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Anthropometric Correlates of Balance Performance in Non-Institutionalized Elderly

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***Abstract*—**Purpose: The fear of falling is a major concern among the elderly. Sixty-five percent of individuals older than 60 years of age experience loss of balance often on a daily basis. Therefore, balance assessment in the elderly deserves special attention due to its importance in functional mobility and safety. This study aimed at assessing balance performance and comparing some anthropometric parameters among a Nigerian non-institutionalized elderly population.

Methods: Sixty one elderly subjects (31 males and 30 females) participated in this study. Their ages ranged between 62 and 84 years. Ability to maintain balance was assessed using Functional Reach Test (FRT) and Sharpened Romberg Test (SRT). Anthropometric data including age, weight, height, arm length, leg length, bi-acromial breadth, foot length and trunk length were also collected. Analysis was done using Pearson's Product Moment Correlation Coefficient and Independent T-test, while level of significance was set as $p<0.05$.

Results: Age-related significant relationship was observed between balance performance and bi-acromial breadth among the elderly population. Gender and visual input also had a significant influence on balance performance. Other anthropometric variables (age, weight, height, arm length, leg length, foot length and trunk length) showed no significant relationship with balance performance among this elderly sample.

Conclusion: Only specific anthropometric variables may affect balance performances among the healthy elderly. The study further highlights the need for routine assessment of both static and dynamic balance to detect and appropriately manage aging-related diseases which could affect balance in the elderly.

***Keywords*—**Balance Performance, Anthropometry, Non-institutionalized Elderly.

I. Introduction

BALANCE is the ability to keep the body in equilibrium in either static or dynamic positions with minimal muscle activity [1]. Kisner and Colby [2] and Smith et al. [3] also described balance as the ability to maintain the body's centre of mass over the base of support which involves a combination of stability and mobility whereas Miller [4] described it as the ability to maintain one's position in space in a stable orientation. The regulation of posture and balance is a vestibular system activity comprising a complex network of inputs from the position of the head in relation to gravity as well as motion through the linear and angular acceleration of the head [4]. As a multi-dimensional activity requiring sensory, neuromuscular and central processing systems, balance control depends on the visual, vestibular, auditory, somato-sensory and motor systems [5], [6]. These complex processes involving a whole series of nuclei and fiber tracts located in the spinal cord, the brain stem, cerebral cortex and the cerebellum have been elaborated [7].

The maintenance of posture and the ability to move about the environment depend on orientation and balance. With advancing age, there is generalized functional degradation; hence some degree of imbalance is present in individuals above 60 years [8]. Although ageing is a gradual process, some changes occur early and may be associated with a wide range of physical, social and psychological problems often characterized by multiple pathologies, functional limitations and impaired intellectual capabilities. Accumulated deficits coupled with reduced functional threshold even without particular traumas or pathologies often call for specialized therapeutic interventions [8].

The danger and fear of falling is of great concern among the elderly population [8]. In the United States of America, falls have been reported as the most common causes of injury and death in elderly people above 65 years of age [9], [10]. Sixty-five percent of individuals older than 60 years of age experience loss of balance often on a daily basis, with many suffering multiple falls at least once a year [11]. Therefore, balance in the elderly deserves special attention because of its importance in functional mobility and safety [12]. With ageing, as the functional degradation progresses, imbalance occurs, independent ambulation becomes difficult, and the likelihood of falls increases during everyday activities. Other factors affecting balance include gender [13], levels of physical activity [5] and body mass [3].

