

Anthropometric surrogates of Birth weight reproducible by Community Health Workers: A hospital-based cross sectional study at Mbarara Regional Referral Hospital, South Western Uganda

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Abstract

Background In many resource constrained countries Uganda inclusive, women continue to give birth from home/in the community where there are no weighing scales to measure and record birth weight. There is also lack of enough weighing scales and skilled health personnel at health facility level to ensure that birth weight for every child is timely determined. Birth weight is an indicator of the chances for survival, growth, long-term health and psychosocial development of neonates. Different anthropometric parameters are reliable surrogates of birth weight although they are highly contextual. This study assessed the best anthropometric surrogate of birth weight usable at facility and community levels in western Uganda. **Methods** A cross sectional study was conducted between July and September 2017, whereby anthropometric values of 553 neonates born at Mbarara Regional Referral Hospital were measured by two midwives and later repeated by two community health workers to determine the reproducibility. Data regarding birth weight, height, foot length and circumference of head, mid upper arm, chest, thigh and calf were collected and recorded. Frequencies, percentages and mean and standard deviation were used to describe categorical and continuous demographics of neonates respectively. Pearson correlations, specificity, sensitivity, likelihood ratios, diagnostic odds ratios and area under the curve (AUC) were determined and used to establish the most reliable anthropometric parameter that best estimates birth weight of neonates. Results Chest Circumference was the most reliable parameter (AUC= 0.89, DOR= 33.57). There were statistical significant mean differences in all the anthropometric measurements made by midwives and CHWs except for chest circumference (Mean difference = 0.03 cm, 95% CI: -0.22-0.29, p = 0.7963) and foot length (Mean difference = 0.03 cm, 95% CI: -0.22-0.29, p = 0.7963). **Conclusions** Chest circumference taken within 24 hours after birth is the best anthropometric surrogate measure of birthweight. Community Health workers can measure chest circumference with almost the same accuracy like midwives.

Background

Resource constrained countries lack enough weighing scales and trained personnel to determine birth weight for every child (Jitta and Kyaddondo, 2008). Birth weight is an indicator of a neonate's chances for survival, growth, long-term health and psychosocial development (McGuire, 2017). Long-term health translates into increased growth domestic product, a strong driver of national development and improved live-hoods of the entire population (Cheruiyot, 2015).

Many scholars have reported different anthropometric parameters that are reliable proxy measures for determining birth weight (Dhar et al., 2002, Gozal et al., 1991). However, the use of anthropometric parameters to determine birth weight is highly contextual (Begić et al., 2016). From a study in eastern Uganda, it was reported that foot length (when compared to chest, mid upper arm, head, thigh and calf circumferences), is the best surrogate measure of birth weight (Nabiwemba et al., 2013). In most of these studies, anthropometric data were collected by only midwives casting doubt on whether the community health workers can effectively use the designed anthropometric tools. Community health workers in Uganda frequently interface with new born babies before trained health workers since a significant number of mothers are still delivering from home/community (Uganda Bureau of Statistics & ICF, 2017). This study aimed at determining the best anthropometric parameter to use as a proxy measure of birth weight and reproducible by community health workers in western Uganda.

Methods

This study employed a cross-sectional study design. The study was conducted at Mbarara Regional Referral Hospital (MRRH) in south western Uganda. The hospital is situated in Mbarara municipality along Kabale road about 270km from Kampala, a capital city of Uganda.

This is a 400 bed capacity hospital but serves a far higher inpatient population since about 4 million people reside within its wide catchment area. It is a University Teaching Hospital for Mbarara University of Science and Technology and its Gaenacology and Obstetric Department has a maternity wing that handles about 21 deliveries per day.

We recruited neonates from labour suit and maternity ward in the gaenacology section of the hospital department in the months of July to September 2017.

Characteristics of study participants

In this study, we recruited neonates within their first 24 hours after birth using consecutive sampling method. Our exclusion criteria were neonates not weighed by midwives within one hour after birth, and before breast feeding. Also, sick and weak neonates or under intensive care, those with congenital abnormalities or dysmorphic features and or weighing <1000g were to be excluded. However, no neonate met the exclusion criteria. Purposive sampling was used to select two midwives who had worked for at least 6 months at maternity ward/ labour suit of MRRH. Similarly, two community health workers (CHWs) with at least ordinary secondary education and worked for more than 6 months as members of village health teams in Mbarara municipality were recruited. Midwives measured birth weight and anthropometric data from the neonates. CHWs repeated measurements of anthropometric parameters on the neonates.

