Predicting Low Birth Weight: A comparison of Anthropometric Measurements taken by Midwives and Community Health Workers in 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 nthropometricsurrogate 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 low birth weight for every child [1]. Birth weight is an indicator of a newborn's chances for survival, growth, long-term health and psychosocial development[2]. Long-term health translates into increased growth domestic product, a strong driver of national development and improved live-hoods of the entire population [3].

Many scholars have reported different anthropometric parameters that are reliably used to predict low birth weight [4, 5]. However, the use of anthropometric parameters to determine birth weight is highly contextual [6]. Anthropometric parameters vary in terms of populations across communities, regions and countries [7]. Genetic factors including ethnicity [8] and environmental factors such as metrological and nutrition [8, 9] have been found to predict anthropometric parameters. 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 predictor of low birth weight [10]. In most of these studies, anthropometric measurements were taken by midwives yet in Uganda, CHWs frequently interface with newborns before trained health workers since a significant number of mothers are still delivering from home/community [11]. This study aimed at predicting low birth weight, and comparing anthropometric measurements of newborns taken by midwives and those taken by community health workes in western Uganda.

Methods

This study employed a descriptive cross-sectional study design. The study was conducted at Mbarara Regional Referral Hospital (MRRH) located along Kabale road, about 270km from Kampala, the capital city of Uganda. MRRH serves about 4 million people in the entire catchment area of south western Uganda and handles about 21 deliveries per day. We recruited newborns from labour suit and maternity ward of the Obstetrics and Gynaecology Department in the months of July and September 2017.

Characteristics of study participants

In this study, systematic random sampling at an interval of 2 newborns, on a daily basis, using patient register as sampling frame was used to recruit 638 eligible newborns within their first 24hours after birth. . We excluded 85 newborns who were not traced on maternal ward for CHWs to take their anthropometric measurements. Therefore, data from 553 newborns were analyzed. 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 working experience of 6 months as CHWs in Mbarara municipality were recruited to take anthropometric measurements. These CHWs were introduced to MRRH setting for familiarization and acclimatization. Midwives recruited to collect the data enrolled newborns into the study, took birth weight and other anthropometric measurements. Using unique identifiers, the CHWs repeated measurements of other anthropometric parameters on the same newborns.

Study processes

Using Kish Leslie formula [12] and a design effect of 2.0 used in childhood anthropometrics [13], a sample size of 638 newborns was determined. From a total of 1,200 newborns born during the study period, 638 newborns were recruited and assessed for anthropometrics. Of the 638 newborns recruited, 85 newborns were not assessed for anthropometrics by midwives CHWs because they could not be traced on the martenity ward (*Figure 1*). Thus only data from 553 newborns were analysed and used in reporting the findings.

Two midwives working in the maternity wing of the hospital and two CHWs from Mbarara municipality were recruited and trained for two days, under one roof, on anthropometric techniques. This was to ensure harmonization with the use of anthropometric techniques prior to data collection. Training was done using tools already validated for use in Uganda [10].

Our main outcome variable was birth weight of newborns. Birth weight was determined by midwives using a weighing scale (Salter model 180). Weighing scale calibration was done on a daily basis using a 1 kg stone throughout the process of data collection. The newborn would be put lying supine on the leveled pan scale of the weighing scale and the midwife read and record weight in grams nearest to 2 decimal places.

Anthropometric parameters including birth weight, circumferences of head, mid upper arm, chest, thigh, and calf, foot and body lengths of newborn were measured [10]. Using non extendable measuring tapes, with a width of 1.0 cm and subdivisions of 0.1cm, midwives measured circumferences of newborns' head, mid upper arm, chest, thigh, and calf. Head circumference was measured in a clockwise direction starting from the glabella through the occipital prominence back to the starting point on the glabella. Mid upper arm circumference was measured from midpoint between tip of shoulder and elbow by rolling the tape around the arm to the starting point. Chest circumference was measured by fixing the starting point of a tape measure at the tip of xiphoid process and rolling it around the back of the newborn to the starting point at the tip of the xiphoid process. While keeping the newborn lying supine, the measurement was recorded only at full inspiration.

The thigh circumference was measured from midpoint between anterior superior iliac spine and knee joint by rolling the tape around the thigh and back to the starting point. The calf circumference was measured from midpoint between knee and ankle joints by rolling the tape around the calf and back to the starting point. The length of the newborn was measured using calibrated length measuring board. The newborn was made to lie supine on the calibrated measuring board. The heel of the newborn was fixed on zero point, then the body length was measured from the heel to the crown and recorded in centimeters. Foot length was measured using a transparent ruler starting from the heel to the tip of the big toe of the right foot. All the measurements, except birth weight, were independently repeated on each newborn by the CHWs. For each anthropometric parameter, two measurements were made and its average calculated and recorded. The midwives recruited newborns into the study, took anthropometric parameters before admitting them into the maternity ward. Unique identifiers were then assigned to each newborn recruited. Unique identifiers were used by CHWs access the newborns, previously recruited by midwives, and take their anthropometric measurements.

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 cleaning and analysis. Categorical characteristics of participants were analyzed and summarized using frequencies. Continuous data were summarized and recorded as means (standard deviation).

Pearson correlation analysis of linearity between birth weight and all other anthropometric parameters understudy was conducted, 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 cut offs were calculated. We used an independent paired *t*-test to find out if there was a statistical significant difference between the anthropometric measurements taken by midwives and those taken by CHWs. Mean, standard deviation, mean and *p* values at 95% confidence interval were determined and reported.

