Impact of an Aerobic Exercise Programme on Blood Glucose and Depression in Patients with Type 2 Diabetes in Kano.

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Abstract

Physical exercises are an essential part of the treatment regimen for diabetes and are administered for the different beneficial effects produced. This study explored the influence of moderate intensity treadmill running on fasting plasma glucose (FPG) and depression in sedentary patients with type 2 diabetes (T2D). The method used in this study consisted of the following: Forty patients (age: 37.9±5.87years) reporting at a diabetes out-patient clinic for routine follow-up care were randomised to a treadmill running group (n = 20) and a control group (n = 20). The exercise group engaged in a 12-week thrice weekly programme of treadmill running (duration per session = 30 minutes, progressed to 40 minutes) and the control group received information on ways to avoid complications in diabetes. In both groups, FPG was analysed using glucose oxidise assay while the Beck Depression Inventory was administered to assess depression. The result obtained at the end of the intervention indicated that there was significant improvement in FPG and depressive symptoms with the exercise. No significant changes were observed in these parameters over time in the control group (P>0.05). Comparison of group difference at follow up, shows a statistically significant difference in favour of the exercise training (P<0.05). It was concluded that the aerobic exercise programme was an important adjunctive therapy that elicited decrease in FPG and depressive symptoms in sedentary individuals with T2D.

Keywords: *Aerobic exercise, Depression, Fasting Plasma Glucose, Type 2 Diabetes*

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Introduction

Diabetes Mellitus (DM) is a complex and chronic endocrine disorder associated with massive human suffering and societal consequences due to severe morbidity, high mortality and huge healthcare cost (Javanbakht *et al*., 2011). The development of the disease is linked to the interplay of genetic, environmental and lifestyle factors (Rathmann, Scheidt-Nave, Roden & Herder, 2013) such as chronic physical inactivity and frequent consumption of high energy-dense food leading to accumulation of excess body fat (American Diabetes Association [ADA], 2010). There is high and escalating global prevalence in DM pertains mostly to type 2 diabetes (T2D) with over 90% of DM patients presenting with the type 2 variety globally (Maleckas, Venclauskas, Wallenius, Lönroth & Fändriks, 2015). The disease occurs in all nations regardless of level of development with the increasing number of people affected occurring at an alarming rate (Zimmet, Alberti & Shaw, 2001). Without doubt, diabetes has become a major public health issue (Spiegel & Hawkins, 2012) owing to this, there is very high and rising prevalence as well as the chronic hyperglycemia-induced complications resulting in detrimental effects on such vital organs as the eye, the kidney and the heart (ADA, 2010).

The chronic nature of diabetes necessitates routine, continuous and usually prolonged care which is a challenge with a potential to elicit significant psychological effects. Thus, diabetes is associated with an increased risk of developing psychological problems, such as anxiety and depression, which are thought to be two to three times more prevalent in people with diabetes than in those without the disorder (Harris, 2003). When depression accompanies diabetes, there is evidence of poorer glycemic control, decreased physical activity, higher obesity, and potentially more diabetes end-organ complications and impaired function (Penninx et al., 2002). There is also evidence that depression is associated with decreased adherence to oral hypoglycemic prescriptions (Ciechanowski, Katon & Russo, 2000), negatively impacts mood and undermines functioning (Von Korff, 1999).

Exercise is a vital therapeutic approach in glycemic control for people with DM (Jensen, Rustad, Kolnes & Lai, 2011) and a wide range of exercise modes is available for use to achieve an array of beneficial effects. In addition to the positive effects on glycaemic control and cardiovascular benefits, exercise has also been shown to enhance psychological health (Wipfli, Rethorst & Landers, 2008) in individuals with diabetes. Physical exercise, irrespective of mode or intensity, is an important correlate of psychological health with evidence linking psychological effects of exercise to antidepressant and anxiolytic effects as well as improved ability to cope with stress (Salmon, 2001). In spite of the significant influence of psychological well-being on diabetes self-care management, the focus on psychological problems, particularly in resource-poor nations, appears to be limited in the overall management of diabetes. Furthermore, research is scant in terms of the relationship between exercise and psychological well-being (van Son, Nyklícek, Pop & Pouwer, 2011). Therefore the study evaluated the effect of an aerobic training programme involving running on a motorised treadmill on glycemic control and depressive symptoms in patients with T2D.

