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BODY COMPOSITION VALIDATION TECHNIQUE USING ANTHROPOMETRICS SURROGATES IN RECUMBENT PATIENTS WITH STANDING INABILITY: A PILOT STUDY REPORT.

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ABSTRACT

The purpose of this study was to develop an alternative technique for the determination of body composition in people or patients who are unable to stand erect as a result of disease or injury. It was a prospective pilot study using apparently normal subjects involving twenty-two (16males and 6females) volunteer subjects randomly recruited for the study. The means and standard deviations for their ages, body weights and heights were 31.20 ± 7.47, 68.59 ± 6.19 and 1.72 ± 0.05 respectively. All the participants gave informed consent to participate in the study. The horizontal body weights of the participants were measured in lying positions using an adaptation of the Guthri Smith apparatus frame to which a firm stretcher and two spring balances were attached on a horizontal level position. The heights of the subjects were also taken on supine lying on a firm plinth. The body weight and height of each of the subjects were also measured in standing with the conventional weighing scale and a stadiometer. The body mass index (BMI) and waist-to-hip ratio (WHR) were calculated for all the subjects with values obtained in both positions. The OMRON body fat monitor was also used to assess the percentage fat per height (%F/Ht) and fat mass per weight (FMWt) of each of the subjects in standing and lying positions. The results of the study showed that there were no significant differences between the body weights, heights, BMI, WHR, %F/Ht, and FMWt measured at vertical standing and horizontal lying positions. However, there were significant differences in the waist and hip circumference measurements taken in the two positions. The results also showed positive correlation between body weight and height, and BMI, %F/Ht andWHR derived from anthropometric parameters taken from both positions.It was concluded that anthropometry in standing and supine lying are of clinical use and associated, and developing practical horizontal weighing system may serve great gains for use in people with difficulties and or inabilities to stand, especially in young and middle-aged patients with spinal cord injuries during their acute and rehabilitative stages.

Introduction

Estimation of body composition parameters is an important aspect of clinical monitoring of progress or deterioration in the management of many medical conditions. The most common way of measuring body weights and heights in clinical settings in Nigeria and many other parts of Africa is through the use of readily available bathroom scale and stadiometer respectively. However, the use of the bathroom scale and stadiometer is applicable in people or patients who are able to stand erect. There is need for an alternative technique for the determination of body composition in people or patients who are unable to stand erect such as patients with spinal cord injuries with

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paraplegia and quadriplegia, patients undergoing dialysis, those with acute head injuries in comatose states, patients with severe pain on weight-bearing joints and others in some medical conditions. Managing nutrition and progression in some of these conditions therefore poses a serious challenge in these groups of patients. Most of the other elaborate and more sophisticated means of body composition determination methods like the underwater or total body water (TBW) weighing, dual energy X-ray absorptiometry (DEXA), body impedance analysis, near infra-red interactance method, etc, are either very limited or not available in clinical settings in Nigeria. Hydrostatic weighing is thought to be the most accurate for measuring body composition[1,2]. However, many of these methods are useful in subjects who are able to stand and or ambulate and most of the time carried out on healthy people. Although Body Impedance Analysis (BIA) measurement can be taken in lying positions, it requires relatively expensive machine that regularly require calibration and standard placement of electrodes[3], and its measurements are also believed to be influenced by hydration level of the subjects[2]. Computed tomography and magnetic resonance imaging are both very accurate for waist circumference but are impractical for routine clinical use[4]. Specialized equipment such as a sitting scale, platform wheelchair scale or bed scale, is needed to weigh paraplegic persons. Such equipment is unfortunately either unavailable or limited in developing countries[5]. The infantometer is used to measure the recumbent length of neonates and infants from birth through age 47months[6]. Such equipment is also unfortunately either unavailable or limited in developing countries[5].Researchers have used different regression equations to estimate weight from surrogate anthropometric measurements[5, 7], but the usefulness or generalization of most of the methods have been limited by reliability in terms of repeatability among races, ethnic groups and other related factors.

The challenge has therefore created the need to develop a technique of horizontal body weight and height determination using anthropometric technique of height-weight indexes, that is simple, inexpensive, and do not require heavy gadgetry. Such a technique should also lend itself to be used as surrogate to other body composition parameters like body mass index, in order that progression or otherwise in recumbent patients can be objectively monitored for proper clinical management and monitoring. The use of common, simple and inexpensive method of anthropometry which satisfies validation requirements becomes inexpedient. This informed the present pilot study where apparently healthy ambulant individuals were used as subjects to validate the instruments and the protocol.

