Normative Values of Spinal Flexibility for Nigerians Using the Inclinometric Technique

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Abstract

Normative values of spine range of motion (ROM) are essential for proper diagnosis of spinal impairments and in the monitoring of effect of treatment and patient's recovery. This study established gender and age normative data and the correlates of spinal flexibility in apparently healthy Nigerians adults. 502 volunteers whose ages ranged between 18 and 47 years participated in the study. Dual inclinometric technique was used to measure spinal flexibility in forward flexion, extension, right and left lateral flexion. Flexibility levels were defined using percentiles as poor (<25th), moderate (between 25th and 75th), good (between 75th and 95th), and very good (>95th) respectively. Data was analyzed using descriptive and inferential statistics at 0.05 alpha level. The mean value for forward flexion, extension right and left lateral flexion for all participants was 43.3+12.7, 16.7+6.81, 17.3+6.25 and 17.0+5.65. Females exhibited significantly higher extension (17.4+6.34 vs. 16.1+7.14) and right lateral flexion (18.4+6.30 vs. 16.3+6.07) ROM than their male counterparts ($p<0.05$). Age and anthropometric parameters were significant correlates of spinal flexibility ($p<0.05$). In conclusion, this study established a set of reference values for lumbar spinal flexibility in healthy Nigerians. Increasing age was associated with decreased spinal flexibility.

Key words: Spinal flexibility, dual inclinometer, normative data, Nigerians

Introduction

The nature of flexibility is complex, involving not only the range of motion of a joint or series of joints *(Anderson and Burke, 1991)* but it is affected by internal influences such as the type of joint, the elasticity of muscle tissues, tendon, ligaments, and the skin and also by external influences such as age, gender, the stage in the recovery process of a joint, time of the day *(Alter, 1996; Gummerson, 1990).* Good flexibility aids in the elasticity of the muscles *(Nelson and Kokkonen, 2007),* provides ease in movement and a wider range of motion in the joints *(Nelson and Kokkonen, 2007; Manescu, 2010),* aids with injury prevention *(Shellock and Prentice, 1985),* helps to minimize muscle soreness and improves efficiency in all physical activities *(Nelson and Kokkonen, 2007),* improves quality of life and functional independence *(Podrasky, 1983; Nelson and Kokkonen, 2007).*

Specifically, previous studies have established a relationship between flexibility of the lumbar spine and back health *(Foster and Fulton, 1991; Plowman, 1992; Stutchfield and Coleman, 2006; Battié et al, 2008).* Adequate flexibility of the lumbar spine and the surrounding soft tissues provides for a functional mechanical *advantage (Farfan, 1975),* healthy lower back *(Foster and Fulton, 1991; Plowman, 1992),* attainment of important functional skills and activities of daily living *(Podrasky,* *1983; Nelson and Kokkonen, 2007)* and unimpaired gait capability *(Podrasky et al, 1983)*. Consequent on the foregoing, spinal range of motion (ROM) measurements as been incorporated as a standard part of evaluation of patients with back pain in most clinical settings *(Rothstien, 1985; Yeoman, 2000)* and as a basis for decisions regarding disability and *compensation (Gatchel and Gardea, 1999; Gross and Battié, 2005).* Evaluation of spinal ROM is important in patients with back problems as well as in general fitness assessments and it is also useful in monitoring therapeutic and training outcomes *(Chadwick, 1984; Mayer et al, 1984; Rothstien, 1985; Yeoman, 2000).*

Numerous techniques have been developed to assess spinal flexibility such as visual estimation *(Youdas et al, 1991; Yeoman, 2000),* finger-to-floor distance *(Macre and Wright, 1969),* sit-and-reach measurements *(Christine et al, 1999; Hoeger and Hoeger, 2008),* standard or modified Schober methods *(Macrae and Wright, 1969; Moll et al, 1971),* subjective reports through questionnaires *(Kuornika et al, 1987)* and the use of devices such as flexicurves *(Anderson and Sweetman, 1975; Burton et al, 1989),* protractors and *goniometers (Troup et al, 1968; Fitzgerald et al, 1983; Alaranta et al, 1994a)* and inclinometers *(Mayer et al, 1984; Gill et al, 1988; Alaranta et al, 1994b; Saur et al, 1996).* The preference of technique of spinal ROM evaluation in routine clinical practice is often based on its reliability, validity, simplicity, cost, level of invasiveness and technicality *(Youdas et al, 1991; Yeoman, 2000).* Establishment of reference norms for spinal flexibility requires assessment techniques with high level of validity and reliability. In light of this, the inclinometric technique has been found to be valid and *reliable (Mayer et al, 1984; Saur et al, 1996)* and has been recommended as a valuable tool in routine clinical for assessment of spinal ROM *(Mayer et al, 1984; Saur et al, 1996; Yeoman, 2000).* It is believed that the inclinometric technique could measure and differentiate movements of the hip from those of the lumbar spine *(Mayer et al, 1984; Petra et al, 1996)* and could be learned quickly within a short period of time *(Saur et al, 1996).* Normative values of spine range of motion (ROM) are essential for proper diagnosis of spinal impairments and in the monitoring of effect of treatment and patient's recovery *(Ensink et al, 1996; Yeoman, 2000; Al-Eisa et al, 2006). Uluçam and Ciğali (2009)* summarized that factors such as medical conditions, pelvic asymmetry age, sex, race and geographical distribution are determinants of joint ROM. Dearth of normative values and dependence on criterion standard is a limitation in the assessment of back functions performance *(Hoeger and Hoeger, 2007).* Therefore, it is expedient that every population should have their age-and-gender specific spinal ROM values. There appears to be a dearth of studies on normative values of spinal flexibility in apparently healthy Nigerians. This study was designed to established gender and age normative data and the correlates of spinal flexibility in apparently healthy Nigerians adults using the dual inclinometric technique.

Materials and Methods

Five hundred and two consenting apparently healthy individuals whose ages ranged between 18 to 47 years participated in this study. The participants comprised of students and staff of

Obafemi Awolowo University (OAU), Ile-Ife, Nigeria and other individuals from Ile-Ife community. The participants were screened via interview to ensure that they satisfied the eligibility criteria for the study. Exclusion criteria were a positive history of LBP within 1 year to the time of the study; any obvious spinal deformity or neurological disease such as post-polio syndrome; any history or cardiovascular diseases such as hypertension, stroke, or other cardiac disorders; participation in high-intensity regular exercise or elite sports at a competitive level. The ethical approval for the study was obtained from the Obafemi Awolowo University Teaching Hospitals Complex Institutional Review Committee. The study was conducted at the Exercise Laboratory of the Department of Medical Rehabilitation, OAU, Ile-Ife, Nigeria.

Measurements

Anthropometric measurements included height, weight, body mass index (BMI), limb length (LL) and trunk length (TL). Height was measured to the nearest 0.1cm with a height meter calibrated from 0-200cm. The subject stood barefooted on the platform of the scale looking straight ahead while the horizontal bar attached to the height meter was adjusted to touch the vertex of the head. Weight was measured nearest to the 0.5Kg on a bathroom weighing scale calibrated from 0-120kg with the subject in minimal clothing, barefoot and standing in an erect posture looking straight ahead. LL was measured by taking the distance between the anterior superior iliac spine and the sole of the foot with the participant in an erect position. TL was measured by taking the distance from the anterior superior iliac spine to the acromion process with the participant in an erect position.

Procedure

Dual inclinometric technique was used to assess spinal ROM in flexion, extension, right and left lateral flexion. The assessment procedure for spinal ROM was explained and demonstrated to each consecutive participant at inclusion. Prior to the test, the participants were required to warm up with back stretches and a 5-minute walk at self-determined pace around the research venue. Measurements were carried out with the universal inclinometer based on guidelines provided in the *American Medical Association (AMA) Guides (1993)*. The mean of three consecutive movements was used in the final analysis to determine spinal ROM.

Forward Flexion and Extension Measurement

The upper edge of the sacrum (S1 vertebra) and the lower edge of the T12 vertebra were palpated in the participants in a standing position. The middle of the platform of the first inclinometer was put on the sagittal plane of the spinous process of T12, and the second inclinometer was set on the sagittal plane of the spinous process of S1 and Lumbar Range of Motion (LROM) was determined in degrees using the technique described by *Loebl (1967)*. In the neutral position, the participants were asked to stand erect with their hands hanging without any effort toward the ground. From this position, the participants were then asked to flex forward as far as possible with their knees straight. The readings on the two inclinometers were then taken. The reading on the first inclinometer was the total lumbar flexion and that on the second inclinometer was the sacral flexion. To get the true LROM, the readings of the lower inclinometer was subtracted from those of the upper inclinometer. The flexion protocol was repeated for extension having the participants extend back for full extension instead of flexing forward. The readings were taken three times and the mean of the three values was used as the lumbar ROM *(AMA, 1993; Yeoman 2000).*

Lateral Flexion Measurement

The inclinometers were placed on the frontal planes of the both the S1 and T12 vertebrae so that the bases of the inclinometers line up with the lines drawn at this planes. The two inclinometers were held upside down and not pressed against the back, so that the gravity dependent pendulum swung freely. The participants were then asked to stand erect against a wall with nose nearly touching the wall. This position kept the participants from bending forward during lateral flexion measurements. The participants were asked to laterally flex to the right by running their right hands down the lateral thigh towards the right knee. The readings were then taken from the two inclinometers. The difference between the T12 and the S1 inclinometers gave the true right lateral flexion value. The right lateral flexion procedure was repeated for left lateral flexion having the participants bend to the left instead of bending to the right. The readings were taken three times and the mean of the three values was used as the lumbar range of motion *(AMA, 1993; Yeoman 2000). Data analysis* Data were summarized using descriptive statistics of mean and standard deviation. Independent t-test was used to compare the general characteristics and spinal flexibility values between male and female participants. Analysis of Variance (ANOVA) was used to compare general characteristics and spinal flexibility values across different age groups. Pearson product moment correlation analysis was used to determine the relationship between spinal flexibility and each of age, height, weight, BMI, LL and TL. Alpha level was set at 0.05. SPSS 16.0 version software was used for data analysis.

Results & Discussion

Table 1: Physical characteristics of the subjects.