Method

The study used a randomised controlled between-subject design and purposively recruited male and female patients with a diagnosis of T2D. All patients were on oral antidiabetic medication, had moderate depression (Beck Depression Inventory [BDI] score of between 20 and 28) and were attending the Outpatient Diabetes Clinic of the Murtala Muhammad Specialist Hospital (MMSH). Furthermore, participants were of similar ethnic and socio-economic backgrounds with fasting plasma glucose ≥7 mmol/L. The study was conducted in conformity with principles outlined in the Helsinki Declaration with ethics approval granted by the Kano State Hospitals Management Board. All participants received detailed information about the procedures and were notified of risks associated with the exercise. Participants then signed written informed consent for participation in the study with anonymity maintained by storing coded data in a computer without reference to their identity. In addition, participants were at liberty to withdraw at any point during the course of the study.

Exclusion criteria were high blood pressure or any form of cardiovascular disease, macro- and micro-vascular diabetic complications, cardiothoracic or abdominal surgery within the previous 6 months, history of spine, hip, knee and/or ankle fractures, weakness and/or deformities of the lower limb. A comprehensive medical screening was conducted and clearance to participate in the exercise was given by a physician prior to randomisation. Sample size was based on improvement in mental health following treadmill walking from a previous study (Maharaj & Nuhu, 2015a) considering an attrition rate of 10% with z for 1-power=0.84 and z for alpha double sided=1.96 yielding an adjusted sample size of 20 participants in each group.

Anthropometric Measures and Blood Chemistry Analyses

Body mass and height measurements were carried out in accordance with standard protocols (Stewart, Marfell-Jones, Olds & De Ridder, 2011) using a calibrated standardised digital weighing scale (Tanita Corporation, Tokyo, Japan) and a portable stadiometer (*Seca*® Company, Hamburg, Germany) respectively. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m).

Blood chemistry analysis was conducted following an overnight fast of at least twelve hours with venous blood drawn from patients by a certified technician pre and post intervention using venipuncture. The blood was transferred into cold tubes containing sodium fluoride and centrifuged to separate plasma from blood cells. This was stored at −70°C for later analysis of glucose by glucose oxidase assay (TECO Diagnostics, California, USA).

Assessment of Depression

The Beck Depression Inventory II (BDI-II), a self-assessment instrument consisting of 21 items, was used to measure participants' level of depression. It is one of the most frequently used measures of depression globally with a high internal consistency of 0.9 and retest reliability of between 0.73 and 0.96 (Wang & Gorenstein, 2013). Study participants were interviewed using the Hausa translated version of the inventory to report feelings consistent with their condition pre and post intervention.

Randomisation

Following the capture of relevant baseline data, patients were randomised electronically into two parallel groups using the [2]Simple Interactive Statistical Analysis allocator. The control group continued with routine medical treatment (use of oral hypoglycaemic medication [metformin, glimepiride or sulfonylurea] plus dietary counselling) and received information about diabetes and related complications. The experimental group received the same routine medical intervention as the control but also performed treadmill running. All participants were asked to maintain their regular diet, medication, normal daily activities and lifestyle throughout the intervention period.

Exercise Intervention

The exercise involved running on a motorised treadmill (Bonte Technology, Zwolle, The Netherlands). Prior to the intervention, participants had three practice sessions to familiarise themselves with the equipment and exercise by running on the treadmill (at low to moderate speed). Each exercise session, for the training intervention, began with a 10-minute warm up and ended with a 10-minute cool down both at 2 km/hr. The speed used for the aerobic phase was based on moderate range of 40-60% of participants' age-predicted maximum heart rate using the Karvonen formula (Karvonen, Kentale & Mustala, 1957) which corresponded with a treadmill speed of 3.5 to 6.5 km/hr at an inclination of 0%. A heart rate monitor (Polar Electro Oy, Kempele, Finland) was used to guide the intensity of the exercise which was progressed at the 7th week from 30 to 40 minutes per session and administered three times per week for 12 weeks. This progress in duration was necessary to ensure moderate intensity with decrease in exercise and

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[2] For detailed visit on the device: www.quantitativeskills.com/sisa/calculations/randmiz.htm

resting heart rates at the 5th to 6th week of training. Participants were monitored throughout each exercise session for subjective fatigue, respiratory distress and inability to maintain a steady gait. Exercise safety was assessed based on the occurrence of symptoms such as nausea and/or dizziness during and after each exercise session or at any time during the study period or after the completion of the study. The exercise training was conducted in the Gymnasium of the MMSH by licensed physiotherapists blinded to the objectives of the study, who took the measurements, monitored the exercise and recorded all pre and post intervention values. All data were reported at baseline and at the end of the 12-week intervention period.

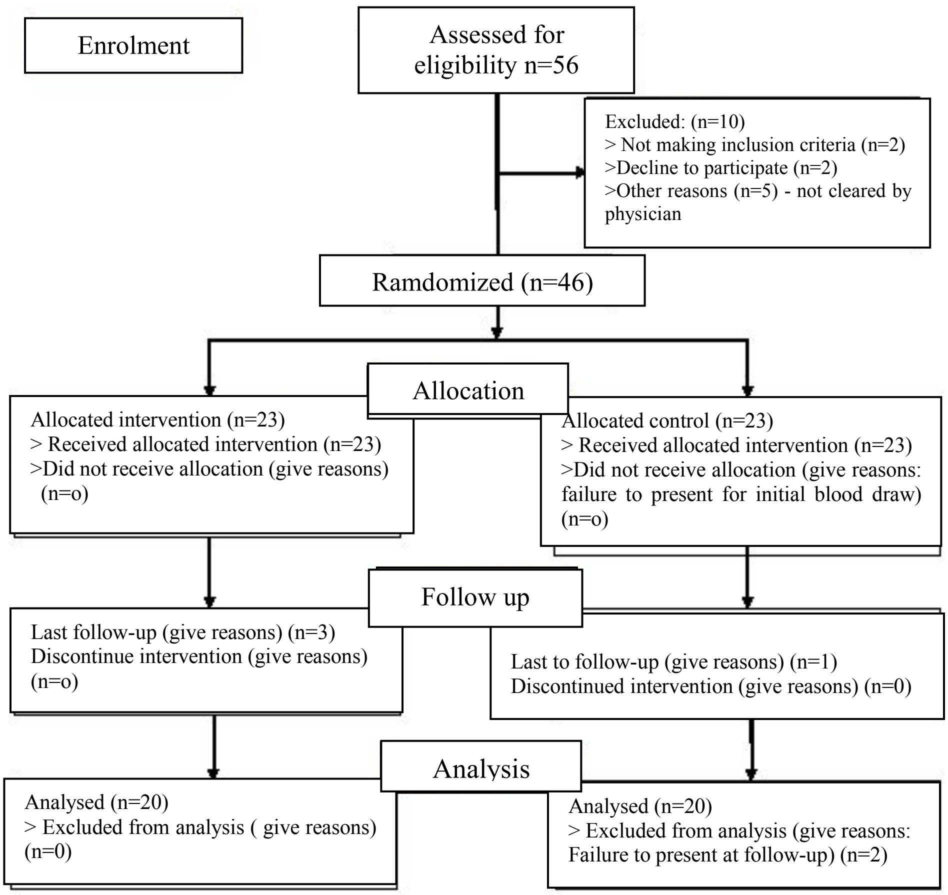

Figure 1: *Flow of participants from recruitment to the end of the intervention*

Statistical Analysis

Data were analysed using SPSS (Version 21.0, SPSS Inc., Chicago, IL, USA). Normality was assessed both numerically and graphically with all the assumptions for the relevant statistics being fulfilled. Differences between groups at baseline were tested using the independent samples *t*-test (for anthropometric and clinical characteristics) and a one-way analysis of covariance (ANCOVA) for between-group post-intervention differences with age, gender, duration of diabetes and baseline clinical characteristics (FPG, BMI and BDI scores) as covariates. All statistical tests were two-tailed with an alpha level of 0.05 or less indicating statistical significance.

Results

A total of 40 patients presenting with T2D participated in the study. The participants were mainly married with a mean age of 37.9±5.87 years and a mean duration since diagnosis of diabetes of 2.83± 1.59years (Table 1). At baseline, the two groups were similar in Fasting Plasma Glucose (FPG) and the Beck Depression Inventory (BDI) scores (p>0.05) (Table 1). To detect differences between group means post-intervention, the study adjusted for age, gender, duration of diabetes and pre-intervention values for FPG, BMI and BDI scores (Table 2).

Table 1: *Participants' socio-demographics and clinical characteristics at baseline.*

Variable	All participants N = 40	Exercise Group N = 20	Control Group N = 20	t	*P*
Sex, n (%)					
Male	19 (47.5)	8 (40.0)	11 (55.0)	-	-
Female	21 (52.5)	12 (60.0)	9 (45.0)	-	-
Marital status, n (%)					
Married	34 (85.0)	16 (80.0)	18 (90.0)	-	-
Single	6 (15.0)	4 (20.0)	2 (10.0)	-	-
Age (years)	37.9±5.87	38.4±5.89	37.4±5.97	0.534	0.597
DSD (years)	2.83±1.59	3.05±1.61	2.60±1.57	0.892	0.378
Weight (kg)	73.1±12.0	72.0±10.7	74.3±13.4	-0.607	0.547
BMI (kg/m^2)	26.3±4.91	25.1±3.93	27.4±5.60	-1.496	0.143
FPG (mmol/L)	9.35± 2.61	9.51± 2.91	9.20±2.33	0.365	0.717
BDI score	22.6± 1.86	22.9±2.07	22.4±1.63	0.932	0.357

Abbreviations: DSD, duration since diagnosis of diabetes; BMI, body mass index; FPG, fasting plasma glucose; BDI, Beck depression inventory.

