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Comparison of actual (measured) weights and heights with the standard formula methods of estimation among children in Enugu

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Abstract *Background:* In paediatric practice, weight and height are required for therapeutic and diagnostic interventions. In some circumstances actual anthropometric measurements are not possible and estimates are used. Several formulae are in use for weight and height estimations. The adequacy of these estimates has not been tested for our children. The aim of the current study was to compare the adequacy of formula methods of weight and height estimation with measured values in children.
Materials and Methods: This was a comparative observational study. Children who met the inclusion criteria were selected consecutively and studied over a two month period using a semi-structured questionnaire. Weight and height of each child were measured and recorded to the nearest 0.1kg and 0.1cm respectively using standard protocols. Weight and height for age were also estimated using the universally accepted formulae. Data were analyzed using SPSS 19.0. Paired
t- test was used to compare the means of actual and estimated weights and heights according to age. The level of significance was set at $p<0.05$.
Results: A total of 370 children were studied. They were aged one year two months to 12years.
Among children ≤2 years the measured weights and estimated values showed no significant difference. However, in children
3-5years, the estimated weights were significantly lower than the measured weights. There was no consistent relationship for children 7–12 years where a different formula was used to estimate weight.
For heights, the estimated values were significantly lower than the measured except for two year olds where both where almost similar. Scatter diagrams comparing actual and estimated plots showed linear relationship.
Conclusion: The current methods of estimation are underestimating weights and heights of children in our environment. There is need for a multi-centre cohort study to test the various formulae in our
children.

Key words: Measured, Estimated, Weight, Height, Children.

Introduction

In the management of very ill children, anthropometric data especially weight and/or height are required for therapeutic interventions. Weight and/or height are important in calculating drug dosages and/or fluid administration and selecting correct equipment sizes[1]. In some circumstances actual measurements of weight or height may not be feasible and estimates are used.
The most accurate method of determining a child's weight or height is to weigh the child or measure the height as the case may be. This "gold standard" should be obtained in all cases when feasible[2].
However, in our setting and even in elsewhere, it has been shown that in paediatric emergency situations requiring resuscitation; this is not often done, as all efforts are geared to save time and apply adequate therapeutic interventions timely.
In such situations it is often more time saving to use estimated formula in calculating height or weight.
Commonly in our setting the age based formulae for weight estimation is usually applied as follows: for

children aged 1 -6 years: 2n +8; for children 7-12years: 7n- 5/2; while for height estimation in children aged 2 – 12 years, the formulae: 6n + 77 (where n = age in years) [3] is applied. The adequacy of these estimates has not been tested for our children. Hence, the aim of this study was to compare the predictive accuracy of actual (measured) with formula estimates of weight and height in children.

Materials and methods

This was a comparative observational study conducted among children aged one year to 12 years attending the children's outpatient clinics (CHOP) of University of Nigeria Teaching Hospital, (UNTH) Enugu State South East Nigeria.

The children's outpatient clinics of the Department of Paediatrics UNTH, Enugu renders primary, secondary as well as tertiary healthcare services to the teeming population of minors in Enugu State and its environs among other services. It runs general paediatric outpatient clinics from Monday through Friday with average daily patient load of 60-80 children. Data was collected by one of the researchers. Ethical approval was sought from the Ethics and Research Committee of UNTH, Enugu.

Data collected included age, date of birth, gender, educational backgrounds and occupation of the parents/ caregivers from where child's socio-economic class was assigned using the method proposed by Oyedeji[4] in Ilesha, Nigeria. The respective age of all the subjects were confirmed through their date of births.

Subjects were excluded if they had any medical condition that would substantially affect their weight and/or height – amputation, or dwarfism, congenital heart diseases, dehydration, volume overload, or oedema, severe joint contracture or neurologic deficits e.g. cerebral palsy that can affect growth. Children who their caregivers gave informed consent and met the study criteria were recruited using convenient (consecutive) sampling method from 1st June to 31st July, 2013.

The weight was recorded with a Tanita HD-314 portable bathroom scale and has a maximum recordable weight of 110kg.At the beginning of each measurement day, accuracy of the weighting scales is checked by using a known standardized weight placed on the scale.

Before, each measurement, the scale is usually turned to 'zero" to correct for zero error. The children were measured wearing only a single layer of light / outdoor clothing. Weights were measured in kilograms to the nearest 100grams.

The standing height was measured (for selected children 2years and older) using a stadiometer. With the child standing upright, the head was positioned in the Frankfurt horizontal plane, and the headboard placed carefully but firmly on his head. The child was asked to take a deep breath while the reading was made.[5]The height measurements were read off to the nearest 0.1cm. Measurements were taken twice and the average recorded in the spaces provided in the proforma.

