Medicina Sportiva (2015), vol. XI, no 4, 2655-2661
Journal of the Romanian Sports Medicine Society

Correlates, predictors and reference values of repetitive squat performance in apparently healthy Nigerians

Chidozie E. Mbada[1,2], Odesanmi Fatai[1], Opeyemi A. Idowu[3], Olubusola E. Johnson[1]
[1]*Department of Medical Rehabilitation, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria*
[2]*African Population and Health Research Center, Nairobi Kenya*
[3]*Department of Physiotherapy, School of Basic Medical Sciences, College of Medical Sciences, University of Benin, Benin City, Nigeria*

Abstract. *Introduction*. Comparing squatting performance of patients with knee pathologies with normative values may help determine the extent of impairment, inform plan for appropriate intervention and also serve as outcome measure. However, dearth of reference values on squatting performance is a significant limitation. This study provides correlates, predictors and reference ranges for repetitive squatting performance (RSP) in apparently healthy Nigerians. *Material and Methods*. Four hundred and forty-five consenting individuals, whose ages ranged between 18 and 54 years, completed the study. Squatting performance was assessed using repetitive squatting test. Data were also obtained on socio-demographics and anthropometric variables. Data were analyzed using descriptive and inferential statistics. Alpha level was set at p<0.05. *Results*. The mean age and RSP of the participants were 25.2±8.0years and 29.5±11.1reps respectively. Male participants had significantly higher RSP than the females (32.9±10.74 vs. 25.3±10.12 reps; p<0.05). Participants in the > 40yrs age group had the least RSP (21.9±8.51 reps). RSP was significant but inversely correlated with age (r = -0.328; p=0.001), weight and the measures of adiposity (p<0.05). However, RSP was directly correlated with height, lean body mass and trunk length (p<0.05). Age and the anthropometric variables were significant predictors of RSP at 85% variability without gender bias (p<0.05). *Conclusion*. This study established a set of reference values for repetitive squatting performance in healthy Nigerians. RSP was significantly higher in male individuals. Older age and high level of adiposity were associated with lower RSP without gender bias. Age and anthropometric parameters were significant predictors of RSP.
Key words: *squatting, repetitive squat test, reference values.*

Introduction

Squat is a commonly used exercise in the strength and conditioning armamentarium (1). It is a prominent test for lower extremities muscles' strength (2, 3). Squat, a functional multiple joint exercise, is biomechanically akin to many motions and movements required in many day to day tasks, chores and hobbies (1). Further, it is regarded as a valuable tool in strength and functional performance training of the lower extremities, hips and lower back musculature usually required for basic skills in many activities of daily living in patients and athletic populations (1-3). In addition to its use in injury and complaint-risk evaluation (4), squat is considered to be a golden exercise for improving quality of life because of its ability to engage multiple muscle groups in a single maneuver (5).

Squat tests are widely documented as a valid functional capacity performance test (6-8). Although, the safety of squat performance tests remains at best debatable (5), the majority of research opines that it is both harmless and effective if performed correctly (9, 10). Squat performance relies on muscle activity at both the hip and ankle joints and recruits the abdominals and spinal erectors as well (11). Majorly, the quadriceps, hamstrings, gastrocnemius and gluteus muscles are involved during a squat (12).

Alongside functional capacity evaluation tests such as back endurance, sit-up and arch-up tests, squat performance testing are gradually becoming common in literature (6, 7, 13-15). Of the different squat tests, Repetitive Squat Test (RST) is reported to demonstrate excellent psychometric properties with respect to

validity and reliability (6, 7, 13, 16). RST, as a functional capacity evaluation tool, is used to establish a rehabilitation prescription, determine return to work goals, and determine an end point of care (6, 7, 13-15).
Establishment of reference or normative databases for functional capacity evaluation tests including repetitive squatting are useful to set clear goals in patients' rehabilitation (15-20), provide documentation of treatment progress and also serve as target and motivation to facilitate better compliance or program adherence (16-22).
However, normative databases developed among Europeans, Caucasians and Asians may have limited applicability among Africans because of the significant anthropometric and morphologic differences that exist. In addition, functional capacity evaluation tests results are significantly influenced by demographic, anthropometric and morphologic, psychological, and pathophysiological characteristics which accounts for the variations that exist in normative or reference databases across different populations (23, 24). Unfortunately, there seems to be a dearth of reference database on squatting performance in sub-Sahara Africa. This study provides correlates, predictors and reference ranges for Repetitive Squatting Performance (RSP) in apparently healthy Nigerians.

Material and Method

Four hundred and forty-five, 243 (54.6%) males and 202 (45.4%) females, consenting individuals whose ages ranged between 18 and 54 years completed the study.
The participants were volunteers who included staff and students of Obafemi Awolowo University (OAU) and individuals from Ile-Ife community and they were screened via interview to ensure eligibility. Participants were excluded if they had a positive history of symptomatic knee pain, osteoarthritis and/or low-back pain within one year to the time of the study, obvious spinal deformity or neurological disease, cardiovascular diseases contraindications to exercise or previous involvement in competitive sport or athletics. Ethical approval for the study was obtained from the Institute of Public Health, Obafemi Awolowo University, Ile-Ife, Nigeria. Each participant granted informed consent to participate in the study.
Anthropometric variables assessed in this study included height, weight, Body Mass Index (BMI), Percentage Body Fat (PBF), Body Fat Mass (BFM), Lean Body Mass (LBM), trunk length (TL) and lower limb length (LL). A height meter was used to assess the height of each participant to the nearest 0.1cm. Participants stood barefoot on the platform of the scale while looking straight ahead during measurement. Body weight in light clothes was measured to the nearest 0.1kg using a weighing scale with the participant in standing and shoes off. A Bioelectric Impedance Analysis (BIA) device (Omron BF306; Mod. HBF-306-E. CC- , Japan) was used to measure the percentage body fat (PBF) of all participants.
BMI was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). Body Fat Mass (BFM) was calculated from the BIA estimate of the Percentage Body Fat (PBF) using the formula:
BFM = (PBF X total body weight)/100. Lean body mass (kg) was calculated from the PBF estimate of the BIA. LBM (kg) was calculated by subtracting BFM (kg) from total body weight (kg).
Procedures. Repetitive squat test was used to assess squatting performance. Prior testing, one of the researchers (OF) demonstrated the test procedure to each of the participants. Each participant stood with his/her feet 15cm apart and squatted until the thighs were horizontal. The participant then returned to the upright (starting) position. The squatting sequence was repeated until fatigue, and each repetition lasted about two seconds in duration. A metronome set at 30 beats/min provided the speed of movement for the squatting. The number of squats performed by each participant synchronous to the metronome tempo was recorded. A maximum number of 50 repetitions was allowed. Participants who could not maintain the starting position, whose squat motions were non-synchronous with the metronome tempo and who refused to continue with the test procedure were excluded from the study (6, 17).
Data analysis. Data were summarised using descriptive statistics of mean, standard deviation, frequency distribution and percentages. The RSP values between male and female participants were compared using the independent t-test. Pearson product moment correlation analysis was used to assess the relationship between RSP and each of age and anthropometric parameters. Spearman's rank correlation was used to test the relationship between gender and RSP. Analysis of Variance (ANOVA) and LSD post-hoc was used to compare RSP across different age groups.

Multiple regression analysis was used to establish the predictors of RSP. Alpha level was set at p<0.05. The data analyses were carried out using SPSS 16.0 version software (SPSS Inc., Chicago, Illinois, USA).

Results

The general characteristics and RSP of all the participants are presented in table I. The mean age and RSP score of all participants was 25.2 ± 8.0 years and 29.5±11.11 reps respectively. The female participants were significantly older than the males (23.9±6.99 years vs. 26.7±8.55 years; p=0.001) while the male participants had significantly higher RSP score (32.9±10.74 vs. 25.3±10.10; p=0.001). The measures of adiposity (BMI, PBF, BFM) and TL were significantly higher among the female participants (p<0.05) while height, LBM and LL values of male participants were significantly (p<0.05). For the purpose of establishing gender and age reference value table for RSP, the participants were classified into <20yrs, 21-30yrs, 31-40yrs and >40yrs age bracket respectively. Most (59.8%) of the participants were in the 21-30yrs age group. Table II shows One-way ANOVA comparison of the general characteristics and RSP across age groups. The highest (31.2±1.10 reps) and least (21.9±8.51 reps) RSP scores were observed in the 21-30 yrs and > 40yrs age group respectively.

