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Exercise Capacity in Type 2 Diabetes Patients: A Preliminary Investigation

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ABSTRACT: To enhance glycaemic control and improve general well being, physical exercises, in addition to drugs and/or diet are usually prescribed to patients with Type 2 Diabetes mellitus (T2D). Assessment of the capacity of these patients to exercise based on the simple Six Minute Walk Test (6MWT) is however not sufficiently documented. We compared the exercise capacities of 58 T2D volunteers matched with 60 non-diabetic individuals using the 6MWT on a 50-meter corridor. The self paced Six Minutes Walk Distance (6MWD) was our outcome measure and it was taken as a display of the exercise capacity of the participants. The diabetic participants had significantly lower ($t = 30.5046$, $P < 0.05$) 6MWD (318.57 ± 43.7, 95% CI = 306.74-329.25 m) than the non-diabetic sample (596. 43 ± 54.78, 95% CI = 582.57-610.29 m) indicating lower exercise capacity. In the diabetic sample, we found significant differences in the 6MWD of the age groups ($F = 9.4738$, $P < 0.05$) and body mass index classifications ($F = 3.3416$, $P < 0.05$) but not for the duration of their diabetes. We found exercise capacity to be lower in patients with T2D than non-diabetic subjects and this was found to be lower in T2D patients who were older and overweight or obese. Exercise prescriptions for T2D patients should consider these factors to avoid exercise induced eventualities.

Key Words: Functional capacity, 6 Minute Walk Test, Body Mass Index

INTRODUCTION

There are several modalities available for the objective evaluation of functional exercise capacity. Whereas the high techs provide a very complete assessment of all systems involved in exercise performance, others provide basic information but are low tech and are simpler to perform (ATS 2002). A review of functional walking tests concluded that the Six-Minute Walk Test (6MWT) is easy to administer, better tolerated, and more reflective of activities of daily living than the other walk tests (Solway *et al*, 2001). Additional advantages of such protocols are their simplicity, safety, negligible cost, and applicability to everyday activities (Arena *et al*, 2007). This test measures the distance that a patient can quickly walk on a flat, hard surface in a period of 6 minutes and it evaluates the global and integrated responses of all the systems involved during exercise such as the pulmonary and cardiovascular systems, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism (ATS 2002).

Functional capacity, exercise capacity, and exercise tolerance are generally considered synonymous and imply that a maximal exercise test has been performed and maximal effort has been given by the individual (Arena *et al* 2007). However, these terms also are used occasionally to express an individual's capacity to perform sub-maximal activities using one of a variety of tests (Arena *et al* 2007). Since most activities of daily living are performed at sub-maximal levels of exertion, the 6MWT may better reflect the functional

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exercise level for daily physical activities (ATS, 2002). The test may be used clinically to measure the impact of multiple co-morbidities, including cardiovascular disease, lung disease, arthritis, diabetes, and cognitive dysfunction and depression, on exercise capacity and endurance in older adults (Enright *et al* 2003).

Walking and other sub-maximal physical activities have usually been prescribed for diabetes patients to improve their glycaemic controls and quality of life. However, there is no readily available literature documenting the exercise capacities of these patients based on the 6MWT, a procedure that is closely similar to the exercise that they are being asked to perform. Also, previously, the 6MWT has been used as a measure of exercise capacities of patients, as well as a predictor of morbidity and mortality for a number of cardiac (Zugck *et al* 2000, Hamilton *et al* 2000) and pulmonary conditions (Solway *et al* 2001, Carter *et al* 2003) and in the elderly (Enright *et al* 2003) with diabetes receiving little attention. This is regardless of the evidence suggesting links between diabetes and some of these conditions (Suskin *et al* 2000, Movahed *et al* 2005). This study was hence conducted to investigate the exercise capacity of a sample of diabetic patients based on the 6MWT and to find out whether this was different from their non-diabetic match.

MATERIALS AND METHODS

Participants for this study were aged between 30 to 60 years. This study was a cross-sectional survey of 58 volunteers with Type 2 Diabetes Mellitus (T2D) attending the Diabetes Clinic of the Murtala Muhammad Specialist Hospital, Kano, Nigeria and 60 matched non-diabetic individuals. Of the 130 diabetic patients who were identified to be eligible for the study, only 58 of them agreed to participate giving us a precision of about +/-10% at 95% confidence level and 0.5 degree of variability (Israel 1992). Eligibility criteria for the diabetic patients included a diagnosis of T2D, not diagnosed of any cardiac dysfunction and hypertension, readiness to fill the Physical Activity Readiness Questionnaire (PAR-Q), willingness to give informed consent and participate in the 6MWT. These criteria were the same for the non-diabetic group except that they had to consent to two fasting plasma glucose tests to rule out diabetes. Diabetes was ruled out if two consecutive day's venous fasting plasma glucose value was less than 7.0mmol/l (126mg/dl) (WHO 2003). Participants were also asked if they were receiving any hypoglycaemic medication. Any prospective participant who answered at least one "yes" to any of the PAR-Q questions was exempted. The study protocol was approved by the Murtala Muhammad Specialist Hospital, Kano. Consent of the physicians attending to these participants as well as the informed consent of the participants was also sought and obtained following detailed explanation of procedures.