Methodology

The present study is a prospective pilot study involving twenty-two (16males and 6females) volunteer subjects drawn from among the staff of the University of Benin Teaching Hospital, Benin City, Nigeria. Inclusion criteria were normal ambulant persons able to stand and walk erect and devoid of any spinal abnormality or deformity like scoliosis or kyphosis. Exclusion criteria included having stiffness or contracture on any of the appendicular joints, limb length discrepancy or presence of any other physical deformity in a particular subject. The means and standard deviations for their age, body weights and heights were 31.20 ± 7.47, 68.59 ± 6.19 and 1.72 ± 0.05 respectively.

The main instrument for the study contained an adaptation of the Guthri Smith apparatus frame to which a firm stretcher and two spring balances were attached on a horizontal level reachable by the operators (Fig 1). The spring balances were suspended on the two ends of the stretcher and attached to the frame. The subjects laid supine on the stretcher and the weight stretch on the two springs were calculated and added together, and then subtracted from the initial weight of the stretcher on the spring balances. Two measurements of each subject were made and the average of these was recorded in kilograms. The subjects were also put on supine lying on a firm bed and a board each was placed against the head and on the feet of each subject (Fig 2). The length between the boards was measured with a non-stretchable tape measure (Seca 201 tape measure; Seca, Hamburg, Germany) as the height of each subject and was recorded in meters. The body weight and height of each of the subjects were also measured with the conventional weighing scale (Hanson Limited, Ireland) and a stadiometer (Seca, England). All subjects had minimal clothing on during all measurements and all the measurements were taken in the morning before breakfast. All the participants gave informed consent to participate in the study. The body mass index (BMI) was calculated for all the subjects with values of body weight and height obtained both in vertical standing and horizontal lying positions. Each participant's waist-to-hip ratio was also calculated from the values of the waist and hip circumferences of measurements taken in standing and lying positions with tape measures to the nearest 0.01 meters. The OMRON fat percentage monitor (BF 302; Omron Co Ltd., Japan) device was also used to assess the percentage fat per height and fat mass per weight of each of the subjects in standing and lying positions. The values were recorded to the nearest percentage and kilogram respectively.

The obtained data were thereafter fed into SPSS version 16 for descriptive statistics of mean and standard deviation as well as the paired sample t-test.The t-test statistical method was used to test the significance of difference in the parameters measured in vertical standing and horizontal lying positions. Pearson's product moment correlation coefficient was also used to test the strength of relationship between measurements taken in vertical standing and horizontal lying positions. Significance level was set at 0.05.

Results

Twenty-two (22) apparently healthy subjects (16males and 6females) whose ages ranged between 26- 50 years (mean ± SD= 31.20 ± 7.46) were recruited into this study. Their vertical standing body weights ranged between 58.00 – 79.20 (mean SD= 68.58 ± 6.18) while their standing heights ranged between 1.60- 1.81 (mean SD= 1.72 ± 0.06). The means and standard deviations of percentage fat per height, fat mass per weight, waist circumference and hip circumference measures on standing position were 14.50 ± 4.12, 10.88 ± 4.46, 30.40 ± 1.82 and 35.60 ± 2.38 respectively. The means and standard deviations for body mass index and waist-to-hip ratio in erect standing position were 24.00 ± 3.56 and 0.85 ± 0.06 respectively (Table 1). The mean and standard deviation for body weight, height, percentage fat per height and fat mass per weight measured in horizontal lying positions on the same participants were 66.00 ± 13.17, 1.72 ± 0.06, 13.5 ± 4.62 and 10.13 ± 4.69 respectively. The waist circumference, hip circumference, body mass index and waist-to-hip ratio were 29.57 ± 1.57, 35.20 ± 2.65, 24.02 ± 3.22 and 0.84 ± 0.06 (Table 1).

Table 1: Physical and anthropometric parameters of the subjects in standing and lying positions.

