics of the patients are shown in Table 1. The control group included 5 males and 10 females patients, and the study group included 6 males and 9 females patients. The average age was $50.33 \pm 8.16$ years in the control group and $54.8 \pm 10.07$ years in the study group. The average weight was $86.53 \pm 8.58$ kg in the control group and $88.97 \pm 7.1$ kg in the study group. The average height was $166.07 \pm 6.92$ cm in the control group and $168.63 \pm 7.37$ cm in the study group. The average BMI was $31.33 \pm 1.78$ kg/cm² in the control group, and $30.99 \pm 1.49$ kg/cm² in the study group. No statistically significant difference was found between the 2 groups in terms of age, sex, height, weight, and BMI ($P > 0.05$).

The decrease in the HbA1c for the control group at the end of the treatment was statistically not significant in comparison to baseline ($P > 0.05$), as shown in Table 2.

The decrease in the HbA1c for the study group at the end of the treatment was statistically significant in comparison to baseline ($P < 0.05$), as shown in Table 2.

The decrease in the HbA1c for the control group at the end of the treatment was significantly lower than in the bilateral group ($P < 0.05$), as shown in Table 2.

The increase in the VO2 max for the control group at the end of the treatment was statistically not significant in comparison to baseline ($P > 0.05$), as shown in Table 3.

The increase in the VO2 max for the study group at the end of the treatment was statistically significant in comparison to baseline ($P < 0.05$), as shown in Table 3.

The increase in the VO2 max for the control group at the end of the treatment was significantly lower than in the study group ($P < 0.05$), as shown in Table 3.

DISCUSSION

Treatment of patients with type 2 diabetes aims to improve the glycemic control, HbA1c, VO2 max and to improve ADL which in turn improves the quality of patient life and care. Consequently, the society will benefit from increasing their working hours.

### Table 1. Baseline characteristics of the patients. 

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control (n = 15)</th>
<th>Study (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years, mean ± SD)</td>
<td>50.33 ± 8.16</td>
<td>54.8 ± 10.07</td>
<td>.193</td>
</tr>
<tr>
<td>Weight (kg, mean ± SD)</td>
<td>86.53 ± 8.58</td>
<td>88.97 ± 7.1</td>
<td>.405</td>
</tr>
<tr>
<td>Height (cm, mean ± SD)</td>
<td>166.07 ± 6.92</td>
<td>168.63 ± 7.37</td>
<td>.334</td>
</tr>
<tr>
<td>Body mass index (kg / cm², mean ± SD)</td>
<td>31.33 ± 1.78</td>
<td>30.99 ± 1.49</td>
<td>.576</td>
</tr>
<tr>
<td>Sex (male / female)</td>
<td>5 /10</td>
<td>6/9</td>
<td>.705</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD or number of patients. *P < 0.05.
Aerobic exercise training has emerged as an approach that leads to positive outcomes in addressing HbA1c and VO2 max after type 2 diabetes. However, studies have not demonstrated improvements in all patients using current outcome measures. Furthermore, the rationale for using this type of training has been incompletely explained.

HbA1c and VO2 max were measured for all participants pre and post treatment period in the present study.

We detected significant increase in VO2 max at the end of the treatment in the study group, at the end of treatment in comparison to baseline.

We detected significant decrease in HbA1c at the end of the treatment in the study group, at the end of treatment in comparison to baseline.

Mourier et al. (23) designed a study of 21 subjects were enrolled (10 exercise and 11 controls) required 39 weeks sessions on cycle ergometer until training at 75% of VO2 peak was attained. The results, based on the 10 completers showed a statistically significant elevated effect versus the sedentary control group on the following parameters: increase in VO2peak, decrease of HbA1c%, decrease of subcutaneous and visceral abdominal fat, increase of mid-tight muscle.

Boule et al. (18) who designed Seven studies, with nine comparisons and a total of 266 subjects with type 2 diabetes The mean frequency was 3.4 sessions/week, with mean duration of 20 weeks, mean session duration of 49 min and the mean intensity of 55% VO2max. Exercise intensity was a better predictor than exercise volume of the difference in HbA1c and VO2max between the exercise and the control group.

The decrease in HbA1c in exercise group is clinically significant, since a reduction in HbA1c by 0.6% was shown to reduce the risk of microvascular complications by 25% (24). This finding is in agreement with Ronnemaa et al., who reported four months of physical exercise decreased HbA1c from 9.6 to 8.6% (25).

Our result is in line with the reported rate by Boule and his colleagues who included 12 aerobic training studies in a systematic review of structured exercise interventions, and reported that post intervention A1c levels were significantly lower in exercise groups than control groups, while no significantly greater change in body mass index was found (17).

Furthermore, our result is in consistent with the statistically significant reduction in A1c that was found in a metaanalysis of Kelly and Kelly (26) and findings of Alam et al. suggesting a significant decrease in A1c level after a 6 month supervised aerobic exercise (27).

Our findings also confirm the report of Sigal et al. (0.59 percentage point reduction) in a well designed DARE trial with a large sample size of 251 participants.10 In an Indian population, Shenoy et al. have reported a similar decline in the average A1c values for aerobic exercise group after 16 weeks training, which is in the target goal according to ADA (28).

### Table 2. HbA1c.

<table>
<thead>
<tr>
<th>Motor assessment score</th>
<th>Control (n = 15)</th>
<th>Study (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>8.57 ± .61</td>
<td>8.79 ± .42</td>
<td>.262</td>
</tr>
<tr>
<td>At the end of the treatment</td>
<td>8.53 ± .58</td>
<td>7.78 ± .67</td>
<td>.003**</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD.

### Table 3. VO2 max.

<table>
<thead>
<tr>
<th>Motor assessment score</th>
<th>Control (n = 15)</th>
<th>Study (n = 15)</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>24.65 ± 5.24</td>
<td>25.17 ± 6.16</td>
<td>.803</td>
</tr>
<tr>
<td>At the end of the treatment</td>
<td>25.19 ± 5.16</td>
<td>32.47 ± 6.53</td>
<td>.002**</td>
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</table>

Data are presented as mean ± SD. **P < 0.01.
In another study, they showed a significant improvement in A1c value with only 8 weeks of resistance or aerobic training, whereas previous short-term programs (i.e. 4-6 week) found no significant reduction in A1c values (29).

In addition, Marcus et al. reported a reduction of 0.31% after a 16-week aerobic exercise, whereas their subjects in a combined aerobic and resistance group showed additional decrease in A1c value and the other parameters such as BMI (30).

In the present study, we didn’t aim to compare the exercise types (aerobic, resistance or combined training), as well as duration or intensity of exercise program that may influence A1c changes. However, compared with resistance exercise, aerobic training may lead much faster to achieve lower A1c levels. Besides, patients would have more adherence to continue these activities by themselves after the period of study even as walking, because such activities are not dependent on equipment and knowledge of exercise techniques (31).

Future intervention studies need to be designed to compare the effects of high-intensity interval training and moderate aerobic exercise on HbA1c and VO2 max levels, as well as other risk markers of T2DM, such as lipid profile, insulin sensitivity, glucose tolerance, and aerobic capacity. This should allow improved management of those with, or at risk of T2DM.

In conclusion, aerobic exercise training has emerged as an approach that leads to positive outcomes in addressing type 2 diabetes. So; aerobic exercise training is a necessary adjunct to the treatments of type 2 diabetes to improve the glycemic control in patients with type 2 diabetes.

Conflicts of Interest: The authors declare that there is no conflict of interest in this study. The manuscript has been read and approved by authors.

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