Table I. General characteristics and Repetitive Squatting of all participants .

	All participants (N=445)			Male (n=243)	Female (n=202)		
Variable	Mean±SD	Min	Max	Mean±SD	Mean±SD	t-cal	p-value
Age (yrs)	25.2±8.00	18.0	54.0	23.9± 6.99	26.7±8.85	-3.744	0.001*
Height (m)	1.7±0.09	1.20	1.90	1.7±0.68	1.6±0.77	18.352	0.001*
Weight (kg)	65.0±11.69	40.0	116.0	65.2±9.71	64.7±13.73	0.415	0.678*
BMI (kg/m^2)	23.3±4.60	14.7	40.0	21.8±3.16	25.2±5.32	-8.363	0.001*
PBF	24.1±10.96	5.80	49.7	17.1±7.56	32.4±8.18	-20.551	0.001 *
LBM	48.7±8.29	25.1	75.8	53.6±6.82	42.9±5.66	17.917	0.001*
BFM	16.2±9.60	22.6	56.6	11.5±6.60	21.9±9.65	-13.364	0.001*
TL	0.8±0.05	0.70	0.90	0.8±0.04	0.9±0.05	-22.97	0.001*
LL	1.3±5.57	0.98	1.34	1.3±5.59	1.2±5.57	0.072	0.943
RSP	29.5±11.1	18.0	50.0	32.9±10.74	25.3±10.10	27.59	0,001*

Key: *BMI= Body Mass Index; PBF= Percentage Body Fat; LBM= Lean Body Mass; BFM= Body Fat Mass; TL= Trunk Length; LL= Limb Length; RSP= Repetitive Squatting Performance*
**Indicates significant difference between groups*

Table II. One – way ANOVA and LSD post-hoc comparisons of the general characteristics and Repetitive Squatting Performance of all the participants by age category

Variable	<20yrs (N=96) $\bar{\chi}$ ±S.D	21-30yrs (N=266) $\bar{\chi}$ ±S.D	31-40yrs (N=53) $\bar{\chi}$ ±S.D	>40yrs (N=30) $\bar{\chi}$ ±S.D	F-ratio	p-value
Age	18.4±0.48^a	23.2±2.73^b	35.1±2.75^c	47.4±4.07^d	1311.3	0.001*
Height	1.7±0.09^a	1.7±0.10^a	1.6±0.08^b	1.6±0.07^b	4.462	0.004*
Weight	58.6±9.76^a	63.8±9.47^b	75.2±13.47^c	77.7±11.30^c	47.253	0.001*
BMI	21.1±3.18^a	22.6±3.80^a	27.7±4.98^b	29.3±4.38^b	60.583	0.001*
PBF	20.1±9.04^a	21.9±9.94^a	33.5±8.97^b	38.8±6.42^c	52.444	0.001*
BFM	12.04±7.13^a	14.2±7.62^a	25.7±9.95^b	30.6±8.17^c	74.118	0.001*
LBM	46.5±7.87^a	49.6±8.48^b	49.5±8.58^b	47.1±5.74^a	3.804	0.010*
TL	0.8±0.05^a	0.8±0.05^a	0.80±0.06^a	0.8±0.04^a	3.643	0.013*
LL	1.1±8.08^a	0.9±0.06^b	1.1±11.97^a	0.9±0.06^b	1.539	0.204
RS	31.1±10.80^a	31.2±11.01^a	22.4±8.92^b	21.9±8.51^b	15.957	0.001*

**Indicates significant difference within groups. Superscripts (^{a,b,c,d}). For a particular variable, mean values with different superscript are significantly (p<0.05) different. Mean values with same superscripts are not significantly (p>0.05) different.*