Study processes

Using Kish and Leslie formula (1965) and a design effect of 2.0 used in childhood anthropometrics (Hulland et al., 2016) were used to recruit 638 neonates. Of a total of 1,200 neonates born during the study period, 562 were not measured in the first hour after birth and 85 neonates measured by midwives were not accessed for measuring by community health workers because they could not be traced on the maternity ward (*Appendix 1*). Thus only data from 553 neonates was analysed.

Two midwives working in the maternity wing of the hospital and two community health workers from Mbarara municipality were recruited and trained for two days, under one roof, on anthropometric techniques.

Our main outcome variable was birth weight of neonates. Birth weight was determined by midwives using a weighing scale (Salter model 180). Weighing scale standardization was done on daily basis throughout the process of data collection. The neonate would be put lying down on the leveled pan scale of the weighing scale and then the midwife could read and record weight in grams.

Anthropometric correlates of birth weight that were measured in this study included circumferences (head, mid upper arm, chest, thigh, and calf), foot length and height were measured. Using non extendable measuring tapes, with a width of 1.0 cm and subdivisions of 0.1cm, midwives measured circumferences of neonates' head, mid upper arm, chest, thigh, and calf. Head circumference was measured between the glabella anteriorly and along the occipital prominence at the back of the head. Mid upper arm circumference was measured from midpoint between tip of shoulder and elbow by moving the tape around the arm to the starting point while chest circumference was measured by fixing the starting point of a tape measure at the tip of xiphoid process and move it around the back of the neonate to the starting point. While keeping the neonate sleeping on its back the measurement would be read on full inspiration.

Similarly, the thigh and calf circumferences were measured from respective fixed points. They used a hard transparent plastic ruler to measure foot length and a calibrated height/length measuring board was used to measure the neonates' lengths. Foot length was measured from the heel to the tip of the big toe of the right foot using a transparent ruler. Length was measured using a calibrated measuring board. The neonate was made to lie supine on the calibrated measuring board.

The heel of the neonate was fixed on zero point then the length from the heel to the crown was noted and recorded in centimeters. These measurements, except birth weight, were independently repeated on each neonate by the Community Health Worker who had been previously introduced to the hospital premises and departmental staff for familiarization on maternity ward.

Data was entered in Microsoft excel version 2010 from where it was edited; checked for completeness and consistency. Data were then exported into SPSS version 20 for analysis. Categorical characteristics of participants were analyzed and summarized using descriptive statistics; frequencies and percentages. Continuous data were summarized and recorded as mean and standard deviation.

Using Pearson correlation analysis of linearity between birth weight and all other anthropometric parameters under study was determined, and Correlation coefficient (r) and confidence intervals reported. Non-parametric receiver operating characteristic (ROC) curve analysis was carried out to calculate 95% confidence intervals of areas under the curve (AUC). Finally the predictive performances of the cut off points were calculated. We used paired t-test to compare the accuracy in anthropometric techniques among mid wives and community health workers. Then mean, standard deviation, mean difference, chi square, and p values at 95% confidence interval were determined and reported.

Results

Table 1 shows that of the 503 neonates, majority 388(70.2%) were from parents residing in Mbarara district, Banyankole, 464(9%), residing in rural setting, 320 (57.9%), males, 294 (53.2%) of mean gestation age of 38.5 weeks ($SD = 1.0$) and birth weight of 3.2 kgs ($SD = 0.5$).

Table 2 shows zero-order correlations between birth weight and other anthropometric parameters under study. Chest circumference and calf circumference showed the highest correlation with birth weight for midwives and CHWs respectively. ROC analysis was conducted to find out the AUC and DOR. This was done to determine the overall accuracy, sensitivity and specificity at selected cut off points to identify best surrogate anthropometric measurement. Sensitivity and specificity for each anthropometric parameter were calculated for a range of measures but the optimum cut off was the parameter value with the highest sum of specificity and sensitivity. Positive likelihood ratio (+LR), negative likelihood ratio (-LR) and diagnostic odds ratio were determined at each cut-off point. This was done to test the effectiveness of each diagnostic parameter. The anthropometric parameter, at a selected cut-off point, with the highest AUC, and diagnostic odds ratio was considered to be the most reliable anthropometric parameter that estimates birth weight.

