Effects of a 12-week aerobic training on glycemic control in type 2 diabetes mellitus male patients

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Type 2 diabetes mellitus (T2DM) is a metabolic disease affecting the metabolism of carbohydrates, proteins and lipids due to initial insulin resistance at the cellular levels followed by progressive insulin deficiency. The consequence of that is gradual increment of serum blood glucose, which binds independent of the enzymes to the proteins in the blood, as well as the tissue proteins; one of these measurable protein is the red blood cells hemoglobin, which enabled the clinician to assess diabetes control by the percentage of glycosylation of this protein every 3 months, which correlates well to the other tissue involvement and the disease control. Diabetes-related complications are related to the micro- and macro vascular derangement due to glycosylated protein in these vessels tissues, leading to nephropathy, retinopathy, neuropathy, myocardial infarction, stroke, and death found to be more frequent and seen at earlier age.[1] Estimate of global T2DM indicates that diabetes now affects 246 million people worldwide, and is expected to affect approximately 380 million by 2025, representing 7.1% of the world adult population.[2] The Kingdom of Saudi Arabia (KSA) has one of the highest prevalence of T2DM worldwide since the percentage of diabetes mellitus is estimated to be 23.7% of the overall population.[3] Structured exercise interventions have been shown to be at least as efficacious as the pharmaceutical agents for improving glycemic control.[4] Most people with T2DM do not do enough physical activity to benefit their health, and in comparison with the general population, people with diabetes experience a higher frequency of relapse to sedentary behavior.[5] Our primary objective is to investigate the effects of supervised aerobic exercise on glycemic control, the glycosylated hemoglobin (HbA1c) level, as well as the effect on medication doses adjustments, before and after the study in T2DM Saudi male patients. Our secondary objective was to assess its effect on their lipid profile.

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This study was performed as collaboration between the Department of Physical Education at the King Fahd University of Petroleum and Minerals (KFUPM) and King Fahd Hospital of the University (KFHU), University of Dammam from July to October 2012. Fifty male patients registered in the diabetes clinic records at KFHU, Al-Khobar, KSA were randomly selected using the stratified random sampling and pooled in the study for inclusion and exclusion criteria filtering. Twenty-four patients diagnosed with T2DM, age range of 25-55 years (43.86±10.3 years) were selected to be enrolled in the study. Their medication profiles were documented at the beginning and at the end of the program from their medical files. Diet and lifestyle of patients were not controlled by the study. We excluded patients known to have cardiovascular disease, hypertension, retinopathy, neuropathy, bronchial asthma, arthritis, and morbidly obese. We also excluded those who were involved in any physical exercise program or subjects living very far from KFUPM, the site of the physical exercise. After initial screening and baseline assessments, all 24 subjects were randomly allocated to 2 different groups namely; intervention group (n=12) and control group (n=12). The exercise group subjects signed a written informed consent after being informed regarding all possible risks associated with exercise training programme. Comprehensive clinical examination, as well as laboratory testing and fitness assessment were performed for each subject before participation in the exercise training programme, as well as at the end of the programme. All subjects went through one week of familiarization before the start of the programme. After a few weeks, 2 subjects withdrew from the intervention group due to personal reasons. Only 10 subjects completed the 12 weeks of the exercise training programme.

The exercise training programme was given at the fitness centre of KFUPM. The entire duration of the 12-week exercise training programme was closely supervised by 2 qualified personnel. Attendance was verified every day through direct observation and documented records. Exercise data were recorded every day on a chart. The exercise session includes running or walking on treadmill, and cycling on bicycle ergometer. We provided 10 minutes of warming up period and 10 minutes of cooling down period in each exercise session. Each participant had to check his blood glucose levels before and after the exercise. Subjects performed exercise 3 times per week on alternate days with no more than a 2-day gap. The training was designed to provide an alternate day as a replacement for missed training sessions during the week. Subjects started with training intensity of 40-50% of maximum heart rate

(MHR), and thereafter, the intensity and duration were increased every 4 weeks. Subjects performed aerobic exercise on treadmill and cycle ergometer for 15-20 minutes for 2 weeks with 30-40 % of MHR as recommended by the American Diabetes Association. All the measurements were evaluated after 12 weeks of the training programme to assess the clinical, glycemic and metabolic effects.

No adverse complications were occurred during the training programme, except for temporary muscle soreness. The changes in the oral hypoglycemic medication doses for each patient before and after the completion of the exercise were recorded on their medical files.

The statistical analysis was performed using the Statistical Package for Social Sciences version 17.0 for Windows (SPSS Inc, Chicago, IL, USA). Normality of distribution was assessed by the Kolmogorov-Smirnov test. The Mann-Whitney test was used to assess the difference between the 2 groups after 12 weeks of aerobic training. Statistical significance was assumed for *p*-values <0.05. Chi square was used to compare hypoglycemic doses before and after 12 weeks of exercise programme.