Parameters	Range	Mean and Standard Deviation in Standing	Mean and Standard Deviation in Lying
Age	26.00 – 50-00	31.20±7.46	31.20±7.46
Weight	58.00 – 79.20	68.59± 6.18	66.00±13.17
Height	1.60 – 1.81	1.72±0.06	1.72±0.06
%Fat/Wt	9.70 – 21.50	14.50±4.12	13.5±4.62
FatMass/Wt	5.60 – 18.50	10.88± 4.46	10.13±4.69
Waist Circum	28.00 -33.50	30.40±1.82	29.57±1.57
HipCircum	32.50 – 39.50	35.60±2.38	35.20±2.65
BMI	20.00 – 31.00	24.00±3.56	24.02±3.22
WHR	0.74 – 0.98	0.85±0.06	0.84±0.66

%Fat/Wt= Percentage fat per weight; FatMass/Wt= Fat mass per weight; Waist Circum= Waist Circumference; HipCircum= Hip Circumference; BMI= Body Mass Index; WHR= Waist-to-Hip ratio.

The results of the paired sample t-test showed that there was no significant difference between the body weight ($t=0.910$; $p< 0.387$), height ($t= -0.978$; $p< 3.54$), percentage fat per height ($t= 3.556$; $p< 0.16$), and fat mass per weight ($t=3.610$; $p< 0.15$) measured at vertical standing and horizontal lying positions. In addition, t-test statistics also showed that there was no significant difference between the body mass index ($t=0.021$; $p< 0.984$) and waist-to-hip ratio ($t= 1.221$; $p< 0.253$) measured from both positions. However, there were significant differences in the waist circumference ($t= 3.521$; $p< 0.007$) and hip circumference ($t= 2.953$; $p< 0.018$) measurements taken in the two positions (Table 2).

Table 2: Showing the Paired t-test results of the subjects in standing compared with lying positions measurements.

Variables	t-values	P significance value
BwtSvsBwtL	0.910	0.387
HtSvsHtL	-0.978	3.54
PFat/HtSvsPFat/HtL	3.556	0.16
FatM/WtSvsFatM/WtL	3.610	0.15
WaistCircumSvsWaistCircumL	3.521	0.007
HipCircumSvsHipCircumL	2.953	0.018
BMIs vsBMIl	-0.021	0.984
WHRs vsWHRl	1.221	0.253

BwtS= Body weight in standing; BwtL= Body weight in lying; PFat/HtS= Percentage fat per height in standing; PFat/HtL= Percentage fat per height in lying; FatM/WtS= Fat mass per weight in standing; FatM/WtL= Fat mass per weight in lying; WaistCircumS= Waist circumference in standing; WaistCircumL= Waist Circumference in lying; BMIs= Body mass index in standing; BMIl= Body mass index in lying; WHRs= Waist-to-hip ratio in standing; WHRl= Waist-to-hip ratio in lying.

Body weight measurements taken in vertical standing and horizontal lying position were found to be positively correlated ($r = 0.802$; $p < 0.005$) with each other and with the body mass index computed from standing anthropometrics ($r = 0.772$; $p < 0.009$). The height measurements in both positions were also found to share high positive correlations ($r = 0.931$; $p < 0.000$). The results also revealed that the percentage fat per height taken in standing position was positively correlated with the one taken in horizontal lying position ($r = 0.993$; $p < 0.000$), the percentage fat per height in standing position was also positively correlated with waist-to-hip-ratio ($r = 0.919$; $p < 0.10$) calculated from standing weight and height anthropometrics and also with fat mass per weight in standing ($r = 0.997$; $p < 0.000$) and in lying positions ($r = 0.990$; $p < 0.000$).

The waist-to-hip ratio measurements taken in standing and horizontal lying positions were also found to be highly positively correlated ($r = 0.937$; $p < 0.000$). The waist circumferential measurements in standing and lying positions were also found to share positive correlation ($r = 0.914$; $p < 0.000$). The result also revealed that body mass index calculated from standing anthropometric parameters correlated with both waist circumference in standing ($r = 0.747$; $p < 0.013$) and in horizontal lying positions ($r = 0.664$; $p < 0.036$). (Table 3).