Findings in Table 2 show AUC and the diagnostic odds ratios of each anthropometric parameter included in the study. Diagnostic odds ratio measured the effectiveness of a diagnostic test since it is the ratio of the odds of the test being accurate if the parameter estimates birth weight relative to the odds of the test being accurate if the parameter does not estimate birth weight. Chest circumference showed the highest diagnostic

odds ratio value (33.57) while foot length showed the lowest value (6.65) as shown in Table 2 above. The measurements taken by the CHWs, MUAC (AUC = 0.734) and chest circumference (AUC = 0.713) showed highest AUC and DOR respectively.

However, chest circumference showed the highest AUC (0.89) and foot length showed the lowest AUC (0.77) (*Figure 1*).

Using apaired t-test, the accuracy of the anthropometric measurements taken by both midwives and community Health workers was compared. There was no statistical difference in the mean differences in chest circumference measurements taken by midwives and community Health workers (Mean difference = 0.03 cm, 95% CI: -0.22-0.29, $p = 0.7963$) and foot length (Mean difference = 0.03 cm, 95% CI: -0.22-0.29, $p = 0.7963$) as measured by midwife and CHWs.

Discussion

In this hospital-based cross-sectional study at Mbarara regional referral hospital in southwestern Uganda, chest circumference was found to be the best surrogate measure of birth weight reproducible by community health workers. Our results are consistent with most reports from other anthropometric studies carried out from similar resource constrained settings. In a hospital-based study in Vietnam, [Thi et al. \(2015\)](#) reported chest circumference as the best surrogate measure of bithweight with an area under the curve of 0.98. Just like in our study, these values were taken in the first 24 hours after birth at a cut-off of 31 cm. The diferrence in the area under curve in both studies may be due to apperent ethnical differences between both population studies. Similarly a hospital-based study in Eastern Uganda reported an area under curve of 0.9 for chest circumference at a cut-off value 31 cm ([Nabiwemba et al. \(2013\)](#)). In this very study, foot length had a close area under the curve (ROC = 0.9) and was recommended as the serrogate measure for birthweight of neonates since it can be measured with minimal disturbance to the neonate compared to chest circumference contrary to the recommendations of our study.

In addition, our study established that at midwives measure chest circumference ≥ 30.9 cm in normal birth weight neonates at 98.8% accuracy compared to 96.6% accuracy when community health workers measured the chest circumference in the same neonates. Though the difference in measurement efficiency between midwives and community health workers is very small, this can be explained by the different training levels and experience in neonatal handling between the two cadres. Since the difference is negligible, with consistency in practice and hands on training, community health workers can reliably use chest circumference values to estimate birth weight, and identify low birth weight neonates for referral to the nearest health center ([Waiswa et al., 2015b](#)).

Similarly, after receiving minimum training, community health workers in Ethiopia were able to measure weight, height and mid-upper arm circumference with almost same accuracy like that of anthropometrists ([Ayele et al., 2012](#)).

Chest circumference can be used as surrogate measure for birth weight where there are no weighing scales, or complements the use of weighing scales. Community health workers can use chest circumference to identify low birth weight neonates for referral. The community health workers package does not include taking anthropometric measurements in the newborns to detect low birth weight. From this study incorporating anthropometric measurements in the community workers package will offer a valuable way of identifying low birth weight neonates at community level and consequently early and timely referral ([Waiswa et al., 2015a](#)).

Limitations

In this study, the Community Health Workers collected data in a hospital environment contrary to their usual community work environmentt that could have affected their work confidence and hence that slight non significant difference in accuracy compared to the midwives.

Conclusions

Chest circumference taken within 24 hours after birth is a surrogate measure of birthweight Community Health workers can measure chest circumference with almost the same accuracy like midwives. Although this was a hospital based study, we involved community health workers in data collection and thus the developed anthropometric tool can be used effectively in the community setting in south western Uganda. The tool however, can be validated for use in other community settings because anthropometric values are population specific.