Variables	**Male**	**Female**	**t-cal**	**p-value**	**All participant**
	N=267	**N=235**			
X +S.D		**X + S.D**		**X +S.D**	
Age (yrs)	**23.1+3.73**	**22.2+3.41**	**2.515**	**0.012***	**22.7+3.60`**
Weight (kg)	**67.2+10.0**	**60.3+10.0**	**7.69**	**0.001***	**64.0+10.5**
Height (m)	**.74+0.08**	**1.65+0.07**	**12.519**	**0.001***	**1.70+0.09**
BMI (kg/m2)	**22.2+2.82**	**22.1+3.57**	**0.422**	**0.673**	**22.1+3.19**
LL	**1.02+0.07**	**0.98+0.06**	**7.262**	**0.001***	**1.00+0.07**
TL	**0.72+0.06**	**0.67+0.05**	**8.989**	**0.001***	**0.70+0.06**

Key: BMI = Body Mass Index; LL= Limb Length; TL= Trunk Length

Table 1 shows the physical characteristics of all participants. The mean age of the participants was 22.7+3.60 years. The result shows that LL and TL of the male participants were significantly higher than that of their female counterparts ($p<0.05$). The participants were classified into four age groups as (<20yrs, 20-25 yrs, 26-30 yrs and >30yrs respectively) and their characteristics were compared as presented in table 2. The result indicated that there were significant differences ($p<0.05$) in all the general characteristics across the different age groups except for height (p=0.303).

Table 2: One-way ANOVA and post-hoc LSD comparison of general characteristics of all participants by age distribution (N=502)

Variables	<20yrs N=45 X±SD	20-25yrs N=388 X±SD	26-30yrs N=56 X±SD	>30yrs N=30 X±SD	F-ratio	p-value
Age	18.6+0.50^{a}	22.0+1.56^{b}	27.1+1.23^{c}	38.0+5.85^{d}	581.285	0.001*
Weight	62.1+12.7^{a}	62.9+10.0^{a}	69.3+8.04^{b}	69.3+8.04^{b}	18.637	0.001*
Height	1.68+0.11	1.69+0.08	1.71+0.08	1.70+0.10	1.218	0.303
BMI	21.9+3.70^{a}	21.8+2.83^{a}	23.6+3.18^{b}	28.0+4.37^{c}	22.812	0.001*
LL	0.98+0.07^{a}	1.01+0.06^{b}	1.01+0.07^{b}	0.92+0.16^{c}	7.809	0.001*
TL	0.70+0.05^{a}	0.69+0.05^{a}	0.71+0.07^{a}	0.78+0.07^{b}	12.089	0.001*

Superscripts** $^{a, b, c, d}$ **– for a particular variable, mode means with different superscript are not significantly (p>0.05) different. Mode means with same superscript are significantly (p<0.05) different

Table 3: Spinal flexibility of all the participants (N=502)

Variables	Male N=267 X +S.D	Female N=235 X + S.D	t-cal	p-value	All participant X + S.D
FF	43.3+12.1^{0}	43.3+13.4^{0}	0.014	0.989	43.3+12.7^{0}
EXT	16.1+7.14^{0}	17.4+6.34^{0}	-2.261	0.024*	16.7+6.81^{0}
RF	16.3+6.07^{0}	18.4+6.30^{0}	-3.666	0.001*	17.3+6.25^{0}
LF	17.0+5.48^{0}	17.1+5.85^{0}	-0.26	0.795	17.0+5.65^{0}

Key: FF = Forward Flexion; EXT = Extension; RLF = right lateral flexion; LLF = Left Lateral Flexion; (˚) = Degree

The spinal flexibility value of all participants is presented in table 3. From the result, significant differences were also observed in right lateral flexion (p=0.001) and extension (p=0.024) between male and female participants.

Table 4: One-Way ANOVA and post-hoc LSD Comparison of spinal flexibility of all participants by age distribution

Variables	< 20yrs N=45 X+S.D	20-25yrs N=388 X+S.D	26-30yrs N=56 X+S.D	>30yrs N=13 X+S.D	F-ratio	p-value
FF	42.9+11.4^{0}	43.2+12.6^{0}	44.3+15.0^{0}	43.4+9.62^{0}	0.153	0.928
EXT	18.5+8.47^{0a}	16.9+6.59^{0b}	15.3+6.68^{0b}	12.3+4.85^{0c}	3.739	0.011
RF	15.6+5.85^{0a}	17.6+6.47^{0b}	17.1+4.75^{0b}	13.3+4.65^{0c}	3.271	0.021
LF	17.06+5.88^{0a}	17.3+5.74^{0a}	16.4+4.64^{0a}	13.4+1.41^{0b}	2.318	0.075

KEY: FF = FORWARD FLEXION; EXT = EXTENSION; RLF = RIGHT LATERAL FLEXION; LLF = LEFT LATERAL FLEXION; (˚) = DEGREE

Superscripts ^{a,b,c} – for a particular variable, mode means with different superscript are not significantly (p>0.05) different. Mode means with same superscript are significantly (p<0.05) different

Table 4 shows the comparison of spinal flexibility of all participants by age distribution. Extension (p=0.011) and right lateral flexion (p=0.021) significantly decreased with increasing age. Forward flexion was comparable across the different age groups (p=0.928). However, left lateral flexion decreased with increasing age but was not statistically significant (p=0.075). The mean, standard deviation, range and 25th, 50th, 75th and 95th percentile scores were determined for four gender/ age categories for spinal flexibility of all participants as presented in tables 5 and 6. Flexibility levels were defined using percentiles as poor (<25th), moderate (between 25th and 75th), good (between 75th and 95th), and very good (>95th) respectively.