Table III shows the mean and percentiles for RSP for all participants by age and gender. The mean, standard deviation, range and 25th, 50th, and 75th percentile scores were determined for four gender/age categories.
Table IV shows the frequency distribution of RSP categories. The result shows that most of the participants had medium squat levels (53.0%). Spearman rank correlation analysis showed a significant inverse correlation between gender and RSP (r = -0.345; p=0.001).
Table V shows the result of the Pearson's correlation between RSP and the general characteristics of the participants. Significant correlation was found between RSP and each of age, height, weight, BMI, PBF, BFM, LBM and TL (p<0.05). However, there was no significant correlation between RSP and LL (p>0.05). Pearson's product moment correlation between RSP and general characteristics participants by gender is presented in table VI.
Regression model was fitted to predict RSP from Age, Height, BMI, PBF, LBM, BFM, TL and LL as the independent variables. The regression model for RSP (Y) from the independent variables for all participants is:

Y = B0 + B1 x 1 + B2 x 2 + B3 x 3 + B4 x 4 + B5 x 5 + B6 x 6+ B7x 7 + B8 x 8

Y = 28.208 + (-0.241) + (20.748) + (1.14) + (2) + (2.045) + (1.464) + (53.921) + (0.064)

Y = 28.208 - 0.241(Age) + 20.748 (Height) + 1.14 (BMI) + 2(PBF) + 2.045 (LBM) + 1.464(BFM) + 53.921(TL) + 0.064 (LL)

The regression model for RSP for males is:

Y = B0 + B1 x 1 + B2 x 2 + B3 x 3 + B4 x 4 + B5 x 5 + B6 x 6+ B7x 7 + B8 x 8 + B9 x 9

Y = 220.087 + (-0.333) + (-226.288) + (3.903) + (-13.98) + (1.48) + (-0.66) + (-5.068) + (166.912) + (-0.486)

Y= 220.087 - 0.333(Age) – 226.288 (Height) + 3.903 (Weight) – 13.98 (BMI) + 1.48 (PBF) -0.66 (LBM) – 5.068 (BFM) + 166.912 (TL) – 0.486 (LL)

The regression model for RSP for females is:

Y = B0 + B1 x 1 + B2 x 2 + B3 x 3 + B4 x 4 + B5 x 5 + B6 x 6+ B7x 7 + B8 x 8

Y = 28.208 + (-0.241) + (20.748) + (1.14) + (-2) + (-2.045) + (1.464) + (53.921) + (0.064)

Y = 28.208 -0.241 (Age) + 20.748 (Height) + 1.14(BMI) -2 (PBF) – 2.045 (LBM) + 1.464 (BFM) + 53.921(TL) + 0.064(LL)

Table III. The mean and percentile data for Repetitive Squatting Performance of all the participants by age and gender

Age group	Subject Gender	n	RSP Mean±SD	minimum	25^{th} percentile	median	75^{th}percentile	95^{th}percentile	maximum
16-54	M	233	33.5±1.03	9.0	25.0	34.0	41.0	50.0	50.0
	F	212	25±1.02	6.0	18.0	23.0	32.0	46.4	50.0
	(M+F)	445	29.5±1.11	6.0	20.0	30.0	38.0	50.0	50.0
<20	M	52	34.1±1.05	13.0	25.3	35.0	43.0	50.0	50.0
	F	44	27.5±1.00	7.0	20.0	29.0	34.0	46.5	50.0
	(M+F)	96	31.0±1.08	7.0	23.0	31.0	39.0	50.0	50.0
21-30	M	159	34.3±1.00	10.0	28.0	35.0	41.0	50.0	50.0
	F	107	26.4±1.07	9.0	20.0	23.0	34.0	50.0	50.0
	(M+F)	266	31.2±1.10	9.0	21.0	31.0	40.0	50.0	50.0
31-40	M	17	26.2±9.26	9.0	20.5	25.0	2.0	41.0	41.0
	F	36	20.6±8.30	7.0	15.3	20.0	26.5	36.8	41.0
	(M+F)	53	22.4±8.90	7.0	16.5	21.0	30.0	40.3	41.0
>40	M	15	21.1±1.08	6.0	13.0	19.0	32.0	43.0	43.0
	F	15	22.7± 5.70	10.0	17.0	23.0	27.0	30.0	30.0
	(M+F)	30	21.9±8.50	6.0	17.0	21.0	27.5	40.3	43.0

Key: M=Male; F=Female; (M+F) = Male and Female; RSP - Repetitive Squatting Performance

Table IV. Frequency distribution of all participants Repetitive Squatting levels

	Performance Category Poor n(%)	Medium n(%)	Good n(%)	χ^2	p-value
Male	66(60.0)	129(54.7)	48(48.5)	2.79	0.25
Female	44(40.0)	107(45.3)	51(51.5)		
All participants	110(24.7)	236(53.0)	99(22.2)		

Percentiles were used to categorize Repetitive Squatting Performance (RSP) as poor RSP (< 25th percentile), medium RSP (25th–75^{th} percentile) and good RSP (>75th percentile).

Table V. Pearson's product correlation between RS and the dependent variables of all the participants (N=445)

Variable	r	p
Age (years)	-0.33	0.001**
Height (m)	0.21	0.001**
Weight (kg)	-0.20	0.001**
BMI (kg/m^2)	-0.31	0.001**
PBF	-0.41	0.001**
BFM	-0.38	0.001**
LBM	0.16	0.001**
TL	0.20	0.001**
LL	0.02	0.622

*p<0.05 **p<0.01

Table VI. Pearson's product moment correlation of relationship between Repetitive Squatting Performance and general characteristics participants by gender

	Male (n=243)		Female (n=202)	
Variable	r	p	r	p
Age	-0.33	0.001**	-0.26	0.001**
Height (m)	-0.02	0.794	-0.03	0.700
Weight (Kg)	-0.27	0.001**	-0.18	0.009**
BMI (Kg/m^2)	-0.29	0.001**	-0.16	0.023*
PBF	-0.30	0.001**	-0.20	0.005**
BFM	-0.33	0.001**	-0.19	0.006**
LBM	-0.07	0.303	-0.11	0.114
TL	0.05	0.457	0.01	0.890
LL	-0.07	0.264	0.03	0.646

Discussion

This study provides the correlates, predictors and reference ranges for RSP in apparently healthy Nigerians. The participants in this study were relatively young. The pattern of anthropometric characteristics of the participants with respect to females having higher measures of adiposity and trunk length were consistent with previous studies on body composition (with the exception of BMI which is usually higher among males) and morphological differences between genders (25, 26). The mean RSP value of participants in this study was (29.5±11.11 reps). Based on percentile scores, a RSP less than 20 reps was considered as poor, RSP between 20 and 38 reps was considered medium performance while RSP between 38 and 50 reps was defined as good performance.

Mean values repetitive squatting test have been documented from some previous studies among normal adults for different populations (7, 13). The normative data exists for the squat test and these are stratified by age, gender, and occupational status (27). For the purpose of establishing gender and age reference value tables for RSP, participants were classified into four age groups <20 years, 21-30yrs,31-40years, >40 years respectively. The gender pattern for RSP showed a propensity for higher repetitive squatting among males. This pattern is consistent with the study by Alaranta et al. (13) who reported higher mean values of repetitive squat test among male white collar workers than their female counterparts (43 ± 10 reps among males vs. 23 ± 12reps among females). In comparison with the study of Alaranta et al (13), the mean RSP value for male participants in RSP in the present study was lower; on the other hand, a higher mean RSP value was recorded among the females in the current study.

As observed in this study and also in the comparison study (13), higher mean values of repetitive squat test among male individuals was evident across the age categories. Comparison was made only with RSP obtained from white collar workers in the previous study because participants in this present study were mostly white collar staff, and also students of the University. Further studies are however warranted on RSP values among blue collar workers in this environment. Further, McIntosh et al. (7) also reported higher median values of repetitive squat test among males than females. Age-linked strength losses are mainly as a result of decline in skeletal muscle mass in men and women. While women may experience earlier strength losses than men, overall, age-associated decreases in strength are similar when controlling for muscle mass

(28). However, comparison of the reference values obtained in this study with previous reports may be difficult. This is because of variations in methodology, sample differences, inconsistent pattern of result presentations and variations in the definition and measurement of the construct which may translate into considerable discrepancies.