Various types of balance tests ranging from expensive laboratory measures to the narrative descriptions used most often by physical therapists exist [6]. Many of the objective measures used in the clinical setting have focused on an evaluation of static standing balance. Examples include the Sharpened Romberg Test (SRT) which requires the subject to maintain balance standing in a heel-to-toe position with maximum balance time of sixty seconds [14], and the Functional Reach Test (FRT) which is a measure of the client's margin of stability during voluntary forward maximal reach [15]. This latter test demonstrates face validity because it has the obvious appearance of testing reaching balance [6]. Also it has met adequate standards of intra-rater and inter-rater reliability as well as concurrent and predictive validity [6]. Fabunmi and Gbiri [16] reported the existence of a significant

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relationship between the Functional reach test and each of age, stature, body mass, trunk length, foot length and bi-acromial breadth except arm length, leg length and hip girth. However, they reported no significant relationship between the Sharpened Romberg test and age, stature, body mass, arm length, trunk length, leg length, bi-acromial and hip girth but was significant with foot length. These contrasting results suggest, therefore, the need for further work to confirm these findings.

The aim of this study was to assess and determine the balance performance comparing some anthropometric parameters among a Nigerian non-institutionalized elderly population. The specific objectives were to investigate the relationship between balance performance and some of the above listed anthropometric parameters among the elderly in Lagos, Nigeria; to determine the relationship between functional reach and each of age, stature, body mass, arm length, leg length, trunk length, foot length, bi-acromial breadth and hip girth among the elderly in Lagos, Nigeria; to determine the relationship between the balance time on the Sharpened Romberg test and each of age, stature, body mass, arm length, leg length, trunk length, foot length, bi-acromial breadth, and hip girth among the elderly in Lagos, Nigeria; to compare the performance of elderly males and females on the Functional reach test and to compare the performance of elderly males and females on the Sharpened Romberg test.

II. Methods

Strict compliance with institutional rules regarding consent for human research was ensured. Ethical clearance was obtained from the Research Grants and Experimentation Ethics Committee of the College of Medicine of the University of Lagos (CMUL) prior to the commencement of sampling and subject selection.

The research design was a correlational study employing simple random sampling technique Sixty-one (61) non-institutionalized elderly individuals (age-range 62 - 84 years) made up of 30 females (49.18%) and 31 males (50.82%) who gave their consent participated in the study. The procedure was explained to each participant prior to the commencement of the study. The participants responded verbally to questions on their general state of health, upper and lower limb dominance and any history of previous fractures. Sharpened Romberg test was performed while the participant assumed a heel-to-toe standing position. The dominant leg was placed behind the non-dominant leg. All the tests were performed with shoes off and with the eyes opened, and then closed while standing. Timing was started after each participant assumed the proper heel-to-toe standing position and indicated their readiness. Timing was stopped if any of the following occurred: (a) if the participants moved their feet from the proper and starting position (b) if they opened their eyes on eyes closed trial (c) if they reached the maximum balance time of 60 seconds (d) if any form of sway was observed. Participants were asked to make a fist and flex the arm at the gleno-humeral joint to 90 degrees, parallel to the meter rule. The initial position of the third metacarpal was recorded as the initial position. Then the participants were asked to reach forward as far as possible keeping their fists parallel to the meter rule without taking a step. The participant's reach was observed and recorded as the final position. The functional reach was taken by subtracting the initial position from the final position and recorded in centimeters [6], [15].

III. Data Analysis

Descriptive statistics of mean, range and standard deviation were used to describe the participants' anthropometric parameters as well as their balance performance while Pearson's product moment correlation (r) test was used to determine the correlation between these variables among the elderly. Independent t-test was also used to determine any difference in functional reach in elderly males and females or any difference in both Sharpened Romberg Tests in elderly males and females.

IV. Results

The descriptive statistics of the participants are summarized in Table I. Functional Reach Test, Bi-acromial breadth had the moderate positive correlation of 0.51, followed by arm length and weight with low positive correlation of 0.13 and 0.16 respectively (Table II). Thus, a 1.0-cm increase in these anthropometric parameters resulted in an increase in Functional Reach Test. Stature, leg length, foot length and trunk length all had a weak positive 'r' of 0.06, 0.08, 0.02 and 0.05 respectively. A negative correlation was observed in age and hip girth (-0.27 and -0.12); thus an increase in these variables resulted in a decrease in Functional Reach Test values.