Table 3: Pearson's Product moment correlation coefficient of standing and lying variables

Variables	Pearson coefficient	Significance value p<0.005
BwtS and BwtL	0.802"	0.005
HtS and HtL	0.931"	0.000
BwtS and BMIS	0.772"	0.009
%Fat/HtS and %Fat/HtL	0.993"	0.000
%Fat/HtS and WHRs	0.919"	0.100
%Fat/HtS and FMwtS	0.997"	0.000
%Fat/HtS and FMwtL	0.990	0.000
WHRs and WHRl	0.937"	0.000
WCs and WCl	0.914"	0.000
BMIs and WCs	0.747'	0.013
BMIs and WCl	0.664'	0.036

WCs=Waist Circumference standing; WCl= Waist Circumference in lying.

Discussion

The aim of this study was to compare and relate the anthropometric body weight relative to height body composition measurement with the use of simple, cheap and readily available tools tried as a pilot study in apparently healthy individuals for validation for use in people with recumbent conditions.

This is the first known study comparing anthropometric parameters measured in standing and lying positions with the aim of validating the results from both positions in apparently healthy people as a pilot study for use in hospitalized and or recumbent patients. For this reason, there are no direct studies to use to buttress or refute our observations.

The result of this study has revealed that body weight and height measurements taken in erect standing and horizontal lying positions are not significantly different. Weight relative to height provides essential information on the growth and nutritional status in an individual than either weight-for-age or height-for-age alone. Weight-for-height helps to determine and classify the nutritional status in the individual patient[8]. Anthropometric and body composition assessments provide important information about the nutritional status of dialysis patients[9]. This study has also revealed that the body mass index (BMI) and waist-to-hip ratio derived from anthropometric measurements from vertical standing and horizontal lying positions parameters are not significantly different. Anthropometry is better than TBW, and as good as segmental impedance as methods of body composition prediction equations or methods, in predicting limb muscle mass in elder men of over 75years of age[10]. BMI is considered the best way to use height and weight to assess fatness[3]. BMI is a measure of generalized obesity while WHR is a better measure of abdominal (central) obesity[11]. The study also revealed that percentage fat per height in standing is correlated with percentage fat per height in lying position, body mass index in lying position, waist-to-hip ratio in standing and lying positions and fat mass per weight in standing. A good correlation between body fat percentage estimated by anthropometric measurements and bio-impedance and severity of a chronic disease called obstructive sleep apnea-hypopnea syndrome (OSAHS) has previously been reported in a study[12]. The same authors also reported that the BMI derived from anthropometry correlated with the prediction accuracy, though to a lesser extent, of OSAHS derived from computed tomography.

A correlation between the percentage fat per height and fat mass per weight measured with OMRON 320 body fat monitor (which uses the bio-electric impedance analysis technique) with anthropometric measurements of body mass index and waist-to-hip ratio was found in this study. A similar observation has also been made in a study which stated that bioelectrical impedance analysis (BIA) has significant potential as a complement to standard anthropometric techniques for assessing the nutritional status of dialysis patients[13]. Percentage body fat measured by the OMRON BF 302 fat monitor has been found to have strong positive correlation with body mass index in apparently healthy individuals[14].

The present study has also revealed that there is a correlation between the body weight and height measured in standing and those measured in horizontal lying positions. There is no literature to buttress or refute this observation. However, the report of a study had revealed that measurement of height and weight in standing and lying are reliable, errors may arise more from practical standing rather than in lying[15]. Weight changes over time may be informative. Authorities have linked percentage of weight changes which can be calculated to possibility of nutritional risk and posited that more than 5% loss in a month or more than 10% loss in six months are significant changes[16], and loss of more than 5% over one year may be linked with increased mortality[17]. The outcome of this study has also revealed a significant difference between the waist and hip circumferential measurements taken in standing and in lying positions. To our knowledge, there are no published reports to support or argue this observation, however, the report of a study on the validity of waist circumference measurement taken in supine position among participants with severe, intellectual, sensory, and motor disabilities is biased towards higher value of standing waist circumference18.

The waist circumference in standing was found to be correlated with supine lying waist circumference. Waist circumference has the potential to be a very useful tool for determining obesity in individuals with spinal cord injury (SCI) because it is relatively simple to obtain, can be monitored over time, and does not require estimation of height19. This study has also showed that the standing body weight is correlated with horizontal lying body weight, and the standing height is also correlated with the horizontal body height measured.

Conclusion

The findings of this study have shown that anthropometry in standing and supine lying are useful and related and may potent some gains for use in people with standing difficulties and or inabilities, especially in young and middle-aged patients with spinal cord injuries during their acute and rehabilitative stages.

References

1. Prentice, W.E.,Rehabilitation techniques in Sports Medicine (2nded.). Toronto: Mosby-Year book, Inc., 1994.

2. Klavora, P., Foundations of kinesiology: Studying human movement and health. (1sted.). Toronto: Sport Books Publisher, 2008.

3. Corbin, C.B, Lindsey, R,Welk, G.J., Corbin, W.R.,Fundamental Concepts of Fitness and Wellness. NY. McGraw-Hill Companies, Inc., 2001.

4. Gormley, J., Hussey J.,Exercise therapy: Prevention and treatment of disease. (1sted.) MA, USA: Black well Publishing Inc. , 2005.

5. Snyman, H., Herselman, MG., Labadarios, D.,The development of a preliminary regression equation for estimating the weight of black South African paraplegic males using anthropometric measurements in Tshwane, South Africa. S Afr J Clin Nutr., 2008,21(3):127-131

6. National Health and Nutrition Examination Survey III. Body measurements (anthropometry). Westat, Inc. Rockville MD., 1998, Pg 6

7. Han, TS&Lean, ME.,Lower leg length as an index of stature in adults. Int J Obes Relat.MetabDisord.,1996, 20(1):21-7.

8. Maqbool, A, Olsen, I.E, Stallings, V.A.,Clinical Assessment of Nutritional Status in Duggan C, et al. Nutrition in Pediatrics. (4th ed.) Hamilton, Ontario, Canada: BCDecker Inc;. 2008.

9. Chumlea, WC., Anthropometric and body composition assessment in dialysis patients. Semin Dial., 2004, 17(6):466-70

10. Fuller, N.J, Sawyer, M.B, Laskey, M.A, Paxton, P, Elia, M., Prediction of body composition in elderly men over 75 years of age. Ann Hum Biol.;1996, 23(2):127-47

11. Czernichow, S,Kengne A, Huxley, R.R, Batty, G.D, de Galan, B,et al.,Comparison of waist-to-hip ratio and other obesity indices as predictors of cardiovascular disease risk in people with type-2 diabetes: A prospective cohort study from ADVANCE. European Journal of Cardiovascular Prevention & Rehabilitation;2011, 18 (2):312-319.

12. Sînziana, L, Raluca, B, Cristian, C, Gianina, R&Traian, M.,Body composition in obstructive sleep apneahypopnea syndrome bio-impedance reflects the severity of sleep apnea. Multidisciplinary Respiratory Medicine, 2010, 5:44-49.

13. Kaysen, GA, Zhu, F, Sarkar, S, Heymsfield, SB, Wong, J.,Estimation of total-body andlimb muscle mass in hemodialysis patients by using multifrequency bioimpedance spectroscopy. Am J ClinNutr.,2005, 82(5):988-995.

14. Oke, KI., Dada, OI., The criterion-validity of the Omron 302 Body Fat Monitor. Accepted for publication in India Journal of Physiotherapy & Occupational Therapy, 2013 (in Press).

15. Rush, EC, Crowley, J, Freitas, IF, Luke, A., Validity of Hand-to-Foot Measurement of Bioimpedance: Standing Compared with Lying Position. Obesity, 2006, 14: 252–257,doi: 10.1038/oby.2006.32.

16. Todorovic, V, Russell, C, Stratton, R, Ward, J.,Elia, M.,The“MUST” Explanatory Booklet. A guide to the “Malnutrition Universal Screening Tool” ('MUST') for adults. Redditch: The Malnutrition Advisory Group British Association for Parental and Enteral Nutrition. 2003.

17. Wallace, JI, Schwartz, RS, LaCroix, AZ, Uhlmann, RF., Pearlman, RA., Involuntary weight loss in older outpatients: incidence and clinical significance. Journal of theAmerican Geriatrics Society, 1995, 43 (4), 329-337.

18. Waninge, A, Ligthart, KAM, Kramer, J, Hoeve, S, van der Shans, Haisma, HH., Measuring waist circumference in disabled adults. Research in Development Disabilities, 2010,31(3): 839- 847.

19. Rajan S, McNeely MJ, Warms C, & Goldstein B., Clinical Assessment and Management of Obesity in Individuals With Spinal Cord Injury: A Review. J Spinal Cord Med.; 2008, 31(4): 361–372.