Table 5: Mean score and percentile data of spinal flexibility in forward flexion and extension (values are in degrees)

Variable	Age group	Sex	N	X+S.D	min	25th	median	75th	95th	max
					Percentile					
Forward Flexion	≤20	M	22	44.2±9.55	24	36.25	46.67	51.17	58.67	58.67
	≤20	F	23	41.7±1.30	18	29.67	48	52.33	57.53	58
	20-25	M	198	42.6+1.23	14	35.5	43.33	49.75	61.88	78.67
	20-25	F	190	43.7+1.28	15.33	34.17	45.67	53.42	64.15	71.33
	26-30	M	40	46.3+1.22	25.33	38.42	49.17	54.85	63.33	69.33
	26-30	F	16	39.4+2.02	8.33	26.75	37	58.58	68.33	68.33
	> 30	M	7	41.8+1.16	25	30	40.67	51.33	56	56
	> 30	F	6	45.2+7.42	36.67	39.92	42.33	54	55	55
	18- 47	M	267	43.3+1.21	14	36	43.67	51	62.67	78.67
	18- 47	F	235	43.3+1.34	8.33	33.33	45.33	53.67	64.07	71.33
		(M&F)	502	43.3+1.27	8.33	35	44	52.33	63.33	78.67
Extension	<20	M	22	18.6+9.87	6.33	10	17.5	24.08	44.15	45
	<20	F	23	18.4+7.11	9.33	13.67	18.33	21.33	40.33	43.33
	20-25	M	198	15.9+6.85	4.67	11	15	20.17	29.67	42
	20-25	F	190	17.8+6.18	5.33	13.33	16.67	21.67	30.15	71.33
	26-30	M	40	15.7+7.07	8	11.42	12.67	18.16	33.4	40
	26-30	F	16	14.5+5.73	7	10.41	13.67	18.42	25.67	25.67
	>30	M	7	14.2+4.97	6	10	14	19	19.67	19.67
	>30	F	6	10.1+4.01	5.67	6.67	9.33	14.5	15	15
	18- 47	M	267	16.1+7.14	4.67	11	15	20	29.67	45
	18- 47	F	235	17.4+6.34	5.33	13.33	16.33	21.33	30	43.33
		(M&F)	502	16.7+6.81	4.67	11.67	15.67	21	30	45

Table 6: Mean score and percentile data of spinal flexibility in forward flexion and extension (values are in degrees)

Variable	Age group	Sex	N	X±S.D	min	25th	median	75th	95th
					Percentile				
Right Spinal Flexion	<20	M	22	14.3+5.72	6.33	9.17	14	19.33	24.87
	<20	F	23	16.8+5.84	7	12	17.33	19.67	28.53
	20-25	M	198	16.6+6.43	5	12.33	15.67	21	28.33
	20-25	F	190	18.7+6.34	6.33	13.92	19	23.08	29.82
	26-30	M	40	16.6+3.98	8	13.33	16.5	19.58	22.98
	26-30	F	16	18.3+6.27	11	13.08	16.83	23.25	30
	> 30	M	7	14.0+5.64	9.67	10	11.67	17.33	25.33
	> 30	F	6	12.4+3.46	8.67	9.67	11.67	15.3	18.3
	18- 47	M	267	16.3+6.07	5	12.33	15.5	20.75	26.67
	18- 47	F	235	18.4+6.30	6.33	13.33	18.33	23.33	29.4
		(M&F)	502	17.3+6.25	5	12.67	17	21.33	28.33
Left Flexion	<20	M	22	16.2+5.47	8	11.83	16	20.16	27.8
	<20	F	23	17.9+6.25	7.33	13	17.67	23.33	31.6
	20-25	M	198	17.5+5.56	2	13.92	18.17	21.08	25.68
	20-25	F	190	17.0+5.93	4	12.33	17.5	21	25.6
	26-30	M	40	15.7+4.58	5	13.08	16	18.58	24.55
	26-30	F	16	17.9+4.55	11.67	13.33	18.5	22.67	24.33
	> 30	M	7	12.1+4.55	11.7	13.33	18.5	22.7	24.33
	> 30	F	6	14.9+5.20	10	11.75	14	16.75	24.33
	18- 47	M	267	17.0+5.48	2	13.25	17	20.67	25
	18- 47	F	235	17.1+5.85	4	12.67	17.33	21	25.27
		(M&F)	502	17.0+5.65	2	13	17.33	20.83	25

The correlates of spinal flexibility were determined among the participants. Significant correlations were found between age and left flexion (r=-0.144; p=0.001), age and extension (r=-0.169; p=0.001), weight and forward flexion(r=0.088, p=0.050), height and extension (r=-0.114, p=0.011) and trunk length and extension (r=-0.109; p=0.014) respectively.

