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Relationship between balance performance in the elderly and some anthropometric variables.

AA Fabunmi and CA Gbiri
Department of Physiotherapy, College of Medicine, University of Ibadan, Ibadan, Nigeria.

Summary
Ability to maintain either static or dynamic balance has been found to be influenced by many factors such as height and weight in the elderly. The relationship between other anthropometric variables and balance performance among elderly Nigerians has not been widely studied. The aim of this study was to investigate the relationship between these other anthropometric variables and balance performance among old individuals aged >60 years in Ibadan, Nigeria. The study used the ex-post facto design and involved two hundred and three apparently healthy (103 males and 100 females) elderly participants with ages between 60 years and 74 years, selected using multiple step-wise sampling techniques from churches, mosques and market place within Ibadan. They were without history of neurological problem, postural hypotension, orthopeadic conditions or injury to the back and / or upper and lower extremities within the past one year. Selected anthropometric variables were measured, Sharpened Romberg Test (SRT) and Functional Reach Test (FRT) was used to assess static balance and dynamic balance respectively. All data were summarized using range, mean and standard deviation. Pearson's product moment correlation coefficient was used to determine the relationship between the physical characteristics, anthropometric variables and performance on each of the two balance tests. The results showed that there were low but significant positive correlations between performance on FRT and each of height, weight, trunk length, foot length, shoulder girth and hip girth. ($p<0.05$). There was low significant and positive correlation between SRT with eyes closed and arm length, foot length and shoulder girth. ($p<0.05$) and there was low but significant positive correlation between SRT with eyes opened and shoulder girth and foot length ($P<0.05$). Anthropometric variables affect balance performances in apparently healthy elderly.

Keywords: *Balance performance, elderly and anthropometric variables.*

Correspondence: Dr. Ayodeji A. Fabunmi, Department of Physiotherapy, College of Medicine, University of Ibadan, Ibadan Nigeria. Email: ayofab@yahoo.com

Résumé
L'habilité de maintenir une balance dynamique ou statique a été démontrée influençant plusieurs facteurs tels que le poids et la taille chez les vieillards. La relation entre les variables anthropométriques et la balance de performance parmi les vieillards Nigérians n'a pas été étudiée. Le but de cette étude était d' investiguer la relation entre ces variables et la performance chez 203 vieillards (103 hommes et 100femmes) âgés entre 60 - 74 ans sélectionner dans les églises, mosquées et marches dans la zone d'Ibadan, Nigeria. Ils n'avaient pas d'histoire de problèmes neurologiques, d'hypertension posturale, de conditions orthopédiques ou blessures des membres supérieurs ou inférieurs depuis un an. Les variables étaient mesurées, les tests de Romberg (SRT) et fonctionnels (FRT) était utilisé pour évaluer la balance statique et dynamique. Toutes les données étaient résumées en intervalle, déviation standard, coefficient de corrélation de Pearson était utilise pour déterminer la relation entre les characteristiques physiques, les variables anthropométriques et la performance de chaque test de balance. Les résultats montraient que ils avaient une réduction mais des corrélations positives et significatives entre le test fonctionnel et le poids, taille, longueur du tronc, longueur de du pieds, largueur des épaules et largueur du bassin ($P<0.005$).Il y avait une faible significatif et une corrélation positive entre le test de Romberg ayant les yeux fermés, la longueur de l'avant bras, longueur du pieds et la largueur des épaules ($P<0.005$).

Introduction

Balance is the ability to keep the body in equilibrium in either the static or dynamic positions with minimal muscle activity [1.] Smith *et al* [2] described balance as the ability to maintain the body's centre of mass over the base of support. Maintenance, restoring and achieving balance during any activity is referred to as postural control and the strategies involved is either predictive or reactive which may involve either a fixed support or a change in response [3]. The ability to maintain balance depends on visual, vestibular, auditory, somato-sensory and motor systems [4]. Balance is a dynamic phenomenon that involves a combination of stability and mobility, and it is necessary to hold a position in space or move in a controlled and coordinated manner [5]

Coordination, balance and functional motor skills are all dependent upon and affected by the sensory systems, particularly the somatosensory and proprioceptive systems if a person is to learn and carry out functional skills [5]. Dynamic balance is a crucial element in performing many activities of daily living. It involves maintenance of balance or equilibrium while moving in a posture by maintaining the centre of gravity within the base of support [2]. Static balance is also as important in many activities that require minimal active muscle effort such as lying, kneeling, sitting and standing. The sense of balance declines with age [6,7]. The likelihood of having difficulty in carrying out basic life activities increases as individual ages. The elderly, who is defined as individuals with age above 60 years [8] are among those at greatest risk for disequilibrium [4]. Therefore balance in the elderly deserves special attention because of its importance in functional mobility and safety.