Table 1 summarizes the effects of exercise on the 2 groups with regard to HbA1c, lipid profile components, daily blood glucose, and reviewed if there is reduction in the hypoglycemic agents between the 2 groups. The HbA1c values in the intervention group were reduced significantly after the 12 weeks of supervised aerobic training programme as compared to control group. Furthermore, blood sugar levels in the intervention group showed significant reduction following the exercise session (t [9]=5.93, *p*=0.001). Therefore, this study establishes the fact that aerobic exercise is effective in controlling the glycemic status of type 2 DM patients. We found a significant reduction of dose in medications after 12 weeks of training programme in intervention group, which might be explained by their significantly improved glycemic control and increased insulin sensitivity, thereby reducing the doses of hypoglycemic medications in the intervention group.

Our findings was supported by a number of studies, which reported reduction or significant improvement in glycated hemoglobin following aerobic training programme.[4,6,7] Improvement in HbA1c was found to be independent of duration of T2DM and dietary intake. Our findings assume more significance, as we did not control the diet of subjects. This could be one reason why we did not get any significant improvement in lipid profiles of the intervention group. Moreover, the present study did not reveal any significant differences in body weight and body mass index since this was not a target of the study, and secondly, there would be increase in the muscle mass explaining the absence of significant weight loss in addition to the relatively short period and

Table 1 - Effects of exercise on the biochemical levels and hypoglycemic medication doses in subjects included in a study at the Department of Physical Education, King Fahd University of Petroleum and Minerals, Dhahran, Kingdom of Saudi Arabia.

Variables	Intervention group		Control group		*P*-value
Glycosylated hemoglobin					0.007
Baseline	8.3	(6.5-10.5)	7.9	(6.5-13.20)	
End of 12th week	7.4	(6.7-9.4)	8.95	(7.2-13.5)	
Total cholesterol					1.00
Baseline	195	(190-206)	197	(120-286)	
End of 12th week	203	(146-220)	227.5	(109-291)	
Low-density lipoproteins					0.592
Baseline	120	(87-138)	125.5	(65-219)	
End of 12th week	124	(91-249)	147	(54-222)	
High-density lipoproteins					0.902
Baseline	41	(32-71)	37	(10-62)	
End of 12th week	42	(31-68)	34.5	(26-60)	
Triglycerides					0.261
Baseline	161	(64-260)	142	(94-402)	
End of 12th week	108	(57-204)	151	(65-900)	
Daily blood glucose					0.001
Pre-exercise session	200.28 ± 36.37				
Post-exercise session	143.28 ± 35.12				
No change in medication dose, n (%)	30	(3)	100	(12)	
Decrease in medication dose, n (%)	70	(7)	0	(0)	0.001

Data are shown as median (range), and mean ± standard error low intensity of the exercise. This is important from a point of view that exercise programme should not be aimed at weight loss in order to have beneficial effects on HbA1c. Total Cholesterol levels did not change after 12 weeks between the intervention and control group. There was no statistical significant difference between the intervention and control group's median total cholesterol, low-density lipoproteins (LDL), high-density lipoprotein (HDL), and triglycerides.

Our results for blood lipid profiles were surprisingly contrary to several studies, which had shown improvement blood lipid profiles along with improvement in glycemic control.[4,6] There could be following possible explanations; first, the intensity of exercise was more or less moderate throughout the duration of training programme, especially when the patient exercised on cycle ergometer. The second possible reason could be that patients might have become more complacent in their daily activity routine in order to counter balance the exercise performed at our supervised training programme. Third, as we did not control the diet of the intervention group they continued to have their usual meals, which might have high calorie contents.

In general practice, people are not motivated towards regular exercise; therefore careful planning was needed to increase the intensity slowly over a period of time. We gave participant's run in phases of weeks to acclimatize to exercise. The intensity and duration of exercise was planned for each patient individually and was increased over a period of time. This leads to 100% compliance to the exercise programme, and no participant withdrew the study giving exercise as an excuse. There was also marked improvement in blood sugar levels after the exercise session. Blood sugar was significantly reduced in patients after the exercise session. Our subjects showed excellent adherence to exercise due to self-motivation, as well as effectiveness of the planned supervised exercise programme. We did not control the diet and life style of any patient during the 12 weeks of study. We did not try to control the diet and activity at home. This was deliberately done to see if uncontrolled diet and lifestyle could affect the results of study. Yet, there was significant improving in intervention group in glycated hemoglobin regardless of the diet control. Although, this might have affected the lipid profiles of the subjects as there was no significant difference observed between the 2 groups.

The limitations of this study include having small number of the patients involved in the study since we recruited only males with specific age group, and excluded any patient with medical or physical disorders that might harm the participants during the exercise. Another limitation is that, since the study is not blinded there is a risk of bias in affecting the results from the sides of the subjects and the trainers. However, none of the researcher was involved in medications adjustment, as well as the medical management of the patients, also their physicians were not involved in the study.

In conclusion, the 12 week closely supervised aerobic training showed to be effective in improving the glycemic control in T2DM male patients, manifested by improved HbA1c and blood sugar level post-exercise sessions collectively might result in reduction of the doses of hypoglycemic agents. Regular aerobic exercise is an effective component of treating patients with T2DM as it improves the glycemic control, and increased insulin sensitivity, enhancing the reduction in their hypoglycemic medications requirement.

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