Table 7: Correlation of age and general characteristics with spinal flexibility of all participants

	AGE	WT	HT	LL	TL	BMI	FF	EXT	RF
AGE	-								
WT	0.330*	-							
	0.001								
HT	0.089*	0.529*	-						
	0.046	0.001							
LL	-0.106*	0.350*	0.768*	-					
	0.017	0.001	0.001						
TL	0.272*	0.385*	0.593*	0.016	-				
	0.001	0.001	0.001	0.178					
BMI	0.329*	0.773	-0.122*	-0.165	0.061	-			
	0.001	0.001	0.006	0.001	0.715				
FF	0.034	0.088*	-0.016	-0.023	0.004	0.119	-		
	0.442	0.05	0.721	0.602	0.922	0.008			
EXT	-0.169*	-0.073	-0.114*	-0.054	-0.109*	-0.017	0.205	-	
	0.001	0.104	0.011	0.226	0.014	0.707	0.001		
RF	-0.078	-0.067	-0.065	-0.035	-0.057	-0.04	0.158*	0.220*	-
	0.079	0.136	0.146	0.433	0.2	0.371	0.001	0.001	
LF	-0.144*	-0.007	-0.064	0.014	-0.117*	0.029	0.048	0.255*	0.230*
	0.001	0.868	0.155	0.749	0.009	0.516	0.288	0.001	0.001

Key: Wt- weight; TL- trunk length; Ht- height; LL- limb length; FF- forward flexion; Ext- extension, RLF- right lateral flexion; LLF- left lateral flexion

Discussion

This study established gender and age normative data and the correlates of spinal flexibility in apparently healthy Nigerians adults using the dual inclinometric technique. Participants in this study were young adults with the mean age of 22.7+3.60 years and the 20-25yrs age bracket. The male participants had significantly higher TL and LL than their female counterparts. Literature is replete on the gender dependent differences in body segment proportions between male and female *(Cooper et al, 1992; Marras et al, 1987; 2001; Xu et al, 1999; Sizer and James, 2008; Norton et al, 2004; Brown et al, 2002).* Contrary to the finding of this study, females generally have been reported to have longer trunk and shorter legs than men *(Tichauer, 1978; Marras et al, 2001)* and these differences can significantly impact on variables such as spine loading *(Marras et al, 2001)* and mechanical efficiency in physical performance assessments *(Decker et al, 2003).* In addition, variation in body segment length have been found to be significantly correlated with range of motion test result especially toe-touch flexibility *(Alter, 1996).* Literature reveals that variation in body morphology and geometry are related to physical performance *(Jaric et al, 2005; Nevill et al, 1992; Winter and Nevill, 1995; Nevill et al, 2005)* which differs among racial groups *(Alter, 1996; Sumiski et al, 2002).* Body morphology and geometry have been found to vary according to race and geographical population *(Tanner et al, 1982; Lohman et al, 1988; Ruff, 2002; Wagner and Heyward, 2007).* Consequently, population-specific health related physical performance norms are recommended *(Ross et al, 1987; Hoffman, 2006; Catley and Tomkinson, 2012).*

The mean value for forward flexion, extension, right and left lateral flexion for all participants in this study was 43.3±12.7, 16.7±6.81, 17.3±6.25 and 17.0±5.65 respectively. *Magee (1992)* submitted that the archetypal lumbar spine should be able to flex forward 40 to 60^0, with extension normally limited to 20 to 35^0, while left and right lateral flexion should be approximately 15 to 20^0. The result of this study revealed that the mean extension ($17.4+6.34^0$) and right lateral flexion ($18.4+6.30^0$) of female participants were significantly higher than that of their male counterparts. These results corroborates with previous studies that suggest that females are more flexible than males *(Haley et al, 1986; Alter, 1996; Knudson et al, 2000).* In addition to structural differences, males appear to have greater stiffness and decreased segmental motion in the lumbar spine compared to females *(Brown et al, 2002). Moll et al (1972)* also confirmed that lateral flexion is greater in females than in male while *Haley et al (1986)* stated that girls had greater lumbar spine mobility than boys in side bending. Furthermore, this study's result showed that there was no significant difference in forward flexion between male and female participants. This is corroborated by *Mellin and Poussa (1992)* who found no significant differences in forward flexion of the lumbar spine between male and female. Although conclusive evidence is lacking, several factors, including anatomical and physiological differences, may account for the difference in flexibility between the sexes. Other factors could be smaller muscle mass, joint geometry, and gender-specific collagenous muscle structure *(McHugh et al. 1992).*

Flexibility is one of the major components of health-related and performance-related physical fitness, and is defined as the maximum physiological passive range of motion of a given joint movement *(Araújo, 2008).* Spinal flexibility values in normal individuals have been documented by previous investigators among various populations using the dual inclinometric technique *(Mayer et al, 1984; Keeley et al, 1986; Gill et al, 1988; Alaranta et al, 1994b; Saur et al, 1996). Alaranta et al (1994b)* established normative data for spinal flexibility among white and blue workers aged 35 to 54 year using the dual inclinometric technique. *Trudelle-Jackson et al (1976)* established normative data of lumbar flexion and extension for women of different age and racial groups. *Troke et al (2001)* established comprehensive normative data base of lumbar spine ranges of motion using a portable modified spine motion analyzer. *Konndratek et al (2007)* provided the basic normative values for lumbar range of motion in children. These normative data contribute to a better knowledge of the flexibility behavior with age and gender and will be useful for professionals who assess flexibility in their professional practice *(Araújo, 2008).* For the purpose of constructing gender and age reference value tables for spinal flexibility among all the participants, forward flexion scores less than 35^0 was regarded as poor, scores between $35\text{-}52^0$ was regarded as moderate; scores between 52- 63^0 was regarded as good scores and greater than 63^0as very good. Extension scores less than 12^0 was regarded as poor, scores between $12\text{-}21^0$ was regarded as moderate; scores between 21- 30^0 was regarded as good scores and greater than 30^0as very good. Right lateral flexion scores less than 13^0 was regarded as poor, scores between $13\text{-}21^0$ was regarded as moderate; scores between 21-28^0 was regarded as good scores and greater than 28^0as very good; while left lateral flexion scores less than 13^0 was regarded as poor, scores between 13-21^0 was regarded as moderate; scores between 21- 25^0 was regarded as good scores and greater than 25^{0}as very good.