Various types of balance test that are available include methods such as Romberg Test (RT) and One-Leg Stance Test (OLST) also called solec test. Sharpened Romberg Test (SRT), which is a modification from RT has been used as substitute for the RT by some clinicians. It requires the subject to maintain balance standing in a heel-to-toe position [9]. The maximum balance time is sixty seconds. The Functional Reach Test (FRT), developed and tested by Duncan *et al* [9], is one of the more familiar of these newer balance tests used by physical therapists in the clinical setting today [10]. Functional reach is a measure of the client's margin of stability during voluntary forward maximal reach [9,10]. This test is a good screening tool for balance problems in elderly population [10]. It meets the need of clinicians because it is easily performed in a clinical setting with inexpensive equipment and requires short time to be administered without either the clinician or the patient being fatigued.

Many factors have been studied to have effect on balance such as: gender [11], and age [6,7], level of physical activity [4], height and weight [2]. Height has been found to be inversely related, and weight is directly related with balance [2]. Age has been found to be inversely related with balance [6,7]. The effects of some other anthropometric indices such as shoulder girth, hip girth and leg length effect have not been documented in this environment (Ibadan, Nigeria), therefore the need for this study was conceived. The aims of this study was to determine the relationship between Functional Reach Test (FRT), Sharpened Romberg Test (SRT) performances and each of weight, height, arm-length, trunk-length, shoulder girth, hip girth, leg-length, foot-length, and age.

Materials and method

A total of 203 apparently healthy participants (103 males and 100 females), whose consent were sought and obtained, were recruited for this study from Churches, Homes and Markets in selected local government areas (South East, South West and North) in Ibadan, Nigeria using multiple step-wise sampling techniques. Participants were between 60 and 74 years of age. They were without any history of postural hypotension, neurological deficits, orthopaedic conditions or injury to the back, lower and / or upper extremities within the past one year. The following venues were used for measurements, the office of the association of market men and women was used as venue for measurement in the selected market, sick bay was used in the selected church, and an available room within the selected mosque was used for measurement. All those who were willing to participate in this study were told to come with sports wear for convenience and ease during measurement. The measurement procedures were performed at comfortable, level floor rooms at venues involved in the study.

The procedure was explained to the subjects prior to the commencement of the tests after their informed consent was sought and obtained. Prior to testing, the participants responded orally to questions on their general health state with specific questions on whether they have pain in any part of their body. Questions were also asked on whether they have fractured any bone in previous two years. Tests such as Romberg test and drift test were performed to assess their neurological status. The Romberg test was performed with subject standing erect with feet together in both eyes opened and closed while maintaining it for 60 seconds. The drift test was performed by asking the subjects to supinate their hands in forward extension in eyes opened and closed for 30 seconds while paying attention to downward or pronation drift of the hands. Any subject that passed these tests was allowed to participate in the study.

The anthropometric variables were measured and recorded. Upper and lower limb dominance was evaluated. All these measurements were taken with subject in standing. The tape measure or the broad blade anthropometer was aligned at the appropriate place as indicated in each measurement. The measurement was taken with the subject maximally exposing or minimally covering the parts as the case may indicate. Arm length was measured from the acromion to the tip of the third metacarpal of their dominant arm flexed 90 degree at the gleno-humeral joint with a non-elastic tape measure (Butterfly brand, China) of range 0-150 centimetres to the nearest 0.1cm. Leg length was measured from the iliac crest to the base of the lateral side of the heel of their dominant with a non-elastic tape measure (Butterfly brand, China) to the nearest 0.1cm. Foot length was measured from the heel to the tip of the big toe of their dominant leg with a non-elastic tape measure (Butterfly brand, China) to the nearest 0.1cm. Trunk length was measured from the spine of seventh cervical vertebrae to that of the second sacral vertebrae with a non-elastic tape measure (Butterfly brand, China) to the nearest 0.1cm.