Abbreviations

AUC: Area under the curve

CHW: Community Health Worker

CI: Confidence interval

DOR: Diagnostic odds ratio

MRRH: Mbarara Regional Referral Hospital

MUAC: Mid Upper Arm Circumference

-LR: Negative likelihood ratio

+LR: Positive likelihood ratio

ROC: Receiver Operating Characteristic curve

SD: Standard deviation

Declarations

Ethics and Consent to participate

The study was approved by Makerere University School of Public Health, Higher Degrees, Research and Ethics Committee on 23rd March 2017. Written informed consent was obtained from parents of neonates.

Consent for Publication

Not applicable

Availability of data and material

Available upon request by journal authorities.

Competing Interests

Authors declare no competing interests other than the data being obtained from Academic dissertation work for the award of Master of Public Health of Makerere University.

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Author's contributions

Savino Ayesiga developed the concept, proposal, data collection and manuscript writing.

Catherine Abaasa led the interpretation of data and discussion of findings.

David Ayebare Santson led the data analysis and participated in manuscript review

Gakenia Wamuyu-Maina supervised the entire process until manuscript review and submission.

All authors read and approved the manuscript for submission to publish.

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Tables

Table 1: Socio-demographic Characteristics of Neonates (N=553)

Variable		Frequency	Percent
District of Origin	Mbarara	388	70.2
	Bushenyi	87	15.7
	Sheema	13	2.4
	Rubirizi	2	.4
	Ntungamo	16	2.9
	Kiruhura	12	2.2
	Isingiro	35	6.3
Tribe	Banyankole	464	83.9
	Bakiga	24	4.3
	Baganda	19	3.4
	Lugbhar	7	1.3
	Banyarwanda	15	2.7
	Batoro	13	2.4
	Basoga	11	2.0
Type of Residence	Rural	320	57.9
	Urban	232	42.0
Gender	Male	294	53.2
	Female	259	46.8
	Range	Mean	SD
Gestation age (wks.)	36- 42	38.5	1.0
Birth weight(kgs)	2.0 - 4.9	3.2	0.5

Table 2: Anthropometric correlates of neonatal birth weight

Variables in the Study	Midwife	CHW
Length	.479**	.183**
Head	.603**	.187**
MUAC	.584**	.241**
Chest	.629**	.230**
Thigh	.585**	.225**
Calf	.567**	.264**
Foot	.364**	.069

* $p < 0.05$. ** $p < 0.01$.

Table 3: Sensitivity, specificity, AUC, likelihood ratios and diagnostic odds ratios for anthropometric parameters at selected cut-offs.

Cut off	Midwife							CHW						
	Sensitivity (%)	Specificity (%)	AUC	95%CI	+LR	-LR	Diagnostic Odds Ratio	Sensitivity (%)	Specificity (%)	AUC	95%CI	+LR	-LR	Diagnostic Odds Ratio
48.2	82.4	58.6	0.82	0.76-0.86	1.99	0.30	6.65	70.8	44.8	0.63	0.54-0.73	1.29	0.65	1.97
10.2	81.90	75.9	0.82	0.74-0.92	3.39	0.24	14.19	86.0	48.2	0.61	0.50-0.72	1.66	0.29	5.72
34.1	83.6	75.9	0.83	0.72-0.92	3.47	0.22	16.01	75.0	44.8	0.74	0.64-0.84	1.36	0.56	2.44
30.9	92.7	72.4	0.89	0.82-0.96	3.36	0.10	33.57	86.4	44.8	0.71	0.61-0.81	1.57	0.30	5.15
14.1	85.9	82.8	0.87	0.82-0.96	4.98	0.17	29.19	87.5	31.0	0.64	0.53-0.75	1.27	0.40	3.16
10.6	82.6	69.0	0.84	0.76-0.92	2.66	0.25	10.57	71.6	48.3	0.60	0.48-0.72	1.38	0.59	2.35
8.0	89.1	51.72	0.77	0.78-0.95	1.85	0.21	8.78	57.4	48.3	0.62	0.52-0.74	1.51	0.69	2.20

Table 4: Mean differences in Anthropometric Parameters measured by Midwife and CHW

Parameters	Midwife		CHW		Mean difference	95% CI	p
	Mean	SD	Mean	SD			
Length	50.79	3.41	49.35	3.37	1.43	1.08-1.80	0.0000**
Head	35.43	1.23	34.83	1.65	0.59	0.45-0.74	0.0000**
MUAC	10.91	0.88	11.17	1.07	-.26	-.36-0.17	0.0000**
Chest	32.64	2.61	32.61	2.31	0.03	-0.22-0.29	0.7963
Thigh	15.43	1.46	15.64	1.45	-.22	-0.36-0.07	0.0034*
Calf	11.34	0.93	11.22	1.04	0.12	0.02-0.22	0.0140*
Foot	8.27	0.49	8.46	2.68	-0.19	-0.41-0.04	0.0991

* $p < 0.05$. ** $p < 0.01$.

