

Access this article online	
Quick Response Code:	Website: www.annalsafmed.org
	
	DOI: 10.4103/1596-3519.93532

## Gender differences in the variables of exercise treadmill test in type 2 diabetes mellitus

Page | 96

Ajayi E. Adekunle, Anthony O. Akintomide<sup>1</sup>Department of Internal Medicine, University Teaching Hospital, Ado Ekiti, <sup>1</sup>Department of Medicine, Obafemi Awolowo University Teaching Hospital, Ile Ife, Nigeria

Correspondence to: Dr. Ajayi E. Adekunle, Department of Internal Medicine, University Teaching Hospital, Ado Ekiti, Nigeria. E-mail: lifecareado@gmail.com

### Abstract

**Background:** Exercise capacity, like some other variables of exercise stress test, is a strong predictor of cardiovascular and overall mortality. Many confounding factors, including gender, have been found to affect exercise capacity. This study evaluated whether exercise capacity differs in age-matched type 2 diabetic Nigerian men and their women counterparts and the hemodynamic variables of exercise treadmill test that correlate with exercise capacity in them.

**Materials and Methods:** A total of 61 type 2 diabetics (male = 34; female = 27) aged 30 to 60 years who were recruited through the Medical Out-patient Department of OAUTHC, Ile Ife, Nigeria, underwent symptom-limited maximal treadmill exercise using Bruce protocol.

**Result:** Patients had comparable clinical and demographic patterns. There was no gender difference in the chronotropic response to exercise. Males had faster heart rate recovery (HRR) than females. Though both sexes had similar resting systolic blood pressure (SBP), males had significantly higher peak SBP than females ( $216.2 \pm 23.7$  mmHg vs  $203.3 \pm 21.7$  mmHg;  $P = 0.03$ ). Exercise capacity was significantly higher in males ( $7.5 \pm 2.0$  METs) than females ( $6.4 \pm 1.5$  METs);  $P = 0.01$ . Significant correlates of exercise capacity in both sexes were fasting plasma glucose, resting diastolic blood pressure, Duke Treadmill Score, and HRR. Majority of the patients were in moderate DUKE risk subgroup and there was no statistically significant difference between males and females in this regard.

**Conclusion:** Gender difference occurs in the exercise capacity of diabetic patients and the factors associated with this disparity may be related to gender differences in resting heart rate and HRR, both reflecting a withdrawal of vagal tone.

**Keywords:** Chronotropic response, exercise capacity, gender, heart rate recovery, type 2 diabetes mellitus

### Résumé

**Fond:** Capacité d'exercice, comme certains autres variables de test de stress en exercice, est un solide prédicteur de mortalité cardiovasculaire et globale. De nombreux facteurs confusionnels, y compris entre les sexes, ont été trouvés pour influencer sur la capacité d'exercice. Cette étude visait à déterminer si la capacité d'exercice diffère en hommes nigérian diabétique de type même âge 2 et leurs homologues de femmes et les variables hémodynamiques d'épreuve sur tapis roulant qui sont en corrélation avec la capacité d'exercice en eux.

**Des matériaux et des procédés:** Un total de 61 2 patients diabétiques de type (mâles = 34 ; femelles = 27) âgés de 30 à 60 ans, qui ont été recrutés par le biais de OAUTHC de la médecine ambulatoire et, Ile Ife, Nigéria, a subi l'exercice symptôme-limited maximale sur tapis roulant en utilisant le protocole de Bruce.

**Résultat:** Les patients ont des profils démographiques et cliniques comparables. Il n'y n'avait aucune différence entre les sexes dans la réponse chronotrope à l'exercice. Les hommes avaient récupération plus rapide du rythme cardiaque (RRH) que les femelles. Bien que les deux sexes étaient semblable au repos pression systolique (SBP), les hommes avaient significativement plus élevée pic SBP que les femelles ( $216.2 \pm 23,7$  mmHg vs  $203.3 \pm 21,7$  mmHg;  $P = 0.03$ ). Capacité d'exercice est significativement plus élevée chez les mâles ( $7,5 \pm 2,0$  METs) que les femelles ( $6,4 \pm 1,5$  METs);  $P = 0,01$ . Corrélats significatives de la capacité de l'exercice chez les deux sexes ont été jeûne glycémie, la pression artérielle diastolique, Score de tapis roulant de Duke et RRH de repos. La majorité des

patients étaient en sous-groupe de risque duc modéré et il n'y n'avait aucune différence statistiquement significative entre les mâles et les femelles à cet égard.