Shoulder girth was measured with a broad blade anthropometer (fabricated by the Instrument Department, U.C.H., Ibadan, Nigeria). It has test-retest reliability of 0.998. Measurement was taken by aligning the broad blade anthropometer at the imaginary straight line drawn between the acromia, while measurement was read-off between the acromia. It was measured to the nearest 0.1cm. Hip girth was measured by aligning the broad blade anthropometer ($r=0.998$) at the tip of an imaginary straight line drawn between the greater trochanters. The anthropometer was used to measure the distance and read off to the nearest 0.1cm.

The height metre was placed against the wall. The participants were asked to stand erect in front of the height metre. They stood vertically erect with their hands by their sides while looking straight forward. The height was read-off by gradually lowering the height metre pointer to touch the tip of the subjects head.

Weight was measured with weighing scale, placed on a leveled floor and the Zero error corrected, with each participant's hands by their side while looking forward. Head straight in erect position. Weight was read-off with minimal clothing and shoes-off.

A brief interview was conducted for each participant with the following questions asked [12].

1. Which hand will you preferentially use for: (a) Writing? (b) Eating? (c) Sweeping? (d) Throwing? (d) Opening and closing door and window shutter?
2. Which leg would you preferentially use for kicking a ball?

The favoured limbs of the subject when replying to those questions and actually carrying out those activities with ease were considered to be their dominant limbs.

Sharpened Romberg Test was performed as described by Briggs *et al,* [9]. The levelness of the flooring was determined with the use of a plumb line (swordfish brand) piaced on the ground and the indicator liquid settling at the centre was used for testing. The participants assumed a heel-to-toe standing position. The dominant leg was placed at the back of the non-dominant leg. All the tests were performed with the shoes-off and with the eyes opened or closed while standing on a white plane sheet of paper. Timing was done with a Swiss precision (Herwins) stopwatch, started after participants have assumed proper position and indicated their readiness. Timing was stopped when any of these occurred: 1. If the participants moved their feet from the proper and starting position. 2. If they opened their eyes on eyes closed trial. 3. If they reached the maximum balance time of 60 seconds. 4. If any form of sway was observed. Three trials were performed by all the participants and the longest time was recorded.

Functional Reach Test was performed as described by Duncan *et al*, [10]. Measurement was taken with a 3 inch by 48-inch (7.5cm by 120cm) transparent metre rule (fabricated by the Instrument Department U.C.H., Ibadan, Nigeria) to the nearest 0.1cm. Participants performed the test in a comfortable stance (Subject stand with the feet apart as wide as the measure of their shoulder girth). The meter rule was mounted on the wall parallel to the floor with the top edge at the level of the subject's acromion. Participants stood with the dominant arm near the wall of the meter rule. i.e. all participants performed the test with his or her dominant arm. The positions of the feet of the participants were marked on a plane sheet of paper on which they maintain their stance during the test. Participant was asked to make a fist, pronate the arm and flex the arm at the glenohumeral joint to 90 degree and parallel to the metre rule. The initial position of the third metacarpal was recorded as the initial position. Then the participant was asked to reach forward as far as possible keeping their fist parallel to the meter rule without taken a step. The participants were not allowed to touch the surface of the wall of the meter rule with either the reaching or non-reaching hand, holding themselves with the non-reaching hand or take a step in the process of measurement. The subject'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 centimetre. The two tests were performed randomly.

Data analysis

Data was summarized using mean, range, and standard deviation. Pearson product moment correlation coefficient (r) was used to determine the relationship between balance performance in each of the tests and each of the anthropometric variables. Significance level was set at $P < 0.05$.

Results

Table 1 showed the physical characteristics of all the participants in this study. Age range of all participants was between 60 and 74 years, with a mean of 65.37±4.53, their height range between 133-186.00 cm, with mean of 163.94±8.99 and weight range was 39.00-101.00 kg with a mean of 65.50±11.93. Arm length range was between 52.00-88.00 cm with a mean of 65.98± 4.93. Foot length range was between 21.00-30.00 cm with a mean of 25.61±1.64. Leg length range was 46.50-99.00 cm with a mean of 87.54±6.79. Trunk length range was 34.50-64.00 cm with a mean of 47.51±5.20. Shoulder girth range was between 31.50-46.60 cm with a mean of 40.04±2.80. Hip girth range was between 21.20-43.00 cm with a mean of 32.39±3.11.