The 6MWT has demonstrated good reliability and validity as a measure of functional capacity (Hamilton *et al* 2000, Poole-Wilson 2000). The instrumentation for this study included a lap and countdown timer, two plastic stools to mark the beginning and turn around points and a light plastic chair that can be easily moved along the walk way. The participants were made to wear comfortable shoes and clothing for the test. All tests were performed on the corridor within the hospital. There was no warm up session before the 6MWT and the participant was allowed to sit in a chair to rest for a minimum of 10 minutes before the test began. The 6MWT was performed along a flat, straight, well ventilated corridor of about 50m long and free of obstacles. The patients made a u-turn at every 30m length of the corridor indicated with a piece of white plastic stool. A full lap was approximately 60m long. The 50m long corridor was marked with a bright coloured tape at every 3m to indicate an optional resting place for the participants (ATS 2002).

Participants instructions as adapted from ATS (2002) was thus: "The objective of this test is to walk as far as possible for 6 minutes. You will walk back and forth in this corridor. Six minutes is a long time to walk, so you will be exerting yourself. You will probably get out of breath or become exhausted. You are permitted to slow down, to stop, and to rest as necessary. You may lean against the pillars while resting, but resume walking as soon as you are able. You will be walking back and forth around the plastic stools. You should pivot briskly around the stools and continue back the other way without hesitation. Now I'm going to show you. Please watch the way I turn without hesitation." One of the researchers demonstrated the way to turn round the landmark without hesitation. "Are you ready to do that? I am going to use this counter to keep track of the number of laps you complete. I will click it each time you turn around at this starting line. Remember that the objective is to walk AS FAR AS POSSIBLE for 6 minutes, but don't run or jog. Start now, or whenever you are ready." The participants were notified of the remaining time every minute and they were encouraged to keep walking. Although we did not have any of these, the 6MWT was meant to be stopped immediately any of these occurred: chest pain, intolerable dyspnoea, leg cramps, staggering and pale appearance.

RESULTS

A total of 118 participants comprising 58 diabetic subjects matched with 60 non-diabetic subjects participated in the study. Our diabetic and non-diabetic participants aged 47.64 ± 8.12 and 49.85 ± 6.35 respectively while the duration of diabetes was almost a decade on the average for the diabetic participants (Table 1). The diabetic participants appeared to be more of overweight (mean BMI = 28.92 ± 4.36) and had lower mean Six Minute Walk Distance (6MWD) (318.57 ± 43.7, 95%CI = 306.74-329.25 m) than that of the non-diabetic participants (596. 43 ± 54.78, 95% CI = 582.57-610.29 m). The difference in the 6MWD between these two groups was found to be significant ($t = 30.5046$, $P < 0.05$) (Table 2). A significant difference also occurred between the 6MWD of the males and females in the diabetic group. We found significant differences in the 6MWD of the age groups ($F = 9.4738$, $P < 0.05$) and BMI classifications ($F = 3.3416$, $P < 0.05$) but not for the duration of the diabetes (Table 3). Post hoc analyses revealed significances between age groups 41-50 and 51-60 while we found significances between the 6MWD of the obese and each of normal and underweight diabetic subjects.

Table 1: Descriptive Characteristics of the participants

Variable	Diabetic (n = 58)		Non-diabetic (n = 60)	
	Mean ± SD	**95% CI**	**Mean ± SD**	**95% CI**
Age (years)	47.64 ± 8.12	45.55-49.72	49.85 ± 6.35	48.24-51.45
Sex				
Males	30 (52%)		33 (55%)	
Females	28 (48%)		27 (45%)	
Duration of diabetes	8.76 ± 2.11	8.21-9.30 (years)		
Weight (Kg)	77.64 ± 9.34	75.23-80.04	73.26 ± 6.67	71.57-74.94
Height (m)	1.64 ± 0.21	1.58-1.69	1.70 ± 0.15	1.66-1.73
BMI (Kg/m^2)	28.92 ± 4.36	27.79-30.04	24.89 ± 5.29	23.55-26.22

Table 2: Comparison of the Exercise Capacity (6 minute walk distance) of diabetic Vs non-diabetic and Males Vs Females of the diabetic participants

Variable	Mean ± SD (m)	t	df	P-Value
Diabetic Vs Non-diabetic				
Diabetic subjects	318.57 ± 43.72	30.5046	112	<0.05
Non-diabetic Subjects	596. 43 ± 54.78			
Males Vs Females (Diabetic group)				
Males	341.30 ± 40.18	4.837	56	<0.05
Females	294.21 ± 33.35			

Table 3: Comparison of exercise capacities (6 minute walk distance) based on different characteristics

Variable	Mean ± SD	df	F	P-value
Age Groups (years)				
31-40 (n = 19)	327.56 ± 44.81	2	9.4738	<0.05
41-50 (n = 23)	346.50 ± 23.34			
51-60 (n = 16)	295.59 ± 39.16			
Duration of Diabetes (years)				
1-5 (n =15)	316.71 ± 40.33	3	2.6572	>0.05
6-10 (n = 17)	311.67 ± 56.80			
11-15 (n = 15)	297.00 ± 26.61			
16-20 (n = 11)	345.50 ± 47.03			
BMI (Kg/m^2)				
Underweight (n = 13)	344.00 ± 51.64	3	3.3416	<0.05
Normal (n = 19)	328.24 ± 46.09			
Overweight (n = 15)	301.75 ± 39.68			
Obese (n = 11)	295.33 ± 41.75			

DISCUSSION

The main finding of this study is that our sample of Type 2 Diabetes (T2D) participants had lower exercise capacity as indicated by lower Six Minute Walk Distance (6MWD) than their matched non-diabetic counterparts; and this was significantly lower in females than males. We also found that younger patients in the age range 41-50 and those who were not overweight or obese had higher 6MWD than the older and overweight or obese patients. The exercise capacities of the patients did not however differ based on the durations of their diabetes. This could indicate that duration of diabetes between one and twenty years may not independently confer low exercise capacities on patients with T2D. The lower exercise capacity seen in T2D patients may not be unconnected among other factors, with their diabetic status since their non-diabetic counterparts had higher 6MWD. This might be because T2D is related with a number of co-morbidities including cardio-pulmonary disorders that have been found to significantly reduce exercise capacities. For instance, T2D has independent adverse cardiac effects, including increased left ventricular mass and wall thicknesses, reduced left ventricular systolic chamber and myocardial function, and increased arterial stiffness (Devereux *et al* 2000). Patients with T2D have also been shown to significantly have higher prevalence of pulmonary embolism and hypertension independent of coronary artery disease, hypertension, congestive heart failure, or smoking (Movahed *et al* 2005). The lower 6MWD in the T2D sample could also be because they had higher mean weight and lower mean height, both factors which are likely to affect walking parameters.

Although we had few studies to rely on with regards to the diabetes focus of this study, nonetheless, our results support an earlier report on healthy adult where it was concluded that men had higher 6MWD than women and the 6MWD was significantly less for men and women who were older and heavier, and for shorter men (Enright *et al* 1998). Also, in a group of patients with chronic obstructive pulmonary disease, it was found that men had significantly higher 6MWD than females (Carter *et al* 2003). The significant difference between the 6MWD of older T2D patients compared to the younger ones could be due to the gradual reduction of skeletal muscle mass and strength that generally occurs with aging (Tolep *et al* 1993). This, in addition to other co-morbidities associated with aging such as degenerative joint diseases, could be responsible for the shorter distance walked by the older T2D subjects. A previous study also reported a mean test score showing a trend of age-related declines for the 6MWD and other test performances such as Berg Balance Scale, Timed Up and Go and gait speeds for both male and female subjects (Steffen *et al* 2002).

The significantly lower 6MWD in our overweight and obese sample compared with the normal weight sample could be because of the extra demand imposed on them by the excessive weights. Obesity increases the workload for a given amount of exercise, which could result in the shorter 6MWD of subjects with a higher body weight or body mass index (Enright *et al* 1998). Although in adolescents, Norman *et al* (2005) also recorded excess adiposity to affect their capacity to do sustained exercise. The higher percentage of oxygen consumed during sub-maximal exercise indicated that overweight adolescents are burdened by the metabolic cost of their excess mass (Norma *et al* 2005). Age and anthropometric variables such as weight, and waist size were independently associated with the 6 minute distance walked and these factors were also associated with gait speed and timed chair stands during baseline examination (Hirsch *et al* 1997).

The fact that we found the 6MWD to be lower in our diabetic subjects did not confirm that the 6MWT is the best for determining exercise capacity or changes in functional capacity due to an intervention in patients with diabetes. Although we did not have a very large sample, we are however able to reveal the clinical relevance of 6MWT in these set of people because it was able to detect a difference between diabetic and non-diabetic individuals. We did not find sufficient literature on 6MWT specifically in persons with diabetes giving credence to the fact that this study was necessary as it will add to knowledge on exercise capacities of individuals with T2D using the simple 6MWT.

The findings of this study have a number of implications for physical management of T2D patients. First it implies that patients with T2D do have lower exercise capacity than their non-diabetic counterparts as revealed by the lower 6MWD. This means that T2D patients should begin exercise gradually at low intensities with the aim of gradual progression as the patient's capacity improves. Secondly, this study also implies that exercise prescriptions especially for female, obese and older T2D patients need to account for the limited exercise capacities imposed on them by these factors so that only activities that will be tolerated should be prescribed to avoid exercise induced complications.

In conclusion, we identified that T2D patients had lower exercise capacities as assessed by the 6MWT than their non-diabetic counterparts and this was lower in women, older and obese subjects. This study was

carried out as a preliminary investigation and we hope that larger studies will be carried out with this focus to further establish and validate the exercise capacities of T2D patients based on the 6MWT. Further studies should also look into the possibility of coming up with normal reference values for 6MWT in populations of African Origin.

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