Results of the Sharpened Romberg Test with eyes open (S.R.T-EO) (Table II) indicate positive correlations between weight, height, trunk length and Sharpened Romberg Test time. Negative correlations were however observed with age, arm length, leg length, foot length, bi-acromial breadth, and hip girth (-0.4, -0.016, -0.0009, -0.2, -0.37, -0.06 respectively) indicating that a decrease in Sharpened Romberg Test time was observed with an increase in these anthropometric variables in the elderly. Sharpened Romberg Test with eyes closed (S.R.T-EC) result showed that the only positive correlation between anthropometric parameters and Sharpened Romberg time was observed in body mass and stature (0.06 and 0.75). A decrease in S.R.T-EC time was observed with an increase in age, arm length, leg length, foot length, bi-acromial breadth, hip girth and trunk length.

TABLE I
DESCRIPTIVE STATISTICS OF STUDY POPULATION

PARAMETERS	X ± S.D	RANGE	
		Minimum	Maximum
Age	71.89 ± 5.67	62	84
Body mass	69.46 ± 14.13	35	100
Stature	165.30 ± 9.50	137	199
Arm length	73.51 ± 5.15	60	82
Leg length	94.62 ± 7.62	72	108
Foot length	25.34 ± 2.25	17	32
Bi-acromial breadth	35.91 ± 3.19	28	43
Hip girth	98.36 ± 12.63	70	129
Trunk length	42.44 ± 4.45	34	51
Functional reach	34.91 ± 6.84	19	51
S.R.T-EO	52.30 ± 13.23	11	60
S.R.T-EC	37.11 ± 19.45	3	60

Key: N: Number of Participants = 61; X: Mean; SD: Standard Deviation; S.R.T-EO: Sharpened Romberg Test with Eyes Opened; S.R.T-EC: Sharpened Romberg Test with Eyes Closed.

TABLE II
PEARSON'S PRODUCT MOMENT CORRELATION COEFFICIENT (R) TABLE TO DETERMINE THE RELATIONSHIP BETWEEN THE ANTHROPOMETRIC PARAMETERS AND THE BALANCE PERFORMANCES [$P< 0.05$]

	Functional Reach				S.R.T-EO				S.R.T-EC			
Parameters	R	95% CI	P.V	r^2	R	95% CI	P.V	r^2	r	95% CI	P.V	r^2
Age	-0.27	-0.48 to -0.07	0.01*	0.1	-0.4	-0.15 to 0.71	0.48	0.009	-0.02	-0.96 to 0.055	0.59	0.005
Weight	0.16	-0.38 to 0.69	0.56	0.001	0.10	-0.17 to 0.38	0.45	0.01	0.06	-0.12 to 0.25	0.53	0.01
Height	0.06	-0.17 to 0.29	0.59	0.19	0.12	-0.36 to 0.60	0.62	0.06	0.75	-0.05 to 0.20	0.23	0.02
Arm length	0.13	-0.05 to 0.33	0.17	0.03	-0.01	-0.12 to 0.08	0.74	0.001	-0.04	-0.11 to 0.03	0.21	0.02
Leg length	0.08	-0.20 to 0.37	0.55	0.01	-0.0009	-0.15 to 0.14	0.99	0.0001	-0.06	-0.16 to 0.04	0.24	0.02
Foot length	0.02	-0.64 to 0.11	0.63	0.003	-0.02	-0.66 to 0.02	0.36	0.01	-0.34	-3.5 to 2.9	0.83	0.12
Bi-acromial breadth	0.51	0.4 to 1.90	0.003*	0.19	-0.37	-1.9 to 1.2	0.63	0.06	0.70	-1.53 to 2.93	0.53	0.12
Hip girth	-0.12	-0.60 to 0.36	0.61	0.004	-0.06	-0.3 to 0.19	0.63	0.003	-0.06	-0.22 to 0.10	0.47	0.01
Trunk length	0.05	-0.11 to 0.22	0.52	0.01	0.01	-0.88 to 0.09	0.89	0.0004	-0.01	-0.06 to 0.05	0.82	0.001