**Conclusion:** Différence entre les sexes se produit dans l'exercice de la capacité des patients diabétiques et les facteurs associés à cette disparité peuvent être liées à des différences entre les sexes au repos de la fréquence cardiaque et RRH, les deux reflétant un retrait du tonus vagal.

**Mots clés:** Réponse chronotrope, exercice de capacité, de sexe, de récupération de la fréquence cardiaque, 2 de diabète de type

## Introduction

Clinical and observational studies have shown that exercise capacity is a strong predictor of cardiovascular and overall mortality.<sup>[1]</sup> This is also true of some of the variables of exercise such as heart rate recovery (HRR),<sup>[2,3]</sup> chronotropic response,<sup>[4]</sup> and Duke Treadmill Score (DTS).<sup>[5]</sup> Despite this, there is widespread tendency to ignore exercise testing in clinical management of patients with diabetes mellitus even when evidence abound showing that exercise improves health status in patients with diabetes mellitus<sup>[6]</sup> and the need to properly evaluate the patients before prescribing such exercise. The prognostic and therapeutic benefits of exercise testing cannot be overemphasized.<sup>[6]</sup>

However, it is known that many factors, including female gender, are associated with a reduction in exercise capacity, as reflected by a decrease in maximal workload achieved or maximal oxygen consumption.<sup>[7]</sup> Though the differences in exercise capacity between men and women have largely been attributed to nonmodifiable differences in cardiac output and skeletal muscle mass,<sup>[7,8]</sup> determining the most important parameters affecting exercise capacity in diabetic men and women is difficult because of the numerous confounding factors such as age, body mass index, and glycemic control.

The purpose of this study was to determine whether exercise capacity differs in age-matched type 2 diabetic Nigerian men *vs* their women counterparts and the hemodynamic variables of exercise treadmill test that correlate with exercise capacity in them. To the best of our knowledge, relevant studies addressing this issue from Nigeria are scarce, if any.

## Material and Methods

A total of 61 type 2 diabetics (male = 34; female = 27) aged 30 to 60 years were recruited through the Medical Out-patient Department of Obafemi Awolowo University Teaching Hospitals Complex, Ile Ife, Nigeria. Ethical clearance for the study was approved by the Ethics and Research Committee of the hospital in conformity with ethical

guidelines of the 1975 Declaration of Helsinki and all the participants gave written consent to participate.

Demographic parameters of subjects were noted and recorded. All subjects were clinically examined to evaluate their body mass index (BMI) and cardiovascular status at rest. Subjects were considered diabetic if they had fasting plasma glucose (FBG)  $\geq 126$  mg/dl (7.0 mmol/l)<sup>[9]</sup> or if they were on hypoglycemic medication. FBG and 2-hour postprandial plasma glucose were obtained 24 hours prior to the procedures. Resting 12-lead electrocardiogram (ECG) was done to exclude patients with baseline ST-segment abnormalities and bundle branch block. Also excluded were patients with coexisting hypertension or who were on antihypertensive(s), established chronic kidney disease or serum creatinine  $> 1.5$  mg% (132  $\mu$ mol/l), congestive heart failure, valvular heart disease, and other diseases known to influence left ventricular (LV) function such as thyroid disease and severe obesity.

All the subjects underwent treadmill symptom-limited maximal exercise using Bruce protocol<sup>[10]</sup> with Schiller CS-200 machine. The protocol continued until one of several endpoints was reached. These included if the patient requested that the exercise be terminated; developed severe chest pain, fatigue, leg discomfort or dyspnea; developed frequent premature ventricular beats, developed a systolic blood pressure (SBP)  $> 250$  mmHg or a drop in the pretest SBP  $> 10$  mmHg; or developed any other reasons necessitating termination of exercise.