This study investigated the correlation between spinal flexibility and individual factors. From the result, there was a significant inverse relationship between age and each of spinal extension and left flexion. This result is consistent with previous reports that flexibility decreases with advancing *age (Alaranta et al, 1994b; Dvorak et al, 1995; Sullivan et al, 1994; Troke et al, 2001). Alter (1996)* submitted that the inverse relationship between age and flexibility is due to the age-related physiological changes in the connective tissues. These changes causes an increased in the amount of calcium deposits, adhesions, and cross-links in the body, an increase in the level of fragmentation and dehydration, changes in the chemical structure of the tissues, loss of suppleness due to the replacement of muscle fibers with fatty, and collagenous fibers *(Alter, 1996).* Furthermore, certain anthropometric measures were found to be significantly related to flexibility in this study. A direct significant relationship was observed between weight and forward flexion, and between trunk length and extension. Previous studies have reported variable results on the anthropometric correlates of spinal flexibility. However, *Battié et al (1987)* concluded that age, sex, and other physical attributes of an individual are important variables that must be taken into account in determining what is normal, excessive, or diminished spinal flexibility.

Clinical Implication of findings

The normative spinal flexibility values derived in this study could be useful in assessing impairment in the function of the back muscles in both healthy and patient populations. These values can be used to compare a patient's score at intake or as an outcome measure in clinical practice. The reference norm values for spinal flexibility could be used in rehabilitation to estimate the level of spinal flexibility improvement in a patient at intake and also serve as outcome measure of improvement. Clinicians who treat low-back pain can use established baseline data on low back flexibility among normal subjects as a means to recognize decreased spinal flexibility as one of the impairments resulting from low-back pain or as an outcome measure to help evaluate residual disability.

Conclusion

This study established a set of normal values for lumbar spinal flexibility in healthy Nigerians. Increasing age was associated with decreasing spinal flexibility without gender bias. Females were found to have a significantly higher extension and right lateral flexion range of motion than males. Age and anthropometric parameters were significant correlates of spinal flexibility.

References

Alaranta, H., Hurri, H., Heliovaara, M., Soukka, A., Harju, R. 1994. Flexibility of the spine: Normative values of goniometric and tape measurements. *Scand. J. Rehab. Med.*, **26:**147-154

Alaranta, H., Hurri, H., Heliovaara, M., Soukka, A., Harju, R. 1994. Non-dynamometric trunk performance tests: Reliability and normative data. *Scand. J. Rehabil. Med.,* **26:** 211-5.

Al-Eisa, E., Egan, D., Deluzio, K., Wassersug, R 2006. Effects of pelvic asymmetry and low back pain on trunk kinematics during sitting: a comparison with standing. *Spine,* 31:E135-43.

Alter, M.J. 1996. Science of flexibility (2nd ed.). Champaign, IL: Human Kinetics.

American Medical Association (AMA). 1993. Guides to the Evaluation of Permanent Impairment. 4th ed. Chicago, IL: American Medical Association. 112-30.

Anderson, B., Burke, E.R. 1991. Scientific, medical, and practical aspects of stretching. *Clin. Sports Med.,* **10:** 63-86

Anderson, J.A.D. and Sweetman, B.J. 1975; A combined flexi-rule/hydrogoniometer for measurement of lumbar spine and its sagittal movement. *Rheumatol. Rehabil.,* **14:** 173-179

Araújo, C.G. 2008. Flexibility assessment: normative values for flexitest from 5 to 91 years of age. *Arq. Bras. Cardiol.,* **90(4):** 257-63.

Battié, M.C., Levalahti, E., Videman, T., Burton, K., Kaprio, J. 2008. Heritability of lumbar flexibility and the role of disc degeneration and body weight. *J. Appl. Physiol.,* **104(2):** 379-385

Battié, M.C., Bigos, S.J., Sheehy, A, Wortley, M.D. 1987. Spinal Flexibility and Individual Factors That Influence *It. Physical Therapy.,* **67(5):** 653-658

Brown, M. D., Holmes, D. C., Heiner, A. D. 2002. Intraoperative measurement of lumbar spine motion segment stiffness. *Spine,* **27(9):** 954-958.

Burton, A.K., Tillotson, K.M., Troup, J.D.G. 1989. Variation in lumbar sagittal mobility with low-back trouble. *Spine,* **14:** 584-590

Catley, M.J. and Tomkinson, G.R. 2012. Normative health-related fitness values for children: analysis of 85347 test results on 9–17-year-old Australians since 1985. Br. J. Sports Med. [Abstract].

Christine, W., Julie, R., Denys, F., Shannon, L. 1999. Comparison of standard and modified sit-and-reach tests in college students. American Alliance for Health, Physical Education, and Recreation & Dance Journal.

Cooper, R.D., Hollis, S., Jayson, M.I.V. 1992. Gender variation of human spinal and paraspinal structures. *Clin. Biomech.,* **7(2):** 120-124

Decker, M. J., Torry, M. R., Wyland, D. J., Sterett, W. I., Steadman, J. R. 2003. Gender Differences in Lower Extremity Kinematics, Kinetics and Energy Absorption During Landing. *Clin. Biomech.,* **18**(7): 662-9.