From the result, participants between the age group of >40years had lower mean number of squats value, the participants between the age group of <20years and age bracket 21-30 years respectively were comparable in their mean repetitive squatting but had higher values than the older age group. Repetitive squatting peaked among the participants in the 21-30yrs age bracket and declined thereafter. Among the female participants, repetitive squatting peaked in the < 20years age bracket and declined thereafter. Among the males however, repetitive squatting rose and peaked at age 21-30 before decline. These findings are line with previous studies which showed that endurance generally decreases with age (7, 13).

The finding of this study showed no significant correlation between repetitive squatting and LL among all the participants. However, significant correlations were found between repetitive squatting and each of age, height, weight, BMI, PBF, BFM, LBM and TL among participants. On gender basis, the result of this study showed no significant correlation between repetitive squatting and each of height, LBM, TL and LL among the female participants. This findings were similar among the male participants, whose repetitive squatting performance correlated only with each of age, weight, BMI, PBF and BFM. In this study, each of the adiposity parameters (BMI, LBM) showed an inverse relationship with repetitive squatting. The mean BMI (23.3±4.6 Kg/m^2) and PBF (24.1±10.96) of the participants in this study implied that over 50% of the participants were in the healthy BMI and PBF categories respectively. Based on the classification of participants into lean, acceptable, moderate, and overweight categories using the percentage body fat level classifications, significant differences were found in the repetitive squatting of all participants respectively among the various categories. This study revealed lower repetitive squatting among the overweight category than the lean, acceptable and moderate categories. This result showed that repetitive squatting decreased with increasing level of adiposity. Lastly, the regression analysis result showed that age, BMI, PBF, LBM, TL and LL were predictors of repetitive squatting. In the regression equation, total body weight was not a variable for predicting repetitive squatting among females, however, height, weight, BMI, PBF, LBM, TL and LL reflected better among males.

Conclusion

This study established a set of reference values for repetitive squatting in healthy Nigerians. Males had significant higher repetitive squatting than females. Higher age and adiposity parameters were associated with lower repetitive squatting without gender bias. Age and anthropometric parameters were significant predictors of repetitive squatting. These values can be used to compare a patient’s score at intake or as an outcome measure in clinical practice.

Acknowledgement. The authors wish to thank the African Population and Health Research Centre (APHRC), Nairobi, Kenya for providing technical support through the African Doctoral Dissertation Research Fellowship (ADDRF) Post-Doctoral Fellowship. ADDRF is funded by the International Development and Research Centre (IDRC), Canada.

References

1. Schoenfeld BJ (2010). Squatting kinematics and kinetics and their application to exercise performance. *J Strength Cond Res*; 24(12): 3497–3506.
2. Escamilla RF (2001). Knee biomechanics of the dynamic squat exercise. *Med Sci Sports Exerc*; 33: 127–141.
3. Escamilla RF, Fleisig GS, Zheng N, Lander JE, Barrentine SW, Andrews JR et al (2001). Effects of technique variations on knee biomechanics during the squat and leg press. *Med Sci Sports Exerc*; 33: 1552–1566.
4. Müller (1999). The effect of axial load on the sagittal plane curvature of the upright human spine in vivo. *J Biomech*; 41: 2850-4
5. Fry AC, Smith JC, Schilling BK (2003). Effect of knee position on hip and knee torques during the barbell squat. *J Strength Cond Res*; 17: 629–633.
6. Yeoman SG (2000). Measuring physical performance. Chapter 16. In: *The Clinical application of outcomes assessment*. Appleton and Lange, Stamford, Connecticut. pp 289-356.