The weights of the enrollees were estimated using the following formulae:

For children aged 1-6 years, the formula: 2n + 8 (where n = age in years)[3] was applied.

For instance a child aged one year six months, the estimated weight using the above formula was determined thus: 2 (1.5)+ 8 = 11.0kg and so on.

Also children aged seven years to twelve years, the formula: 7n-5, all divided by 2 (where n = age in years) was used.[3]

For height estimation: the formula: 6n + 77 (where n = age in years) as recommended for children aged 2-12 years of age)[3]was applied. The estimated height for children aged one year was taken as 75cm.[3]

Data Analysis

Data were analyzed using SPSS 19.0. Paired t- test was used to compare the means of actual and estimated weights and heights according to age. Scatter diagram was plotted to determine the relationship between actual and estimated heights; actual and estimated weight based on weight formula for children aged 1-6years and 7 – 12years. The level of significance was set at $p < 0.05$.

Results

A total of 370 children were studied. They were aged one year two months to twelve years (mean age 6.0 ± 3.7 years). Two hundred and twenty five (60.8%) were males while 145 (39.2%) were females. One hundred and sixteen (31.4%) and 168 (45.4%) children were from the middle and lower socio-economic classes respectively. The socio-demographic characteristics of the children are shown in Table 1.

Table 1: Socio-demographic characteristics of the subjects

Variables	Frequency (%) (N = 370)
Gender:	
Males	225 (60.8)
Females	145 (39.2)
Socio-economic class:	
Upper	86 (23.2)
Middle	116 (31.4)
Lower	168 (45.4)

Table 2 shows the measured weight (mean ± SD) and estimated weight (mean ± SD) by age. Here for children two years and or below, the measured weight and estimated showed no significant difference. However, in children 3-5years, the estimated weights were significantly lower than the measured weights. There was no consistent relationship for children 7 – 12 years where a different formula was used to estimate weight. In children7-8years the estimated weights were significantly lower than the actual values while in those aged

9 -11years estimated values showed no significant difference. Also in the 12year olds the estimated weights were significantly lower than the measured values.
For heights, the values were significantly lower than the measured except for two year olds where both where almost similar.
A comparison of the mean actual and estimated weights and heights according to age is shown in Tables 2 and 3 respectively.

Table 2: A comparison of the mean actual and estimated weight by age

	Mean weight (kg)		
Age (years)	Actual (SD)	Estimated (SD)	p-value
1.	10.3±1.3	10.0±0.0	0.340
2.	12.3±1.6	12.0±0.0	0.260
3.	15±1.8	14.0±0.0	0.001
4.	17.2±2.4	16.0±0.0	0.005
5.	19.2±2.7	18.0±0.0	0.030
6.	21.2±3.2	20.0±0.0	0.120
7.	23.7±3.4	22.0±0.0	0.010
8.	27.4±3.5	25.5±0.0	0.009
9.	30.5±4.6	29.0±0.0	0.140
10.	34.0±6.3	32.5±0.0	0.270
11.	37.0±5.9	36.0±0.0	0.480
12.	44.0±7.9	39.5±0.0	0.001

Table 3: A comparison of the mean actual and estimated heights by age

Mean heights (kg)			
Age (years)	Actual (SD)	Estimated (SD)	*p-value*
1.	80.4±4.6	75.0±0.0	<0.001
2.	88.3±5.2	89.0±0.0	<0.340
3.	99.2±4.8	95.0±0.0	<0.001
4.	105.4±4.3	101.0±0.0	<0.001
5.	112.9±4.6	107.0±0.0	<0.001
6.	120.9±5.6	113.0±0.0	<0.001
7.	125.8±5.3	119.0±0.0	<0.001
8.	132.4±6.6	125.0±0.0	<0.001
9.	138.5±4.6	131.0±0.0	<0.001
10.	141.9±7.4	137.0±0.0	0.007
11.	147.3±7.0	143.0±0.0	0.020
12.	153.8±22.8	149.0±0.0	0.017

The overall median measured and estimated weights were 20kg (range 8-63kg) and 18kg (range 10-43kg) and the difference was statistically significant (p = <0.01) while median measured and estimated heights were 114.8cm (range 73-177cm) and 107cm (75-149cm) respectively and the difference was statistically significant (p = <0.01).
Pearson's product moment correlation showed a very strong correlation between actual and formula estimated weight with an r – value of 0.934 (p = < 0.01) and height with an r – value of 0.930 (p = <0.01) respectively.
The overall mean measured and estimated weights were 23.2 ± 11.5kg and 21.7 ± 9.8kg respectively. There was a statistically significant difference between the mean actual and estimated weights (p<0.001). The overall mean measured and estimated heights were 118.8 ± 25.9 cm and 112. 1 ± 23.1cmrespectively. The difference in mean of actual and estimated heights was statistically significant (p<0.001).
Kruskal Wallis test, did not show significant difference between the various socio-
economic classes and either the difference of estimated weight from actual weight (p=0.229)
or the difference of estimated height from actual height (p=0.15). The mean bias was 1.15kg for the weight for age formula (95% CI -0.71 to-1.59) and -5.19 for the height for age formula (95% CI -4.55 to -5.83).
A negative mean bias is noted in both formulae for weight and height estimation.
There was no statistically significant difference between males and females; and the difference of estimated weight from actual weight (p=0.625). The difference between mean measured height among females (120.2 ± 25.6 cm) and males (114.6 ± 25.8 cm) was statistically significant (p=0.04).
Scatter diagrams comparing actual and estimated weights and heights are shown in Figures 1
and 2 respectively. The plots showed linear relationship between actual and estimated values. However, there appears to be more positive linear relationship for weights among children
aged 7-12 years than those aged 1- 6 years (Fig 1).

Fig 1: Scatter diagrams showing the relationship between actual and estimated weights for children aged 1-6 years (left) and 7-12 years (right).

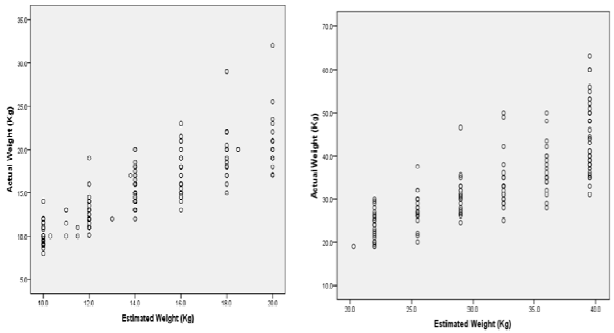
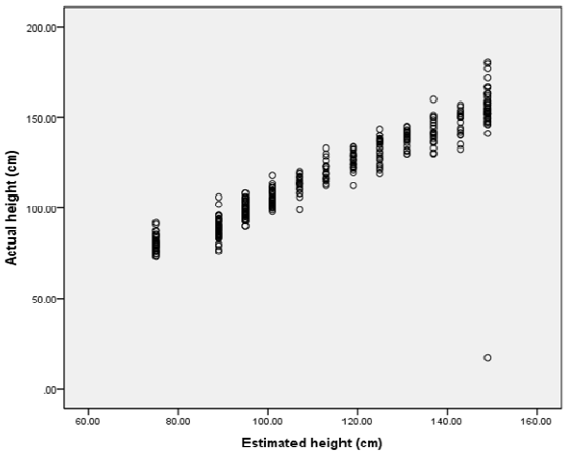


Fig 2: A scatter diagram showing the relationship between actual and estimated heights.



Discussion

Knowledge of weight and/or height is an invaluable tool in paediatric practice. The assumption is that the formulae for weight and height estimation will give a value not significantly different from actual weight and height. This study shows that both methods of weight estimation gave values that were significantly lower than the actual values with some outliers in certain cases. Similarly, the estimated heights were significantly lower than the measured except for the two year olds where they were comparable.

It has been shown in a previous study that certain weight formula like the new Advanced Paediatric Life Support (APLS) formula published in 2011 under – estimated weight with the under – estimation increasing in children aged one to five years[6]. Similarly other methods of weight estimation including the Broselow tape and the age formulae have also been shown to under- estimate weights in studies done in Switzerland and Australia respectively[1,7].

It has being reported that visual[8], parental estimation[9] and estimation by attending nurses and doctors[11] are often inaccurate and potentially unreliable.

Previous investigations of the accuracy of parental estimation of children's weight produced conflicting results; in one series estimates were within 10% of the subjects' actual weight[9]; where as in another study only 42% of weight were accurate[10].

Similarly, "guessitimation" of children's weight gives inaccurate results[2].

The under-estimation of weight and height using current formula methods will result in significant under - dosing of some emergency drugs, as has been reported in a similar study by Luscombe and colleagues[11].

Some of the drugs used in emergencies like phenytoin employed in treatment of status epilepticns and opioids used for analgesia should be based on total body weight in obese patients because of distribution in fat mass[12].