Table 1: Physical characterisitics of subjects

Parameter	Range	Mean + S.D.
Age (years)	60.00-74.00	65.37 + 4.53
Height (cm)	133.00-186.00	163.94 + 8.99
Weight (kg)	39.00-101.00	65.50 + 11.93
Trunk length (cm)	34.50-64.00	47.51 + 5.20
Foot length (cm)	21.00-30.00	25.61 + 1.64
Leg length (cm)	46.50-99.00	87.54 + 6.79
Arm length (cm)	52.00- 88.00	65.98 + 4.93
Shoulder girth (cm)	31.50-46.60	40.04 + 2.80
Hip girth (cm)	21.20-43.00	32.39 + 3.11

n = 203

Table 2 showed the relationship between anthropometric variables and Functional reach test, Sharpened Romberg test with eyes opened and eyes closed. There was positive and significant relationship between performance on FRT and each of height, weight, trunk length, foot length, shoulder girth and hip girth. (r = 0.273, 0.229, 0.219, 0.268, 0.368 and 0.166 respectively all at $p < 0.05$). There was a significant and negative correlation between FRT and age. (r = -0.245, $p < 0.05$). There was significant and positive correlation between SRT with eyes closed and arm length, foot length and shoulder girth. (r = 0.182, 0.159, 0.250; all at $P < 0.05$) and there was significant positive correlation between SRT with eyes opened and shoulder girth and foot length. (r = 0.149, 0.172; $P < 0.05$).

Discussion

This study showed low significant positive relationship between height, weight, trunk length, foot length, shoulder, hip girth and FRT. This finding agrees with that of Duncan *et al* [10] who reported significant positive relationship between FRT and each of height, trunk length, arm length and foot length but only disagrees in arm length, which does not have significant correlation in this study.

Table 2: Pearson's product moment correlation coefficient between balance performance and anthropometric variables

	Height	Weight	Trunk	Leg	Arm	Shoulder	Hip	Foot
Static balance tests								
Sharpened Romberg Test (Eyes opened)	0.110	0.004	0.131	-0.094	0.106	0.149	-0.009	0.172
p value	0.117	0.953	0.062	0.181	0.131	0.034	0.904	0.014
Sharpened Romberg Test (Eyes closed)	0.097	0.019	0.117	-0.001	0.182	0.250	0.033	0.159
p value	0.170	0.789	0.097	0.978	0.009	0.000	0.639	0.024
Dynamic balance test								
Functional Reach Test (FRT)	0.273	0.229	0.219	0.028	0.075	0.368	0.166	0.268
P value	0.000	0.000	0.002	0.689	0.289	0.000	0.018	0.000

Key: n=203 *Hip = Hip Girth* *Shoulder = Shoulder girth*
Leg = Leg Length *Arm = Arm length* *Trunk = Trunk Length* *Foot = Foot Length*

The low positive significant relationship between FRT and each of height, weight, trunk length, foot length, shoulder and hip girth, showed that FRT increases as these parameters increase. The positive significant relationship obtained between balance performance and foot length could be explained by the fact that increase in foot length increases base of support so thereby making the individual more stable. This is also applicable to the increase in the reach with increase in foot length. Increase in weight makes the individual much more stable and hence perform better on the balance performance tests. The increase in reach with increase in height and trunk length could be due to the fact that taller people may reach better than shorter people with all other factors constant.

There was positive significant relationship between SRT (eyes closed) and each of Arm length, Foot length and shoulder girth. The positive relationship between foot length and Static balance performance in eyes closed can be explained by the fact that balance performance increase with increase in the base of support explained by increase in foot length. There was positive significant relationship between SRT (eyes opened) and each of foot length and shoulder girth, which also can be explained by the fact that balance performance may have been influenced by the base of support. The elderly performed better in eyes opened performance than in eyes closed performance of SRT showing the importance of visual input in balance performance.

According to Kejonen *et al* [13] the low relationship values obtained between balance performance and selected anthropometric variables could mean that there is no single anthropometric variable that wholly explains the variation in balance. All the anthropometric variables contribute in explaining variation in balance in the elderly.

The elderly with higher values of measured anthropometric variables may likely perform better in balance with fewer tendencies towards falling risks. In rehabilitation towards improving balance performance to reduce risk of fall in the elderly other factors such as wide base of support, slow walking speed, muscle strength training and clear visual input with the use of visual aide may also be incorporated in achieving significant improvement in balance performance.

Conclusion

The elderly person with higher anthropometric variables (height, weight, trunk length, foot length and shoulder girth) may perform better in maintaining balance statically and dynamically. In improving balance in individual elderly person other factors such as increased wide base of support with a walking aide, slow speed of ambulation, balanced muscle strength, improved coordination will be of added advantage in the elderly in reducing risks of fall.

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