The following exercise variables (as defined) were recorded:

1. Peak systolic blood pressure (pSBP): Highest SBP during exercise
2. Peak diastolic blood pressure (pDBP): Highest DBP during exercise
3. Exercise capacity: estimated metabolic equivalent (MET) of workload which was calculated from the exercise time using the regression equation:  $MET = 1.11 + 0.016Y$  (exercise time in seconds).<sup>[11]</sup>

4. Percentage of normal exercise capacity achieved: (Achieved exercise capacity/the predicted peak exercise capacity) x 100; where predicted peak exercise capacity is  $18 - (0.15 \times \text{age})$ .<sup>[12]</sup>
5. Heart rate reserve:  $[(\text{peak HR} - \text{HR at rest}) / (220 - \text{age} - \text{HR at rest})] \times 100$ , with value  $\leq 70\%$  taken as low.<sup>[13]</sup> This is also a measure of chronotropic competence.<sup>[14]</sup>
6. HRR: measured as the difference between maximal heart rate and 1-minute heart rate immediately after peak exercise. Abnormal HRR was defined as  $\text{HRR} \leq 12$  beats per minute.<sup>[3]</sup>
7. Recovery time: Time between end of exercise and reversal of heart rate to pre-exercise rate.
8. DTS: Exercise duration (minutes) - 5 x ST-segment deviation (millimeters) - 4 x treadmill angina index<sup>[15]</sup> with the Duke risk grouping, as shown in Table 1.

### Statistical Analysis

SPSS version 11.0 software (SPSS, Chicago, IL, USA) was used in the analysis of the data. Continuous variables were expressed as mean  $\pm$  SD, while categorical variables were expressed as counts (percentages). Comparison between two groups was assessed by the Students *t*-test for independent variables, while the Chi-square analysis was used to compare proportions. Pearson's correlation was used to investigate the correlation of variable factors. *P* values  $< 0.05$  were considered statistically significant.

### Results

As shown in Table 2, clinical and demographic patterns were comparable in both sexes, except the resting heart rate that was significantly higher in females than males.

There was no significant difference in the number of males who attained at least 85% of the age-predicted maximum heart rate compared with females. A trend similar to this observation was also seen in the percentage of heart rate reserve used by both sexes during exercise. On the whole, 23% of the study population did not achieve at least 85% of the age-predicted maximum heart rate, and their resting systolic and DBPs were observed to be significantly higher than those who achieved at least 85% of the age-predicted maximum heart rate ( $127.45 \pm$

$17.43 \text{ mmHg}$  vs  $145.71 \pm 17.47 \text{ mmHg}$ ;  $P = 0.001$  and  $79.68 \pm 10.43 \text{ mmHg}$  vs  $90.86 \pm 7.83 \text{ mmHg}$ ;  $P < 0.001$ , respectively). HRR was significantly higher in males than females. Table 3 shows that more males also had normal HRR than females.

Though both sexes had similar resting SBP, males had significantly higher pSBP than females ( $216.2 \pm 23.7 \text{ mmHg}$  vs  $203.3 \pm 21.7 \text{ mmHg}$ ;  $P = 0.03$ ).

The mean exercise capacity for the study population was  $7.02 \pm 1.84$ . As shown in Table 4, exercise capacity was significantly higher in males ( $7.5 \pm 2.0$  METs) than females ( $6.4 \pm 1.5$  METs);  $P = 0.01$ . Percentage of expected normal exercise capacity achieved in males was also significantly higher than in females ( $72.7 \pm 19.9\%$  vs  $59.9 \pm 13.3\%$ ;  $P = 0.01$ ). Significant correlates of exercise capacity in both sexes are shown in Table 5. They were FBG, resting DBP, DTS, and HRR. Other gender-specific correlate was heart rate reserve ( $r = 0.80$ ,  $P = 0.002$ ) in males.

The reason for terminating exercise was fatigue in 95.1% and SBP greater than 250 mmHg in 4.9% of the patients.

Majority of the patients were in moderate DUKE risk subgroup [Table 6] and there was no statistically significant difference between males and females in this regard.