Considering the fact that under-nutrition is prevalent in Nigeria especially among under -five children[13,14] it would have been expected that the formula methods would over- estimate the weight and heights of our children. These formulae as applied in the current study were proposed many years ago. The growth pattern of children may have changed with better nutrition. Weight and height increments occur earlier. This is very obvious in height as observed in the current study.

Martorell et al[15] documented that obesity levels increased overtime but at varying rates, and concluded that rising incomes in developing countries and increased 'westernization' will most likely lead to increased levels of obesity in developing nations. The overall implication is that they accumulate a lot of weight and excess fat mass deposits.

In the paediatric emergency situations, fast and accurate methods of weight and height estimation are needed for immediate therapeutic interventions in order to save lives. Many estimation methods currently exist but most may now be overtaken by time as many developing countries including Nigeria are grappling with "double burden" of malnutrition with obesity/overweight being on the increase resulting in the fact that the formula estimation of weight or height may be under- estimating the actual value in many of the children.

Conclusion

In conclusion the formula methods of estimating weights and heights for the various ages in children are under- estimating their actual values. This is more obvious for height.

We have been using these formulae in our local practice without finding out the actual statistical relationship. The current trend as found in this study calls for further studies preferably multi-centred with larger cohort of children to test the various formulae.

Authors' contributions

Ibe BC: Conceptualization of the study/ critical editing of the final draft

Eke CB: Data collection/ data analysis and study write-up

Ubesie AC: Data analysis, and manuscript writing

Conflict of interest: None

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References

1. Black E, Barnett P, Wolfe R, Young S. Are methods to estimate weights in children accurate? *Emerg Med (Fremantle) 2002; 14 (2): 160 – 165.*
2. Argall JAW, Wright N, Mackway – Jones K, Jackson R. A comparison of two commonly used methods of weight estimation. *Arch Dis child 2003; 88: 789 – 790.*
3. Keane V. Assessment of growth. In: Nelson textbook of pediatrics, 18th edition.
4. Kliegman RM, Jenson HB, Behrman RE, Stanton BF (editors). Saunders Elsevier, Philadelphia, USA; 2007; 70-74.
5. Oyedeji GA. Socio- economic and cultural background of hospitalized children in Ilesha. *Niger J Paediatr 1987;12: 111-117.*
6. SOWC 2008 statistical tables. The State of the World's Children 2008. Available @: www.unicef.org/sowc08/docs/sowc08.pdf.pp118- 120. Accessed 15th January, 2009.
7. Seddon C, Lockitt L, Dhanjal S, Eseahut M, ISRN Pediatrics, 2012. Article ID: 869634, 4 pages. Available @: http://dx.doi.org/10.5402/2012/869634. Accessed: November 8th, 2013.
8. Hofer CK, Ganter M, Tucci M, et al. How reliable is length - based determination of body weight and tracheal tube size in the paediatric age group? The Broselew tape reconsidered. *Brit J Anaesth 2002;88:283- 285.*

9. Anglemyer BL, Hernandez C, Brice JH, Zou B. The accuracy of visual estimation of body weight in the emergency department. *Am J Emerg Med 2004; 22 (7): 526 – 529.*
10. Leffler S, Hayes M. Analysis of potential estimates of children's weights in the ED. *Ann Emerg Med 1997; 30 (2); 167 – 170.*
11. Harris N, Patterson J, Norse J. Doctors, nurses and parents are equally poor at estimating paediatric weights. *Pediatric Emerg Care 1999; 15 (1): 17-18.*
12. Luscombe M, Owens B. Weight estimation in resuscilution: is the current formula still valid. *Arch Dis child 2007; 92 (5); 412 – 415.*
13. Cheymol G. Effects of obesity on pharmacokinetics: implications of drug therapy. Clinical pharmacokinetics 2000; 39 (2): 215 – 231.
14. Sebanjo IO, Olayiwola IO, Afolabi WA, Sebanjo OC. Maternal and child undernutrition in rural and urban communities of Lagos State, Nigeria: the relationship and risk factors. BMC Research Notes 2013, 6:286.
15. Ndukwu CI, Egbuonu I, Ulasi TO, Ebenebe JC. Determinants of undernutrition among primary school children residing in slum areas of a Nigerian City. *Niger J Clin Pract 2013; 16:178-183.*
16. Martorell R, Khan LK, Hughes ML, Grummer – Strawn LM. Obesity in women from developing countries. *Eur J. Clin Nutr 2000; 54: 247 – 252.*