7. McIntosh G, Wilson L, Affleck M, Hall H (1998). Trunk and lower extremity muscle endurance: normative data for adults. *J Rehabil Outcome Meas*; 2: 20–39.
8. Cook G, Burton L, Hoogenboom B (2006). Pre-participation screening: the use of fundamental movements as an Assessment of function – part 1. *North Am J Sports Physical Therapy*; 1(2): 62-72
9. Chandler TJ. & Stone MH. (1991). The Squat exercise in athletic conditioning: A position statement and review of the literature. *National Strenght & Conditioning Association Journal*; 13(5): 51-8.
10. Dunn BK, Klein B, Kroll T, Mclaughun P, O'Shea, Wathen D. (1984). Coaches round table: The squat and its application to athletic performance. *Strength Cond. J*; 6: 10-22, 68.
11. Delavier F. (2001). *Strength Training Anatomy Champaign*, Human Kinetics. pp79-82.
12. Baechle T & Earle R. (2000). *Essentials of Strength Training and Conditioning* (2nd ed.). Champaign: Human Kinetics. pp366-369.
13. Alaranta H, Hurri H, Heliovaara M. (1994). Non-dynamometric trunk performance test: reliability and normative data. *Scand J Rehab Med*; 26:211-215.
14. Moreau CE, Green BN, Johnson CD, Moreau SR. (2001). Isometric back extension endurance tests: a review of the literature. *J Manipulative Physiol Ther*. 24(2): 110-22.
15. Soer R, van der Schans, CP, Geertzen JH, et al (2009). Normative values for a functional capacity evaluation. *Arch Phys Med Rehabil*; 90:1785-94.
16. McGill SM, Childs A, Liebenson C. Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database. *Arch Phys Med Rehabil*; 80(8): 941–944.
17. Yeomans SG and Liebenson C. (1996). Functional Capacity Evaluation and Chiropractic Case Management. *Topics In Clinical Chiropractics*; 3 (3): 15-25.
18. Gibson L and Strong J. (1997). A review of functional capacity evaluation practice.*Work*; 9(1): 3-11.
19. Gross DP, Battle MC, Cassidy JD. (2004). The Prognostic Value of Functional Capacity Evaluation in Patients with Chronic Low Back Pain: Part 1: Timely Return to Work. *Spine*; 29(8): 914–919.
20. Chen JJ. (2007). Functional Capacity Evaluation & Disability. *Iowa Orthop J*; 27: 121–127.
21. Lechner, Deborah E., Jill J. Page, Grover Sheffield. (2008). Predictive validity of a functional capacity evaluation: The physical work performance evaluation. *Work: A Journal of Prevention, Assessment and Rehabilitation*; 31(1): 21-25.
22. Mahmud N, Schonstein E, Schaafsma F, et al (2010). Functional capacity evaluations for preventing re-injuries in injured workers. *Cochrane Database of Systemic Reviews*. 7. Art. No.: CD007290
23. Bouchard C, Lotrie G. (1984). Heredity and endurance performance. *Sports Medicine*; 1: 38-64.
24. Bouchard C, Malina RM, Pérusse L. (1997). *Genetics of Fitness and Physical Performance*. Human Kinetics, Champaign, IL.
25. Docherty D, Gaul CA. (1991). Relationship of body size, physique and composition to physical performance in young boys and girls. *International Journal of Sport Medicine*; 12: 525-532.
26. Marras WS, Jorgensen MJ, Granata KP, Wiand B. (2001). Female and Male Trunk Geometry: Size and Prediction ofthe Spine Loading Trunk Muscles Derived from MRI. *Clinical Biomechanics*; 16(1): 38-46.
27. Liebenson C. & Yeomans SG.(1997). Outcomes assessment in musculoskeletal medicine. Man Ther. 2:67-74.
28. Doherty TJ. (2001). The influence of aging and sex on skeletal muscle mass and strength. *Current Opinion in Clinical and Metabolic Care*; 4(6): 503-508.

Corresponding author
Dr. Olusola Ayanniyi,
Physiotherapy Department,
College of Medicine,
University of Ibadan/ UCH,
Ibadan, NIGERIA
Email address: *drayanniyi@gmail.com*

Received: July 10, 2015
Accepted: October 20, 2015