Key: P.V: Probability Value; r: Correlation Coefficient; 95%CI: 95% Confidence Interval
S.R.T-EO: Sharpened Romberg Test with Eyes Opened S.R.T-EC: Sharpened Romberg Test with Eyes Closed
* Significant

TABLE III
COMPARATIVE INDEPENDENT T-TEST RESULTS OF FUNCTIONAL REACH, SRT-EO AND SRT-EC BY GENDER

Parameters	Functional Reach				SRT- EO				SRT-EC			
	n	OM	SE	SD	n	OM	SE	SD	n	OM	SE	SD
Female	30	32.82	1.26	6.88	30	51.326	2.481	13.592	30	33.446	3.444	18.868
Male	31	36.92	1.13	6.27	31	53.238	2.339	13.028	31	40.658	3.529	19.650
Combined	61	34.91	0.88	6.84	61	52.298	1.694	13.232	61	37.111	2.490	19.451
Difference	-4.099	1.68	-7.47	00.73	-1.912	3.408	-8.732	4.908	-7.211	4.935	-17.086	2.663

Key:1: Females; 0: Males; Difference = Mean (1) – Mean (0)
OM= ObservedMean, SE=Standard Error, SD=Standard Deviation

V. DISCUSSION

The study results showed no significant correlation between Sharpened Romberg Test and age. This finding is in agreement with the results of previous studies [14], [16] which also reported no significant correlation between Sharpened Romberg Test and age. This study results also revealed no significant correlation between Sharpened Romberg Test and each of stature, body mass, arm length, leg length, foot length, hip girth, bi-acromial breadth and trunk length and is partly consistent with a study [16] which reported no significant relationship between Sharpened Romberg Test and these anthropometric parameters but reported a significant correlation with trunk length and foot length.

The study also revealed a negative significant correlation between functional reach and age indicating that with increasing age, functional reach decreases. This finding is consistent with other reports [14], [15], [6] and [16] which also found a negative significant correlation between age and Functional reach test. However, this finding contradicts some findings [14] which reported a negative non-significant correlation between Functional Reach Test and age. The finding that there was no significant correlation between Functional Reach Test and each of body mass, stature, foot length and trunk length is in partial agreement with the results of [14] who reported no significant correlation between functional reach test and weight, height and trunk length, but a significant correlation with foot length. The results also showed no significant relationship between functional Reach Test and arm length, leg length and hip girth, but showed a significant correlation with bi-acromial breadth.

A possible explanation for this observed significant correlation between bi-acromial breadth and balance may be viewed from the perspective of body alignment related to body mechanics and kinesiology. The bi-acromial breadth is a measure of the transverse diameter of the body which is perpendicular to stature. It is also related to the torque or turning forces required for adjustment during motion [17], [18].

Furthermore, the results that both elderly males and females performed better with their eyes opened than with their eyes closed in the Sharpened Romberg Test is in agreement with the findings of [16] who reported that both elderly males and females performed better with their eyes opened than with their eyes closed in Sharpened Romberg Test. This observation is in line with the effect of visual function on physical and balance performance [7].

However, the observation that elderly females performed significantly better than elderly males in both functional reach test and Sharpened Romberg Test contrasts the results of [5] and [16] who had reported that elderly males performed better than elderly females in both functional reach test and Sharpened Romberg Test. A possible reason for this finding may be traced to the fact that participants in the previous studies were institutionalized while participants in this study were not. Thus, the females in this study may still be actively involved in their home chores more than their male counterparts.

VI. Conclusion

This study assessed balance performance and its relationship with some anthropometric parameters among non-institutionalized elderly population in Lagos State, Nigeria. Among the variables tested, only bi-acromial breath appeared to have a significant influence on functional reach while the Sharpened Romberg Test was performed better with the eyes opened. In both tests, results were better in the females. The findings suggest a health policy need for routine assessment of static and dynamic balance performance of the elderly in order to detect and appropriately manage the diseases associated with aging that could affect balance. It is further recommended that a normative database of performances on Sharpened Romberg Test and Functional Reach Test be developed for both elderly males and females to prevent falls and complications arising from it.

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