Figures

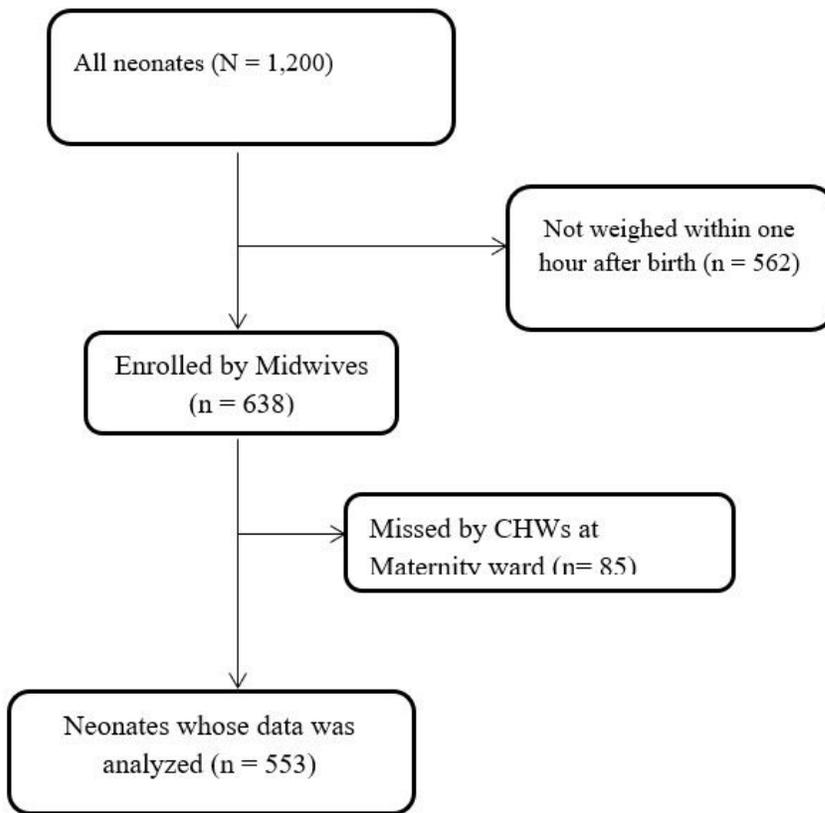


Figure 1

Flow chart showing recruitment process of neonates

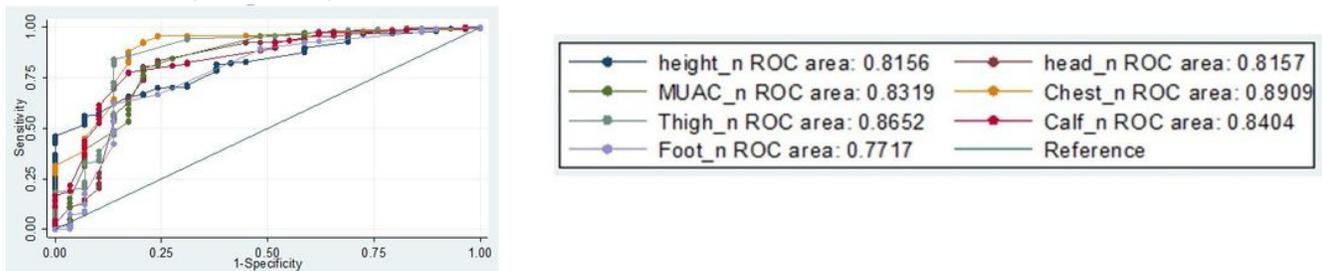


Figure 2

ROC curve for anthropometric parameters of Neonates at Mbarara Regional Referral Hospital This graphical plot illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied.