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Impact of Gender Sensitivity on Anthropometric Measurements

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ABSTRACT

Errors can easily be introduced into anthropometry measurements. The measurer's confidence may not be equal between same-sex and opposite-sex measuring, hence the need to evaluate and compare errors arising from anthropometric measurement when participants are measured by a practitioner of the same gender and vice versa. A sample of 100 students of Ebonyi State University (60 males and 40 females, aged between 18 and 45 years) was used for this study. From this number were extracted 17 different parameters by a trained male anthropometrist. A separate sub-sample of 59 adults (20 males and 39 females) was measured for skinfold thickness at eight sites by a trained female anthropometrist. Comparison of two sets of measurements extracted by a male indicated that first set measured did not differ significantly from the second set apart from the neck girth measurements. However, when a male anthropometrist extracted measurements on females, nine parameters' measurements significantly differed ($P<0.05$) when the first measurement of each was compared with the second measurements. In comparison using Technical Error of Measurement (TEM) and Relative Technical Error of Measurement (RTEM), the measurements on males extracted by a male had lower error when compared with the measurements on females extracted by a male. When a female measured male, there were significant differences ($P<0.05$) in most of the parameters considered. However, the measurements extracted from females by a female did not indicate significant difference in all the measurements extracted from different sites apart from measurement extracted from the abdominal site. TEM and RTEM analysis indicated lower error on the two different skinfold thickness extracted from females by a female when compared with magnitude of errors that arose from two different measurements extracted from males by a female. Gender sensitivity is another challenge to reproducibility and accuracy of data in anthropometry.

Key words: gender sensitivity, anthropometric measurements, accuracy, reproducibility, TEM, RTEM

INTRODUCTION

Accurate and reproducible anthropometric data provide information about the distribution of body fat and skeletal muscle mass, which can, over time, identify nutritional deficiencies or excesses in calorie and protein reserves when compared with normative values. Anthropometry involves a simple reliable method for quantifying body size and proportions through the external measurement of morphologic traits of human beings (Ulijaszek and Kerr 1999) and may include stature, body mass, circumferences, skinfold thickness, and other measurements of skeletal size and proportions (Kouchi et al 1996). These measurements are non-invasive and represent an affordable and convenient means of assessing patients' nutritional status in clinical practice. Data from anthropometric measurements provide information about the distribution of body fat and skeletal muscle mass, and over time, identify nutritional deficiencies or excesses in calorie and protein reserves compared with normative values (Reber et al., 2019).

However, anthropometric measurements cannot be acquired without some errors. These errors could arise through technical error of the measurement (i.e. imprecision, via human error),which include errors arising from the measurer or observer, imprecision errors from the devices and those arising from the failures of methods(Ulijaszek and Kerr 1999), and biological variability causing the 'true' value to change over time. Based on these errors, it is plausible to suggest that interpretation of anthropometric results may be impaired(Ulijaszek and Kerr 1999)and the greater the error level the greater the variance associated with a particular measurement can be artificially inflated(Cohen1988;Guo, 2000;Goto, 2007).Measurement errors generally involve accuracy (the closeness of the value measured to the true value)(Appannah, 2008)and reproducibility (closeness of two repeated measurement values) (Appannah, 2008,Mueller1988, Johnson et al, 1997).Both are fundamental to clinical and epidemiological research concerning interpretation and prediction of health status.

In as much as errors emanating from physical characteristics diversity of the population cannot be controlled, the variability on the anthropometrical measurements caused by variations in technique can be controlled. Errors arising due to technique can be caused by inadequate time intervals between successive measurements, errors due to participants' postures(Johnson et al 1997, variations in the determination of landmarks (Kouchi et al 1996;Hung et al,2004;Wang et al, 2003;Verwei et al 2013), poor handling of anthropometric tools or variability of measuring instruments(Ulijaszek and Kerr, 1999;Himes, 2009;Townsend et al, 2011,Schlegel-Pratt andHeizer, 1990;Oberlander et al 1981;Biehl et al, 2013;Whitehead, 1990;Cyrino et al 2003and poor reading of measurement values, and inconsistency of measurement techniques executed (Johnson et al 1997;Perini et al,2005) which may be exacerbated if the measurer becomes anxious.

International Society for the advancement of Kinathropometry (ISAK) has adopted Technical Error of Measurement (TEM) as an index for expressing the error margin in repeated anthropometric measurements

(Bennett and Osborne 1986; Stewart et al., 2011). This index can be used for an intra-evaluator differences which involves comparison of the differences between repeated measures extracted by an individual or for inter-measurer differences which involves the differences observed between two or more persons' measurements (when they measured the same parameters in the same group of participants)(Pederson and Gore, 2000;Jamaiyah et al 2010;WHO, 2006).

For accurate and reliable measurements, anthropometrists undergo specialized training for ISAK accreditation, which includes measuring within permissible error targets (Mueller et al 1988; Stewart et al., 2011; WHO, 2006). This usually involves measuring both males and females, however, due to cultural and religious factors; gender differences pose additional challenges for quality assured anthropometric measurements. Some participants are uncomfortable being measured by an anthropometrist of the opposite gender and those who give their consent to be measured by the opposite gender may discover latent fears only when their 'space envelope' is invaded by anthropometrist. Equally, the anthropometrist may feel compromised by such close proximity; however, the effect of this has not been reported in the literature. As a result, this study aimed to compare and evaluate measurement when participants are measured by an anthropometrist of same gender and by the opposite gender.

METHODS

Subjects: A sample of 100 students of Ebonyi State University (60 males and 40 females) between the age group of 18 and 45 years drawn from different faculties (Physical sciences, Health sciences and Basic Medical Sciences) was used for this study. From this number were extracted different parameters by a trained male anthropometrist. A separate sub-sample of 59 adults drawn from the sample (20 males and 39 females) was measured for skinfold thickness by a trained female anthropometrist.

The objectives and the methods of the study were explained to each of the subjects. Informed consent was acquired from the subjects before measurements were taken. Individuals were all apparently healthy, and those with skeletal abnormalities, physical disabilities such as limb amputees or those with visible body asymmetry were excluded. Each parameter was extracted in duplicate from the right side of the body after landmarking (Stewart et al, 2011).

Study design: A male and a female anthropometrist who had undertaken training in the Body Composition Research Unit (BCRU) of the department of Anatomy, Ebonyi State University, Abakaliki, Nigeria, were selected to extract anthropometric measurements from male and female samples. Each participant was invited for two sessions' measurements where the second measurements were extracted the following day with the measurer blinded to the first set of measurements.

The **male measurer** extracted the following anthropometric parameters from male and female participants: body mass, stature, head girth, neck girth, chest girth, waist girth, gluteal girth, thigh girth, biacromial breadth, A-P abdominal depth, A-P chest depth, humeral breadth (biepicondylar), shoulder breadth, radiale-stylion, waist circumference, knee height, sitting height. The **female measurer** extracted skin fold thickness from the following sites Triceps, Biceps, Subscapular, Iliocristae, Supraspinale, Abdominal, Front thigh and Medial calf from both males and females.

Approval for this study was obtained from the Ethics/Research Committee of the Faculty of Basic Medical Science, Ebonyi State University, Abakaliki. Informed consent was also obtained from subjects before the commencement of the measurements.

Procedures for anthropometric measurements: Stature and sitting height were measured using stadiometer [Seca 218, Hamburg Germany].Body mass of the participants was measured using electronic weighing balance [Camry electronic scale, China]. Girths were measured using Lufkin W606PM flexible and inextensible steel tape [Rosscraft, Vancouver, Canada].A CESCORF Anthropometer[Porto Alegre, Brazil] was set as a large sliding caliper and was used to measure Biacromial breadth, Transverse chest breadth, A-P chest depth and A-P abdominal depth. Anthropometric box was used to facilitate measurement of sitting height. It was placed in front of the stadiometer. Its dimension is 40cm (tall) x 50cm (wide) x 30cm (deep) as recommended by ISAK (Bennett and Osborne, 1986; Stewart et al. 2011).

Statistical analysis: The data were expressed as mean ± standard deviation (SD). Paid t-test was used to compare the first and second measurements: P values less than 0.05 ($P<0.05$) was considered statistically significant. The first and second measurements were expressed in absolute TEM and %TEM to establish level of variance. Statistical analysis was performed using SPSS version 21(SPSS Inc. Chicago, IL).

RESULTS

The physical characteristics of the participants who were mainly young adults were shown on table 1. Males had slightly higher values in all the physical characteristics than females.

Table 1: Physical characteristics

	Male = 60		**Female = 40**	
Parameters	**Mean**	**Std. Dev**	**Mean**	**Std Dev**
Age (years)	21.79	1.99	20.5	1.95
Body mass(kg)	64.85	8.43	58.44	7.78
Stature(cm)	175.43	6.62	160.24	26.33
Sitting height (cm)	86.99	7.78	80.69	4.05
Arm span (cm)	183.01	12.13	169.91	10.72

Comparison of first and second measurements in males and females extracted by a male: On table 2 which compared the first and second measurements extracted by a male, the first set of measurements did not differ significantly from the second set of measurements apart from the first and second measurements of the neck girth. However, on table 3 where a male anthropometrist extracted measurements on females, nine parameters' measurements significantly differed (P<0.05) when the first measurement of each was compared with the second measurement. The varied measurements were got from the following: Chest, Waist, Gluteal, Thigh, Calf and Ankle girths as well as Biacromial breadth, A-P Abdominal depth and A-P Chest depth.

Table 2: Comparison of first and second measurements in males extracted by a male anthropometrist [60 males]

Parameters	Mean dif	Std	P-value
Arm span1 - Arm span2 (cm)	0.67	16.54	0.78
Head grth1 - Head grth2 (cm)	-0.60	3.25	0.21
Neck grth1 - Neck grth2 (cm)	-0.24	0.78	0.04*
Arm grth relaxed1 - Arm grth relaxed2 (cm)	-0.07	0.47	0.29
Arm grth flexed and tensed1 - Arm grth flexed and tensed2 (cm)	0.08	1.47	0.72
Forearm grth1 - Forearm grth2 (cm)	-0.13	0.59	0.13
Wrist grth1 - Wrist grth2 (cm)	-0.14	0.67	0.17
Chest grth1 - Chest grth2 (cm)	-0.02	1.39	0.91
Waist grth1 - Waist grth2 (cm)	-0.32	1.30	0.10
Gluteal grth1 - Gluteal grth2 (cm)	0.01	1.12	0.93
Thigh grth1 - Thigh grth2 (cm)	0.33	4.43	0.60
Calf grth1 - Calf grth2 (cm)	-0.11	0.79	0.33
Ankle grth1 - Ankle grth2 (cm)	-0.20	0.81	0.10
Biacromial brth1 - Biacromial brth2 (cm)	-0.10	0.96	0.46
A-P Abd depth1 - A-P Abd depth2 (cm)	-0.97	3.82	0.09
Tr.Chest brth1 - Tr.Chest brth2 (cm)	0.06	1.96	0.83
A-P Chest depth1 - A-P Chest depth2 (cm)	-0.09	0.82	0.46

Grth = Girth, A-P = Anteroposterior, Abd = Abdominal, brth = breadth, Tr = Transverse *=P<0.05(significant)

Table 3: Comparison of first and second measurements in females extracted by a male anthropometrist [40 females]

Parameters	Mean dif	Std	P-value
Arm span1 - Arm span2 (cm)	-0.82	5.62	0.40
Head grth1 - Head grth2 (cm)	-0.10	0.79	0.47
Neck grth1 - Neck grth2 (cm)	-0.76	2.31	0.06
Arm grth relaxed1 - Arm grth relaxed2 (cm)	-0.03	0.63	0.77
Arm grth flexed and tensed1 - Arm grth flexed and tensed2 (cm)	0.14	1.41	0.56
Forearm grth1 - Forearm grth2 (cm)	-0.09	0.97	0.59
Wrist grth1 - Wrist grth2 (cm)	-0.11	0.61	0.31
Chest grth1 - Chest grth2 (cm)	-1.04	2.66	0.02*
Waist grth1 - Waist grth2 (cm)	-1.98	3.88	0.00*
Gluteal grth1 - Gluteal grth2 (cm)	-2.78	7.12	0.03*
Thigh grth1 - Thigh grth2 (cm)	-2.60	7.41	0.04*
Calf grth1 - Calf grth2 (cm)	-0.77	1.77	0.01*
Ankle grth1 - Ankle grth2 (cm)	-0.45	0.71	0.00*
Biacromial brth1 - Biacromial brth2 (cm)	-0.49	0.94	0.00*
A-P Abd depth1 - A-P Abd depth2 (cm)	-1.46	1.42	0.00*
Tr.Chest brth1 - Tr.Chest brth2 (cm)	-0.57	2.62	0.21
A-P Chest depth1 - A-P Chest depth2 (cm)	-0.75	1.92	0.03*

Grth = Girth, A-P = Anteroposterior, Abd = Abdominal, brth = breadth, Tr = Transverse

***=P<0.05(significant)**

On Absolute TEM and Relative TEM analysis of the extracted data, the first and second measurements of the parameters were analysed using absolute and relative TEMs as indicated in figures 1 and 2, respectively. The measurements on males extracted by a male had fewer errors when compared with the measurements on females extracted by a male. Unimaginable differences in females measured by a male were observed in following parameters: thigh girth with RTEM of 18%, A-P abdominal depth with RTEM of 16.04% and A-P chest depth with RTEM of 16.04.

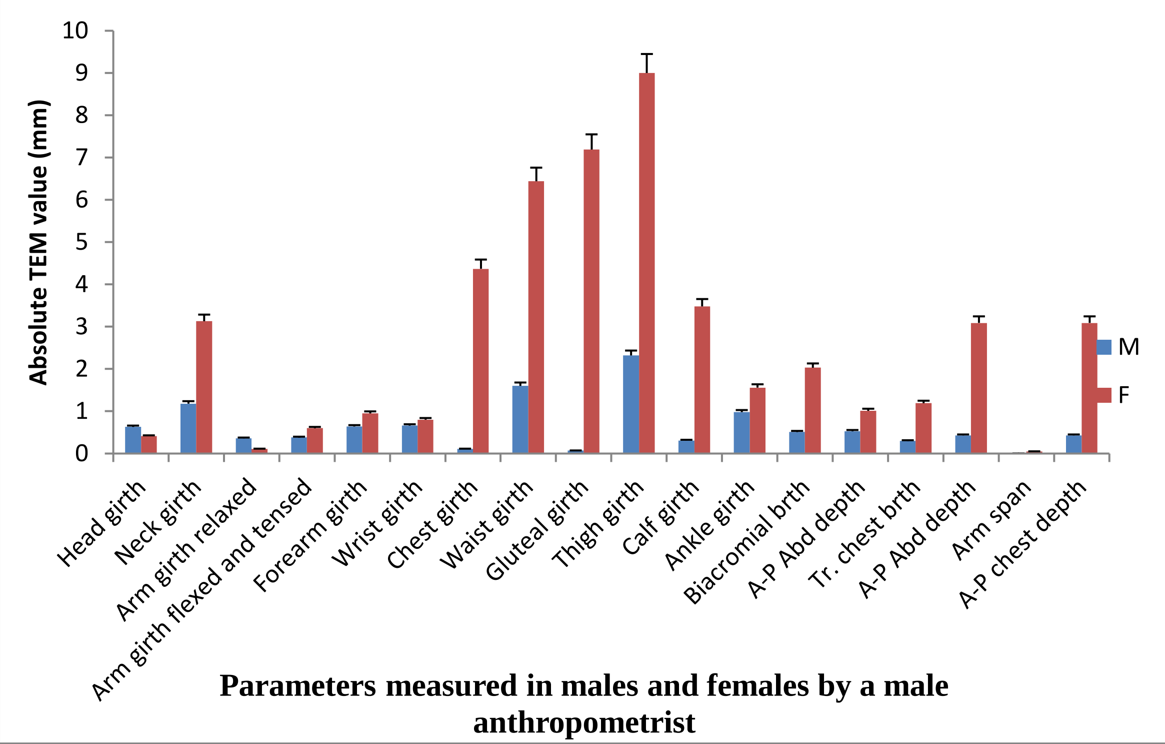

Figure 1: **Technical error of measurements (TEM) of selected body contact measurements in males and females measured by a male anthropometrist**

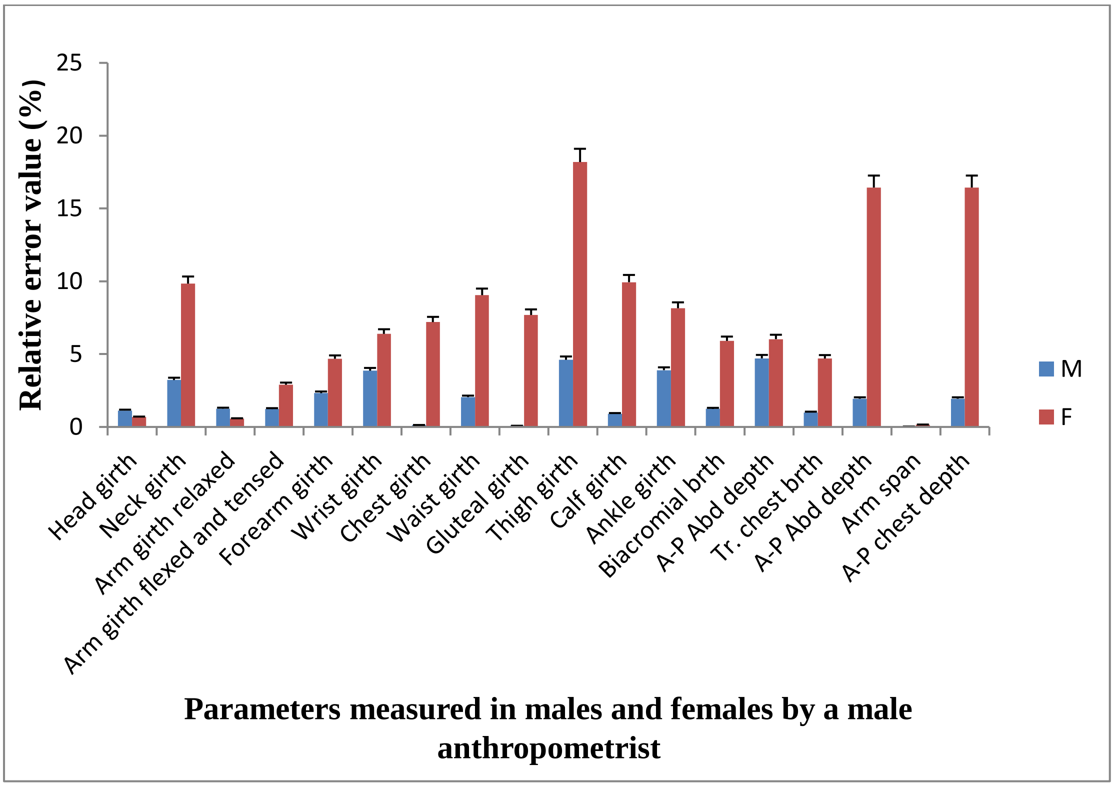

Figure 2: **Relative technical error of measurements (%TEM) of selected body contact measurements in males and females measured by a male anthropometrist. M represents males and F represents females**

Comparison of first and second skinfold measurements in males and females extracted by a male: On table 4 which compared the skinfold thickness measurements extracted from males by a female, there were significant differences (P<0.05) in most of the parameters considered which include Biceps, Triceps, Abdominal, Supraspinale, Front thigh and medial calf but there was no significant difference (P>0.05) in skinfold thickness extracted from two sites: Subscapular and Iliocristae. However, the measurements extracted from females by a female did not indicate significant difference in all the measurements extracted from different sites apart from measurement extracted from the abdominal site as depicted in table 5.

The analysis using absolute TEM and Relative TEM as presented on figures 3 and 4 indicated fewer errors on the two different skinfold thickness extracted from females by a female after 24 hours when compared with magnitude of errors that arose from two different measurements extracted from males by a female after 24 hours.

Table 4: Comparison of first and second skinfold measurements in females extracted by a female anthropometrist

Parameters	Mean dif	Std	P-value
Triceps 1 – Triceps 2	0.04	0.56	0.71
Biceps 1 – Triceps 2	-0.17	0.78	0.30
Subscapular 1 – Subscapular 2	-0.04	0.37	0.58
Iliocristae 1 –Iliocristae 2	0.02	0.43	0.81
Supraspinale 1 – Supraspinale 2	0.87	2.70	0.14
Abdominal 1 –Abdominal 2	-0.26	0.54	0.03*
Front thigh 1 – Front thigh 2	0.09	0.42	0.33
Medial calf 1 – Medial calf 2	0.30	1.82	0.43

Table 5: Comparison of first and second skinfold measurements in males extracted by a female anthropometrist

Parameters	Mean dif	Std	P-value
Triceps 1 – Triceps 2	-0.27	0.70	0.013*
Biceps 1 – Biceps 2	-0.38	0.90	0.008*
Subscapular 1 – Subscapular 2	-0.01	0.60	0.900
Iliocristae 1 – Iliocristae 2	-0.11	0.86	0.383
Supraspinale 1 – Supraspinale 2	-0.55	0.99	0.001*
Abdominal 1 – Abdominal 2	-0.66	1.67	0.012*
Front thigh 1 – Front thigh 2	-0.79	1.80	0.006*
Medial calf 1 – Medial calf 2	-0.41	1.15	0.023*

DISCUSSION

In the present study, gender sensitivity affected the accuracy and reproducibility of data extracted from male and female population by an opposite gender. When the 1st and 2nd measurements extracted from males and females by a male measurer were compared there was significant difference ($P<0.05$) in most of the parameters derived from females than those derived from males as indicated in tables 2 and 3, respectively. Comparing the same measurements using absolute TEM and Relative TEM, measurements derived from the opposite gender indicated higher number and magnitude of error as compared with the error that arose from measurements derived from a group by the same gender (figures 1 and 2). Higher magnitude of errors was observed in the purported reserved body regions such as thigh, upper trunk, and gluteal regions.

The same was observed when a female extracted SKF from male and female populations. There was greater consistence when a female extracted SKF from a female population than when she did same to the male population (tables 4 and 5, respectively). In most of the SKF parameters measured, there existed significant difference in greater number of SKF extracted from males by a female than those extracted from a female population by a female measurer. TEM and RTEM indicated higher error in 1st and 2nd measurements extracted from a population by the opposite gender than those extracted from a particular population by the same gender (figures 3 and 4).

Considering the number of participants that gave their consents, the number was always lower when an opposite gender was extracting the measurement and higher when the measurements were extracted by the same gender as the participants. As a male was measuring, 60 males gave their consent and participated against 40 females that gave their consent and participated. The same applied to when a female anthropometrist was measuring; it was 20 males' participants against 39 females.

Typically, the sources of error in anthropometric measurements as stated by Kouchi and Mochumaru (2011) and Lu et al (2010) involves the accuracy of measuring instrument, skill of the measurer and ability to maintain a repeated posture by the participants. However, invasion of "space envelope" of a participant by the measurer can induce fear on the participant and this can result to inconsistency in postures in case of repeated measurements. When the "space envelope" of the participant is invaded by the measurer, the participant unconsciously undergo several movements of different body parts and can as well undertake irregular breathing during the two or more measuring sessions. Swaying of the body (Kouchi, M. and Mochimaru 2011; Jamaiyah et al 2008) affect anthropometric measurements, and breathing cycle (Njokuand Stewart 2018) has been reported to affect landmarking site and accurate data extraction especially on the trunk.

The same applies to the measurer who in the bid to apply caution especially when measuring an opposite gender may make wrong landmarking, inaccurate reading and recording. Since landmarking involves palpation, many are usually uncomfortable to be palpated, and the measurer too may not be disposed to spend much time to locate exact site for measurement on an opposite gender. Based on this, observer's error is the cause of most errors in anthropometry since it includes wrong location of landmark, subject positioning, and the use of instrument (Perini et al., 2005).

CONCLUSION

Although errors arising from extraction of data for various purposes can not be totally removed, it can be reduced drastically if the established standardized protocols are followed. Training of the measurers or anthropometrists has been a means of error reduction in anthropometry especially following a standardized approach like ISAK (Stewart et al., 2011; Canada, 2003); however, gender sensitivity is another challenge to reproducibility of data. Males tend to be accurate and reproducible in extracting data from males than females; and females do same to their counterparts than males. However, gender sensitivity could be reduced by given the participants some durational training. This will enable them to readily give their consent, get accustomed to measuring protocols, overcome fear and be confident throughout the measuring sessions.

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