Gross, D.P. and Battié, M.C. 2005. Factors Influencing Results of Functional Capacity Evaluations in Workers' Compensation Claimants With Low Back Pain. *Phys. Therap.,* **85(4):** 315-322

Dvorák, J., Vajda, E.G., Grob, D., Panjabi, M.M. 1995. Normal motion of the lumbar spine as related to age and gender. *Eur. Spine. J.,* **4:** 18–23.

Ensink, F.B., Saur, P.M., Frese, K., Seeger, D., Hildebrandt, J. 1996. Lumbar range of motion: influence of time of day and individual factors on measurements. *Spine,* **21:** 1339-43.

Farfan, H. F. 1975. Muscular mechanism of the lumbar spine and the position of power and efficacy. *Orthop. Clinics of North American,* 6, 135-144.

Fitzgerald, G.K., Wynveen, K.J., Rheault, W. 1983. Objective assessment with establishment of normal values for lumbar spinal range of motion. Phys. Ther., **63:** 1776-1781,

Foster, D. N., and Fulton, M. N. 1991. Back pain and the exercise prescription. *Clinics in Sports Medicine,* 10, 187-209.

Gatchel, R.J., Gardea, M.A. 1999. Psychosocial issues: their importance in predicting disability, response to treatment, and search for compensation. *Neurol. Clin.,* **17:** 149–166.

Gill, K., Krag, M.H., Johnson, G.B., Haugh, L.D., Pope, M.H. 1988. Repeatability of four clinical methods of assessment of lumbar spine motion. *Spine,* **13:** 50-53

Gummerson, T. 1990. Mobility Training for the Martial Arts. A & C Black.

Haley, S., Tada, W. Carmichael, E. 1986. Spinal mobility in young children: a normative study. *Phys. Ther.,* **66:** 1697-1703.

Hoeger, W.W.K. and Hoeger, S.A. 2008. The Assessment of Muscular Flexibility: Test Protocols and National Flexibility Norms for the Modified Sit-and-Reach Test, Total Body Rotation: A Personalized Programme. Belmont, CA: Wedsworth/Thomson

Hoeger W.W.K., and Hoeger S.A. 2007. Lifetime Physical Fitness and Wellness: A Personalized Programme. Belmont, CA: Wedsworth/Thomson

Hoffman, J. 2006. Norms for fitness, performance and health. Human Kinetics, Champaign, Ill.

Jaric, S., Mirkov, D, Markovic, G. 2005. Normalizing physical performance tests for body size: a proposal for standardization. *J. Strength Cond. Res.,* **19(2):** 467-74.

Keeley, J., Mayer, T.G., Cox, R., Gatchel, R.J., Smith, J., Mooney, V. 1986. Qunatification of lumbar function. Part 5: Reliabilityof range of motion measures in the sagittal plane and in an in vivo torso rotation measurement technique. *Spine,* **11:** 31-35.

Knudson, D., Magnusson, P. and McHugh, M. 2000. Current issues in flexibility fitness. President's Council on Physical Fitness and Sports Research Digest, 3(9): 1-8.

Konndratek, M., John, K., Christine, S. Ronald, O. 2007. Normative Values for Active Lumbar Range of Motion in Children. Pediat Phy Therap, 19(3): 236-244

Kuornika, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sorensen, F., Andersson, G., Jorgensen, K. 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl. Ergon.,* **18(3):** 233-237.

Loebl W.Y. 1967. Measurement of spinal posture and range of spinal movement. Ann Phys Med; 9:103-10.

Lohman, T.G.; Roche, A.F.; Martorell, R. 1988. Anthropometric Standardization Reference Manual; Human Kinetics Publishers: Champaign, IL, USA.

Macrae, J.F., and Wright, V. 1969. Measurement of back movement. Ann Rheum Dis 28:584-589,

Magee, D. 1992. Lumbar spine. In: Orthopaedic physical examination (ed. Biblis, M.) pp. 247 – 307. Saunders & Co.

Manescu, C.O. 2010. Importance of good flexibility and stretching movements in fitness and bodybuiding training. *Body Building Science Journal*, **2(2):** 97-107.

Marras, W.S. Jorgensen, M.J. Granata, K.P. Wiand, B. 2001. Female and Male Trunk Geometry: Size and Prediction of the Spine Loading Trunk Muscles Derived from MRI. *Clin. Biomech.,* **16(1):** 38-46.

Marras, W.S., Rangarajulu, S.L., Lavender, S.A. 1987. Trunk loading and expectation. *Ergonomics;* **30:** 551-562.

Mayer, T.G., Tencer, A.F., Kristoferson, S, Mooney, V. 1984. Use of noninvasive techniques for quantification of spinal range of motion in normal subjects and chronic low back dysfunction patients. *Spine.,* **9:** 588-595.

McHugh, M.P., Magnusson, S.P., Gleim, G.W., Nicholas, J.A. 1992. Viscoelastic stress relaxation in human skeletal muscle. *Med. Sci. in Sports & Exer.,* **24(12):** 1375–1382

Mellin, G., Poussa, M. 1992. Spinal mobility and posture in 8- to 16-year-old children. *J Orthop Res.,* **10(2):** 211-6.

Mellin, G., Kiiski, R., Weckstrom, A. 1991: Effects of subjects position on measurement of flexion, extension, and lateral flexion of spine. *Spine,* **16:** 1108-1110.