### Discussion

Exercise stress testing is presently used to assess physical fitness, determine exercise capacity,

**Table 2: Gender distribution of clinical and demographic pattern of the study population**

Parameters	Male n = 34	Female n = 27	<i>P</i> value
Age (Years)	50.3 $\pm$ 5.9	49.0 $\pm$ 6.2	0.43
Duration of DM (months)	42.7 $\pm$ 4.60	30.4 $\pm$ 3.30	0.29
FPG (mmol/l)	8.1 $\pm$ 1.6	8.1 $\pm$ 2.9	0.95
2 hr postprandial glucose (mmol/l)	12.3 $\pm$ 3.8	11.8 $\pm$ 3.1	0.74
Body mass index (kg/m <sup>2</sup> )	25.3 $\pm$ 3.0	25.6 $\pm$ 4.7	0.20
Resting heart rate (per min)	86.3 $\pm$ 10.9	96.3 $\pm$ 23.5	0.03
Resting systolic blood pressure (mmHg)	131.8 $\pm$ 16.3	131.4 $\pm$ 22.2	0.93
Resting diastolic blood pressure (mmHg)	84.0 $\pm$ 11.0	80.0 $\pm$ 10.7	0.16
Resting pulse pressure (mmHg)	47.82 $\pm$ 9.3	51.37 $\pm$ 16.5	0.29

**Table 1: DUKE risk subgroup<sup>[16]</sup>**

#### Risk group treadmill score

Low $\geq +5$
Moderate-10 to +4
High $\leq -11$

**Table 3: Proportion of males vs females with some exercise treadmill test variables**

Variables	Males	Females	P value
Heart rate recovery			
Normal n (%)	30 (88)	14 (52)	0.002
Abnormal n(%)	4 (12)	13 (48)	
Heart rate reserve			
Normal n(%)	26 (77)	21 (78)	0.576
Low n(%)	8 (23)	6 (22)	
Achieved $\geq 85\%$ age-predicted HR			
Yes n(%)	25 (74)	22 (82)	0.337
No n(%)	9 (26)	5 (18)	

**Table 5: Matrix of correlations of exercise capacity in both sexes**

Variables	Males	Females	r value	P value
FBS	0.55	0.04	0.62	0.007
rDBP	0.63	0.02	-0.87	<0.001
DTS	0.75	0.004	0.44	0.04
HRR	0.80	0.002	0.47	0.04

FBS: Fasting Blood Glucose; rDBP: Diastolic Blood Pressure at rest; DTS: Dukes Treadmill Score; HRR: Heart Rate Recovery, r value = Correlation Coefficient

diagnose cardiac disease, define the prognosis of known cardiac disease, prescribe an exercise plan, and guide cardiac rehabilitation.<sup>[17]</sup> Exercise treadmill test is one of the various ways by which a patient's exercise capacity can be assessed. It had been demonstrated that a woman's inability to reach a MET level of 5 was associated with a 3.1-fold increase in the risk of death compared with MET levels  $>8$ , and that asymptomatic women whose exercise capacity was  $<85\%$  of the age-predicted value had twice the risk of death from cardiac causes than those whose exercise capacity was  $\geq 85\%$  of the age-predicted value.<sup>[18]</sup> As expected, the females in our study had a lower exercise capacity, measured in METs, than their male counterparts. This gender difference in exercise capacity is well-described in published data and is attributed to the higher body fat composition, lower hemoglobin content, and smaller heart size of women. Again, a decreased peak stroke volume associated with female gender had also been associated with a reduced exercise capacity.<sup>[7]</sup> Interestingly, this gender difference in exercise capacity was not associated with a difference in exercise efficiency either at baseline or after training, unlike what obtains in the elderly where a decreased exercise capacity is associated with decreased exercise efficiency. Thus, the gender-related differences in exercise capacity may largely be explained by gender-related differences in cardiovascular hemodynamic factors such as peak heart rate and stroke volume.<sup>[19]</sup>

The linkage between exercise capacity and left ventricular diastolic function is also well

**Table 4: Gender distribution of exercise treadmill testing variables**

Parameters	Male n = 34	Female n = 27	P value
Peak heart rate (per min)	154.8 $\pm$ 18.1	159.7 $\pm$ 26.2	0.39
Peak systolic blood Pressure (mmHg)	216.2 $\pm$ 23.7	203.3 $\pm$ 21.7	0.03
Peak diastolic blood pressure (mmHg)	100.9 $\pm$ 12.1	97.0 $\pm$ 14.9	0.18
Exercise duration (secs)	401.6 $\pm$ 121.7	329.1 $\pm$ 92.8	0.01
Exercise capacity (METs)	7.5 $\pm$ 2.0	6.4 $\pm$ 1.5	0.01
% Normal Exercise capacity achieved	72.7 $\pm$ 19.9	59.9 $\pm$ 13.3	0.01
Heart rate reserve (/min)	82.6 $\pm$ 22.2	88.5 $\pm$ 28.5	0.37
Heart rate recovery (/min)	26.0 $\pm$ 14.2	19.2 $\pm$ 16.0	0.01
Recovery time (min)	6.5 $\pm$ 2.6	5.7 $\pm$ 1.7	0.20
Heart rate increase (/min)	66.44 $\pm$ 20.3	63.48 $\pm$ 25.1	0.40

Page | 99

**Table 6: DUKE risk groups in the study population**

	Low	Moderate	High
Males n(%)	10 (29.4)	24 (70.6)	0
Females n(%)	4 (14.8)	21 (77.8)	2 (7.4)
Total n(%)	14 (23)	45 (74)	2 (3)

Chi square = 4.88, P value = 0.087

established.<sup>[20]</sup> There is an association between left ventricular diastolic dysfunction and exercise performance in patients without<sup>[20]</sup> and with<sup>[21]</sup> type 2 diabetes. Subjects with impaired left ventricular diastolic dysfunction have been found to have reduced exercise capacity. Though left ventricular functions were not assessed in our study, previous reports have shown that the absolute reduction in exercise capacity in women compared with men is similar across the spectrum of diastolic dysfunction, suggesting that diastolic parameters do not account for the sex differences in exercise capacity.<sup>[22]</sup>

We also examined the effect of autonomic function on this gender difference in exercise capacity in our diabetic subjects. Though female diabetics in this study had higher resting heart rate, this became blunted when compared with male counterparts at the peak of exercise. There was also no significant difference in the heart rate reserve and the number of males who achieved at least 85% maximum age-predicted heart rate with exercise compared with females. In short, there was no significant gender difference in chronotropic response to exercise in our study. However, HRR was faster in males than females and in discrete term, more

females had abnormal HRR compared with males. The pathophysiology of abnormal HRR and chronotropic response is not fully understood. Both HRR and chronotropic response appear to measure the autonomic response to exercise, abnormalities of which have been demonstrated to independently predict adverse cardiac outcomes.<sup>[16,23]</sup> Predisposition to fatal arrhythmias, sudden cardiac death, and significant coronary artery disease has been postulated as potential mediators of these outcomes.<sup>[4,24]</sup> HRR appears to measure the capacity of the cardiovascular system to reverse the vagal withdrawal that occurs during exercise.<sup>[25,26]</sup> Abnormalities in this reversal, as indicated by abnormal HRR, are associated with mortality in asymptomatic patients, patients..... undergoing coronary angiography, stress echocardiography, and nuclear perfusion imaging. This association is independent of left ventricular systolic function and severity of coronary artery disease. Chronotropic response on the other hand appears to assess the autonomic response to exercise. Abnormalities in this response may indicate disruptions in autonomic balance and an inability of the cardiovascular system to respond appropriately to the sympathetic discharge and parasympathetic withdrawal that occurs during exercise.<sup>[27]</sup>

Increased resting heart rate itself may reflect autonomic dysfunction, especially dysfunction in parasympathetic nervous system. Patients with high parasympathetic activation usually have low resting heart rate and baseline oxygen consumption and may achieve high workload for a certain level of oxygen consumption. Physiologically, exercise results in prompt withdrawal of vagal tone and subsequent sympathetic activation, while recovery is associated with parasympathetic activation followed by sympathetic withdrawal. HRR correlates with vagal activity.<sup>[25,26]</sup> Previous studies have shown that reduced HRR is associated with type 2 diabetes.<sup>[28]</sup> The present study further showed that the reduced HRR is more in females than males. Taken together, the higher resting heart rate and slower HRR may reflect a more serious damage to parasympathetic nervous system in female diabetics compared with male diabetics. That an abnormality in HRR correlated with exercise capacity in our study is consistent with previous studies.<sup>[29]</sup> The fact that exercise training improves both autonomic function and exercise capacity in type 2 diabetes<sup>[30]</sup> is noteworthy. This should encourage physicians to emphasize the need for exercise training as part of management strategies to reduce morbidity and mortality in type 2 diabetes.

Peak exercise SBP was significantly higher in the male than the female subjects in our study.

Type 2 diabetes is associated with reduced LV systolic volume, altered myocardial and diastolic functions, and increased arterial stiffness,<sup>[31,32]</sup> which are important parameters related to BP regulation and equally potential contributors to the reduced exercise capacity documented in diabetic individuals. How then does one explain the higher pSBP in the male subjects and their observed better exercise capacity compared with female diabetics seen in our study?

A likely explanation could be that a relatively more important LV remodeling,<sup>[33]</sup> induced by diabetes and triggered more specifically by arterial stiffness,<sup>[31]</sup> might be present and induce a transitory adaptive beneficial impact such as a higher cardiac output before the appearance of diastolic dysfunction in subjects with higher exercise SBP compared with subjects with lower exercise SBP. This might override the deleterious impact induced by diabetes on left ventricular function. To buttress this argument, a positive relationship has been reported between a nonpathological left ventricular hypertrophy with a preserved diastolic function<sup>[34]</sup> and elevated exercise SBP and exercise capacity in athletes.<sup>[35]</sup> However, this positive influence on exercise capacity is probably lost with the appearance of diastolic dysfunction.<sup>[21]</sup>

Lastly, the DTS has been recommended by the American College of Cardiology and the American Heart Association as a tool for post-test cardiac risk stratification.<sup>[5]</sup> The use of multivariable statistical techniques to estimate probability of cardiac events or angiographic findings has led to several valid scores. The most universal of these tests is the DTS. Considering the likelihood that a large number of diabetic patients will have obesity, hypertension, peripheral vascular disease, peripheral neuropathy, physical deconditioning, and decreased exercise capacity, which are factors that may influence the ability of the patients to exercise long enough to achieve a workload adequate to induce ischemia and its related symptoms and electrocardiographic findings, significant coronary artery disease may be present but remain undetected. As a result, these individuals may fall into the low or intermediate DTS range erroneously as may have been the case in our present study where majority of the patients fell into the intermediate DTS, despite the fact that exercise was terminated in majority of the patients as a result of fatigue and not reported chest pain. They therefore may be wrongly managed conservatively, similar to their nondiabetic counterparts. Lakkireddy *et al.*<sup>[5]</sup> demonstrated the clinical value of the DTS in the risk stratification of nondiabetic and diabetic patients. They noted a strong association between DTS and the combined outcomes of cardiac death, nonfatal myocardial infarction, congestive heart

failure, and revascularization in both nondiabetic and diabetic patients.

A major limitation of this study was the small sample size and non-measurement of glycated hemoglobin of the patients which assesses glycemic control over a longer period of time than FPG.

## Conclusion

Gender difference occurs in the exercise capacity of diabetic patients. The factors associated with this difference may be related to gender differences in resting heart rate and HRR, both reflecting a withdrawal of vagal tone. The need to prescribe exercise as part of the management strategies in type 2 diabetes is well established, but then, not until appropriate cardiac risk stratification has been done with a noninvasive method such as exercise stress test.

## References

- Snader CE, Marwick TH, Pashkow FJ, Harvey SA, Thomas JD, Lauer MS. Importance of estimated functional capacity as a predictor of all-cause mortality among patients referred for exercise thallium single-photon emission computed tomography: Report of 3,400 patients from a single center. *J Am Coll Cardiol* 1997;30:641-8.
- Mora S, Redberg RF, Cui Y, Whiteman MK, Flaws JA, Sharrett AR, *et al.* Ability of exercise testing to predict cardiovascular and all-cause death in asymptomatic women: A 20-year follow-up of the lipid research clinics prevalence study. *JAMA* 2003;290:1600-7.
- Watanabe J, Thamilarasan M, Blackstone EH, Thomas JD, Lauer MS. Heart rate recovery immediately after treadmill exercise and left ventricular systolic dysfunction as predictors of mortality: The case of stress echocardiography. *Circulation* 2001;104:1911-6.
- Ellestad MH. Chronotropic incompetence. The implications of heart rate response to exercise (compensatory parasympathetic hyperactivity?). *Circulation* 1996;93:1485-7.
- Lakkireddy DR, Bhakkah J, Korlakunta HL, Ryschon K, Shen X, Mooss AN, *et al.* Prognostic value of the Duke Treadmill Score in diabetic patients. *Am Heart J* 2005;150:516-21.
- George DH, Russell DW. Exercise stress testing in patients with type 2 diabetes: When are asymptomatic patients screened? *Clin Diabetes* 2007;25:126-30.
- Proctor DN, Beck KC, Shen PH, Eickhoff TJ, Halliwill JR, Joyner MJ. Influence of age and gender on cardiac output-VO<sub>2</sub> relationships during submaximal cycle ergometry. *J Appl Physiol* 1998;84:599-605.
- Coggan AR, Spina RJ, King DS, Rogers MA, Brown M, Nemeth PM, *et al.* Histochemical and enzymatic comparison of the gastrocnemius muscle of young and elderly men and women. *J Gerontol* 1992;47:B71-6.
- World Health Organization. Second Report of the Expert Committee on Diabetes. Geneva: World Health Org: 1980: (Tech Rep Ser 646).
- Bruce RA. Exercise testing of patients with coronary disease. Principles and normal standards for evaluation. *Ann Clin Res* 1971;3:323-32.
- Bruce RA, Kusumi F, Hosmer D. Maximal oxygen intake and normographic assessment of functional aerobic impairment in cardiovascular disease. *Am Heart J* 1973;85:546-52.
- Morris CK, Myers J, Froelicher VF, Kawaguchi T, Ueshima K, Hideg A. Nomogram based on metabolic equivalents and age for assessing aerobic exercise capacity in men. *J Am Coll Cardiol* 1993;22:175-82.
- Bangalore S, Yao SS, Chaudhry FA. Comparison of heart rate reserve versus 85% of age-predicted maximum heart rate as a measure of chronotropic response in patients undergoing dobutamine stress echocardiography. *Am J Cardiol* 2006;97:742-7.
- Lauer MS, Francis GS, Okin PM, Pashkow FJ, Snader CE, Marwick TH. Impaired chronotropic response to exercise stress testing as a predictor of mortality. *JAMA* 1999;281:524-9.
- Mark DB, Hlatky MA, Harrell FE Jr, Lee KL, Califf RM, Pryor DB. Exercise treadmill score for predicting prognosis in coronary artery disease. *Ann Intern Med* 1987;106:793-800.
- Mark DB, Shaw L, Harrell FE Jr, Hlatky MA, Lee KL, Bengtson JR, *et al.* Prognostic value of a treadmill exercise score in outpatients with suspected coronary artery disease. *N Engl J Med* 1991;325:849-53.
- White RD, Evans CH. Performing the exercise test. *Prim Care* 2001;28:29-53.
- Gulati M, Black HR, Shaw LJ, Arnsdorf MF, Merz CN, Lauer MS, *et al.* The prognostic value of a nomogram for exercise capacity in women. *N Engl J Med* 2005;353:468-75.
- Woo JS, Derleth C, Stratton JR, Levy WC. The influence of age, gender, and training on exercise efficiency. *J Am Coll Cardiol* 2006;47:1049-57.
- Genovesi-Ebert A, Marabotti C, Palombo C, Giaconi S, Rossi G, Ghione S. Echo Doppler diastolic function and exercise tolerance. *Int J Cardiol* 1994;43:67-73.
- Poirier P, Garneau C, Bogaty P, Nadeau A, Marois L, Brochu C, *et al.* Impact of left ventricular diastolic dysfunction on maximal treadmill performance in normotensive subjects with well-controlled type 2 diabetes mellitus. *Am J Cardiol* 2000;85:473-7.
- Grewal J, McCully RB, Kane GC, Lam C, Pellikka PA. Left ventricular function and exercise capacity. *JAMA* 2009;301:286-94.
- Azarbal B, Hayes SW, Lewin HC, Hachamovitch R, Cohen I, Berman DS. The incremental prognostic value of percentage of heart rate reserve achieved over myocardial perfusion single-photon emission computed tomography in the prediction of cardiac death and all-cause mortality: superiority over 85% of maximal age-predicted heart rate. *J Am Coll Cardiol* 2004;44:423-30.
- Jouven X, Empana JP, Schwartz PJ, Desnos M, Courbon D, Ducimetière P. Heart-rate profile during exercise as a predictor of sudden death. *N Engl J Med* 2005;352:1951-8.
- Myers J, Tan SY, Abella J, Aleti V, Froelicher VF. Comparison of the chronotropic response to exercise and heart rate recovery in predicting cardiovascular mortality. *Eur J Cardiovasc Prev Rehabil* 2007;14:215-21.
- Rosenwinkel ET, Bloomfield DM, Arwady MA, Goldsmith RL. Exercise and autonomic function in health and cardiovascular disease. *Cardiol Clin* 2001;19:369-87.
- Colucci WS, Ribeiro JP, Rocco MB, Quigg RJ, Creager MA, Marsh JD, *et al.* Impaired chronotropic response to exercise in patients with congestive heart failure. Role of postsynaptic beta-adrenergic desensitization. *Circulation* 1989;80:314-23.
- Carnethon MR, Jacobs DR Jr, Sidney S, Liu K. Influence of autonomic nervous system dysfunction on the