Values are means ± SD unless otherwise indicated

P values are for the independent samples t-test

Table 2: *Summary of ANCOVA data for outcome measures*

Variables	Rebound exercise			Control			*P*	η_p^2
	M	adj M	SD	M	adj M	SD		
Weight (kg)	70.7	71.9	10.1	75.0	73.9	13.2	0.000*	0.387
BMI (kg/m^2)	24.7	25.8	3.81	27.9	26.6	5.45	0.000*	0.369
FPG (mmol/L)	7.26	7.19	1.99	8.93	9.00	2.40	0.005*	0.213
BDI score	16.9	16.8	1.17	22.2	22.3	2.31	0.000*	0.758

Abbreviations: BMI, body mass index; FPG, fasting plasma glucose; BDI, Beck depression inventory; M, unadjusted mean; adj M, adjusted mean; SD, standard deviation; η_p^2, partial eta squared.

Values are means ± SD for post intervention
* indicates statistical significance.

Significant improvement occurred in FPG post exercise ($p<0.05$) with the control group showing no significant change over time ($p>0.05$) (Table 2). At follow up, between-group comparison indicated significantly lower FPG in the exercise group than in the control (Table 2). Decrease in BDI scores also reached statistical significance at the end of the intervention ($p<0.05$) with no change being observed in the control group ($p>0.05$) (Table 2). The values for the primary outcome measures for baseline and post intervention for the two groups are shown in figures 2 and 3.

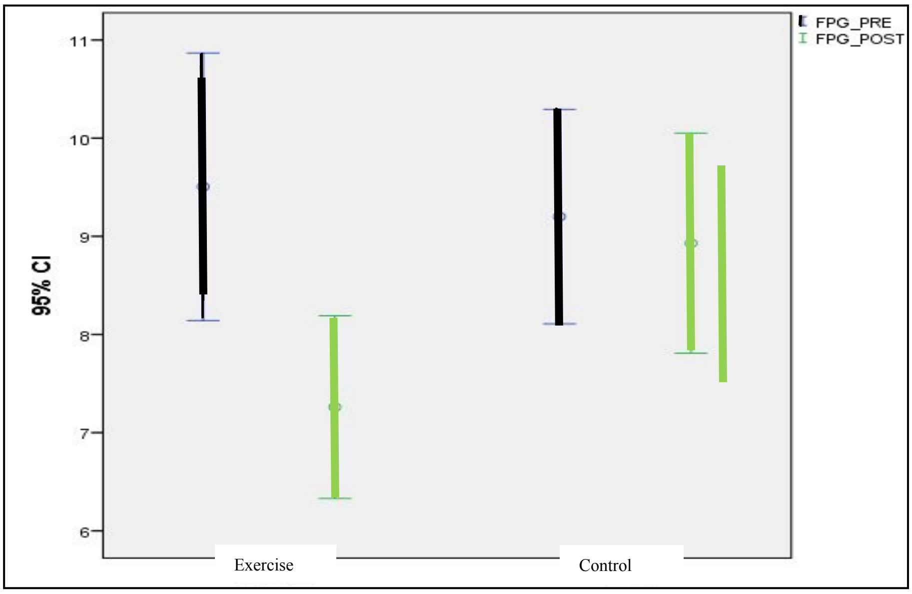

Figure 2: *Fasting plasma glucose (FPG) showing significant improvement*

for the exercise group. ■, FPG_PRE = pre-intervention FPG values; ■, FPG_POST = post-intervention FPG values; CI = confidence interval

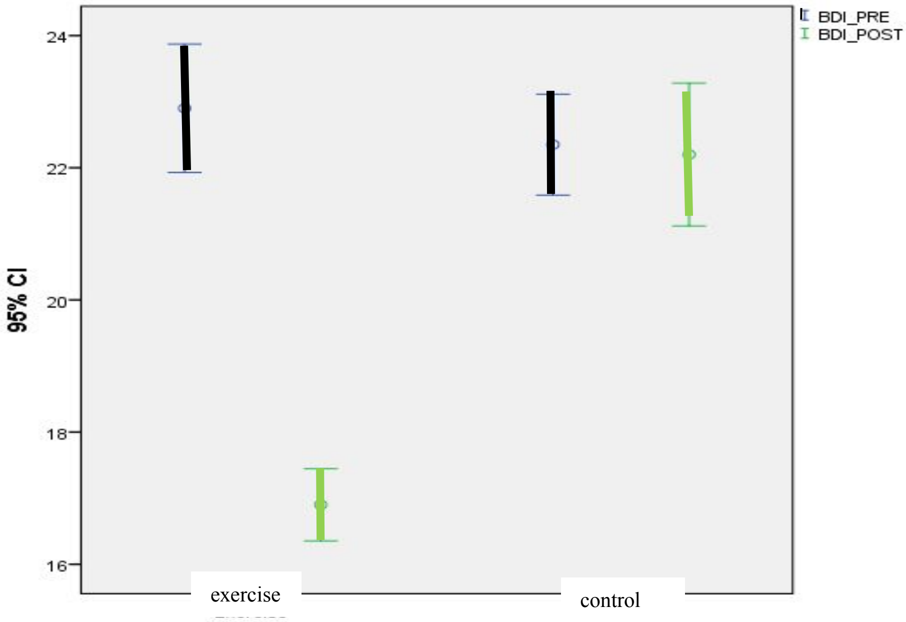

Figure 3: Beck Depression Inventory (BDI) scores showing significant improvement for the exercise group. ■, BDI_PRE = pre-intervention BDI scores; ■, BDI_POST = post-intervention BDI scores; CI = confidence interval

Discussion

This study explored the effect of a simple exercise programme on FPG and depression in patients with T2D. Improvements in these parameters were observed with the exercise post intervention. These positive changes are supported by previous research. Aerobic exercise administered in T2D patients resulted in significant reduction in FPG following three months of an aerobic training programme (Tomar, Hashim & Al-Qahtani, 2013) supporting the findings of this study. The current results also corroborate an earlier study (Maharaj & Nuhu, 2015b) and agree with the findings of Thomas, Elliott and Naughton (2006) who found that improvements in FPG correlated with significant decrease in BMI. Azimi, Marefati, Yousefzadeh and Mohajeri (2012) found significant improvement in FPG after eight weeks of cycle ergometer exercises and Thomas et al (2006) observed that improvement in this parameter was correlated with improvement in BMI. However, Bello, Adegoke and Emannuel (2011) found no significant effect of an aerobic exercise training on FPG and quality of life among individuals with T2D.

Low levels of physical activity are a major risk factor for chronic diseases and all-cause mortality and are associated with poor mental health (Campbell, Khan, Cone & Raisch, 2011). A positive correlation has been shown between consistently applied physical exercise and improvement in psychological well-being in T2D (Yavari, Abbasi, Vahidi, Najafipoor & Farshi, 2011) which is linked to decrease in stress, anxiety and depression (Dunn, Trivedi & O'Neal, 2001). Improved levels of fitness are also associated with more effective management of stress (Hassmen, Koivula & Uutela, 2000). The decline in depressive symptoms in the current study concur with the results of Abbas, Abbasi, Vahidi, Najafipoor and Farshi (2011) who found exercise training to elicit improvement in anxiety and depression in patients with T2D. Saiiaria, Moslehi and Sajadiyan (2011) also noted reduction in symptoms of depression following eight weeks of exercise training involving swimming. However, McKay, King, Eakin, Seeley and Glasgow (2001) found no effect of a physical activity intervention on symptoms of depression in type 2 diabetics contradicting our findings possibly due to partly the individualised nature of their intervention. The most likely explanation for the improvement in psychological well-being is physical activity-induced elevations in beta-endorphins which have been linked to a number of psychological and physiological changes such as exercise-induced euphoria which is related to alteration in mood and modulation in pain perception (Harber & Sutton, 1984). In addition, participants in the present study had social contact on the days exercises were administered. Therefore, the potential for gaining new experiences and capabilities or skills as well as interaction with new people possibly promoted well-being and mental health. Social relationships and support can increase commitment to a programme of regular physical exercise (Wilbur, Chandler, Dancy & Lee, 2003) enhancing quality of life and providing a buffer against adverse life events. This supportive relationship might have also contributed to decrease in symptoms of depression in the present study.

Conclusion

It was concluded that an exercise programme of running on a treadmill in patients with T2D can significantly improve FPG and symptoms of depression. Therefore, this exercise can be used as an adjunct with routine diabetic medication and dietary counselling in diabetes management.

Limitation of the Study

Some participants possibly had modification in medication or diet during the course of the intervention. Although they were requested to notify the researchers of such changes, there might be instances when these were not reported which could obscure post-exercise weight and BMI.

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Conflict of Interests

The author declares no conflicts of interest related to this article.

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