Moll, J. M. and Wright, V. 1971. Normal range of spinal mobility. An objective clinical study. *Ann. Rheum. Dis.,* **30(4):** 381–386.

Nelson A.G., and Kokkonen, J. 2007. Stretching anatomy. Champaign, IL: Human Kinetics.

Nevill, A.M., Bate, S., Holder, R.L. 2005. Modeling physiological and anthropometric variables known to vary with body size and other confounding variables. *Am. J. Phys. Anthropol.,* **Suppl 41:** 141-53.

Nevill, A.M., Ramsbottom, R., Williams, C. 1992. Scaling physiological measurements for individuals of different body size. *Eur. J. Appl. Physiol. Occup. Physiol.,* **65(2):** 110-7.

Norton, B. J., Sahrmann, S. A., Van Dillen, F. L. 2004. Differences in measurements of lumbar curvature related to gender and low back pain. *J. Orthop. Sports Phys. Ther.,* **34(9):** 524-534.

Plowman, S. A. 1992. Physical activity, physical fitness, and low back pain. In J. O. Holloszy (Eds.), Exercise and Sport Sciences Reviews (pp. 221-242). Baltimore: Williams & Wilkins.

Podrasky, E.M. 1983. Treatment of rheumatic diseases in childhood: The role of physical and occupational therapy in evaluation and management. In: Kelly V, editor. Practices in Pediatrics. New York, NY: Harper and Row, Publishers Inc; pp. 1–7.

Ross, J.G., Pate, R.R., Delpy, L.A., Gold, R.S. and Svilar, M. 1987. New health related fitness norms. JOPERD, Nov/Dec, pp 66-70.

Rothstein J.M. 1985. Measurement in physical therapy, Churchill Livingstone, New York

Ruff, C. Variation in human body size and shape. Ann. Rev. Anthropol. 2002, 31, 211-232.

Saur, P., Ensink, F., Frese, K., Seeger, D., Hildebrandt, J. Lumbar range of motion: reliability and validity of the inclinometer technique in clinical measurement of trunk flexibility. *Spine,* 1996; 21: 219-224.

Shellock, F.G, Prentice, W.E. Warming-up and stretching for improved physical performance and prevention of sports-related injuries. *Sports Med.,* 1985; 2(4):267-78.

Sizer, P. S., and James, C. R. 2008. Considerations of sex differences in musculoskeletal anatomy. In J. J. Robert-McComb, R. L. Norman & M. Zumwalt (Eds.), (pp. 25-55). Totowa, N.J.: Humana Press.

Stutchfield, B.M., Coleman, S. 2006. The relationships between hamstring flexibility and lumbar flexion and low back pain in rowers. *Europ. J. Sports Sci.,* **6(4):** 255-260.

Sullivan, M.S., Dickinson, C.E., Troup, J.D. 1994. The influence of age and gender on lumbar spine sagittal plane range of motion: a study of 1126 healthy subjects. *Spine,* **19:** 682–6.

Suminski, R.R., Mattern, C.O., Devor, S.T. 2002. Influence of racial origin and skeletal muscle properties on disease prevalence and physical performance. Sports Med. 32(11):667-73.

Tanner, J.M., Hayashi, T., Preece, M.A., Cameron, N. 1982. Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese Americans. *Ann. Hum. Biol.,* **9:** 411-423.

Tichauer, E.R. 1978. The Biomechanical Basis of Ergonomics: Anatomy Applied to the Design of Work Stations, New York: John Wiley and Sons.

Troke, M., Moore, A.P., Maillardet, F.J, et al. 2001. A new, comprehensive normative database of lumbar spine ranges of motion. *Clin. Rehabil.,* **15:** 371–9.

Troup, J.D., Hood, C.A., Chapman, A.E. 1968. Measurement of sagittal mobility of the normal lumbar spine and hips. *Ann. Phys. Med.*;

Trudelle-Jackson, E., Fleisher L.A., Borman N., Morrow J.R., Frierson G.M. 2010. Lumbar Spine Flexion and Extension Extremes of Motion in Women of Different Age and Racial Groups. *Spine* (Phila Pa, 1976), **35(16):** 1539-1544

Uluçam, E., Ciğali, B.S. 2009. Measurement of Normal Lumbar Spine Range of Motion in the College-Aged Turkish Population Using a 3D Ultrasound-Based Motion Analysis System. *Balkan Med. J.,* **26(1):** 029-035.

Wagner, D.R, Heyward, V.H. 2000. Measures of body composition in blacks and whites: a comparative review. *Am. J. Clin. Nutr.,* **71:** 1392–402.

Winter, E.M., Nevill, A.M. 1996. Scaling: adjusting for differences in body size. In: Eston R, Reilly T, editors. Kinanthropometry and Exercise Physiology Laboratory Manual: Spon 321-335.

Xu, R., Burgar, A., Ebraheim, N. A., & Yeasting, R. 1999. The quantitative anatomy of the laminas of the spine. *Spine,* **24(2):** 107-113.

Yeoman, S.G. Spinal range of motion: Is this a valid form of outcome assessment. Chapter 14. In The Clinical application of outcome assessment. Pg 185-224

Youdas, J.W., Carey, J.R., Garret, T.R. 1991. Reliability of measurements of cervical range of motion – comparison of three methods. *Phys. Ther.,* **71:** 98-104.