- development of type 2 diabetes: The CARDIA study. *Diabetes Care* 2003;26:3035-41.
29. Fang ZY, Sharman J, Prins JB, Marwick TH. Determinants of exercise capacity in patients with type 2 diabetes. *Diabetes Care* 2005;28:1643-8.
  30. Loimaala A, Huikuri HV, Koobi T, Rinne M, Nenonen A, Vuori I. Exercise training improves baroreflex sensitivity in type 2 diabetes. *Diabetes* 2003;52:1837-42.
  31. Devereux RB, Roman MJ, Paranicas M, O'Grady MJ, Lee ET, Welty TK, *et al.* Impact of diabetes on cardiac structure and function: The strong heart study. *Circulation* 2000;101:2271-6.
  32. Poirier P, Bogaty P, Philippon F, Garneau C, Fortin C, Dumesnil JG. Preclinical diabetic cardiomyopathy: Relation of left ventricular diastolic dysfunction to cardiac autonomic neuropathy in men with uncomplicated well-controlled type 2 diabetes. *Metabolism* 2003;52:1056-61.
  33. Ajayi EA, Balogun MO, Akintomide OA, Adebayo RA, Ajayi OE, Ikem RT, *et al.* Blood pressure response to exercise treadmill test and echocardiographic left ventricular geometry in Nigerian normotensive diabetics. *Cardiovasc J Afr* 2010;21:93-6.
  34. Lewis JF, Spirito P, Pelliccia A, Maron BJ. Usefulness of Doppler echocardiographic assessment of diastolic filling in distinguishing "athlete's heart" from hypertrophic cardiomyopathy. *Br Heart J* 1992;68:296-300.
  35. Karjalainen J, Mantysaari M, Viitasalo M, Kujala U. Left ventricular mass, geometry, and filling in endurance athletes: Association with exercise blood pressure. *J Appl Physiol* 1997;82:531-7.

**Cite this article as:** Adekunle AE, Akintomide AO. Gender differences in the variables of exercise treadmill test in type 2 diabetes mellitus. *Ann Afr Med* 2012;11:96-102.  
**Source of Support:** Nil, **Conflict of Interest:** None declared.