Results

Table 1 shows that of the 553 newborns, majority 388(70.2%) were from parents residing in Mbarara district, Banyankole, 464(9%), residing in a 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.

Table 3 shows that the overall prevalence of low birth weight was 29 (5.2%). It also shows that chest circumference at the cut off of 30.9 cm was able to predict the highest low birth weight, from the analysis of anthropometric data by midwives and CHWs with 79.3% and 44.8% respectively.

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 predictor 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 4 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 an independent paired *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 descriptive cross-sectional study conducted at Mbarara regional referral hospital in southwestern Uganda, the prevalence of low birth weight of newborns was 5.2% compared to 12% reported in eastern Uganda [10]. Chest circumference was found to be the best predictor of low birth weight as indicated by the highest diagnostic odds ratio for both midwives and CHWs. Also, chest circumference at the cut off of 30.9 cm was able to predict the highest low birth weight for both midwives and CHWs with 79.3% and 44.8% respectively. This was higher than 91.8% of low birth weight in eastern Uganda [10]. This difference was attributed to a higher cut off point of 31.0 cm [10] compared to 30.9 cm in this study.

When an independent paired *t* test was conducted, there was no statistical difference in the anthropometric measurements taken by CHWs compared to those taken by midwives (p = 0.7963). 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, [14] reported chest circumference as the best predictor of low bithweight. Just like in our study, these values were taken in the first 24 hours after birth at a cut-off of 31 cm. The small diferrence in the area under curve in both studies may be due to the difference in the cut off points.

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 [10]. 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 newborns since it can be measured with minimal disturbance to the newborn 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 newborns at 98.8% accuracy compared to 96.6% accuracy when community health workers measured the chest circumference in the same newborns. 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 newborns for referral to the nearest health center [15].

Similarly, after receiving minimum training, community health workers in Ethiopia were able to measure weight, length and mid-upper arm circumference with almost same accuracy like that of anthropometrists [16] .

Chest circumference can be used as predictor 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 newborns 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 newborns at community level and consequently early and timely referral [17].

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 accurancy compared to the midwives.

Conclusions

Chest circumference taken within 24 hours after birth was the best predictor of low birthweight with both midwives and Community Health workers. Although this study was conducted in a hospital based setting, 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 anthropmetric 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 andEthics Committee on 23rd March 2017. Written informed consent was obtained from parents of newborns.

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 dessertation work for the award of Master of Public Health of Makerere University.

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Author’s contibutions

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 proces 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 Newborns (*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: Proportion of neonates detected at anthropometric cut offs

Parameter	Cut off	*Midwife*			*CHW*		
		NBW, n = 524, 94.8% *f(%)*	LBW, n = 29, 5.2% *f(%)*	*p*	NBW, n = 524, 94.8% *f(%)*	LBW, n = 29, 5.2% *f(%)*	*p*
Length	<48.20 cm	152(92.12)	13(7.88)	0.070	95(81.20)	22(18.8)	0.000**
	>=48.20 cm	372(95.9)	16(4.12)		429(98.4)	7(1.61)	
MUAC	<10.2 cm	95(81.2)	22(18.8)		95(81.2)	22(18.8)	0.000**
	>=10.2 cm	429(98.4)	7(1.6)	0.000**	429(96.8)	15(3.2)	
Head	<34.1 cm	86(79.6)	22(20.4)	0.000**	130(90.9)	13(9.1)	0.000**
	>=34.1 cm	438(98.4)	7(1.6)		393(96.1)	16(3.9)	
Chest	< 30.9 cm	41(64.1)	23(35.9)	0.000**	73 (84.9)	13(15.1)	0.000**
	>= 30.9 cm	483(98.8)	6(1.2)		450(96.6)	16(3.4)	
Thigh	<14.1cm	74 (75.5)	24(24.5)	0.000**	65(87.8)	9(12.2)	0.000**
	>=14.1cm	450(98.9)	5(1.1)		459(95.8)	20(4.2)	
Calf	< 10.6 cm	91(82.0)	20(18.0)	0.000**	148(91.4)	14(8.6)	0.021*
	>= 10.6 cm	433(98.0)	9(2.0)		376(96.1)	15(3.8)	
Foot	<8.0 cm	57 (79.2)	15(20.8)	0.000**	71 (88.7)	9(11.3)	0.009**
	> =8.0 cm	467(97.1)	14 (2.9)		453(95.8)	20(4.2)	

*p<.05. **p<.01. N=553

Table 4: Sensitivity, specificity, AUC, likelihood ratios and diagnostic odds ratios for anthropometric parameters at selected cut-offs.

	Midwife							CHW						
Cut off	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-ˉ0.17	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

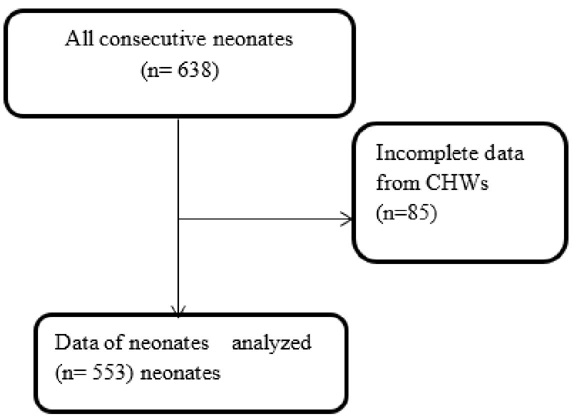
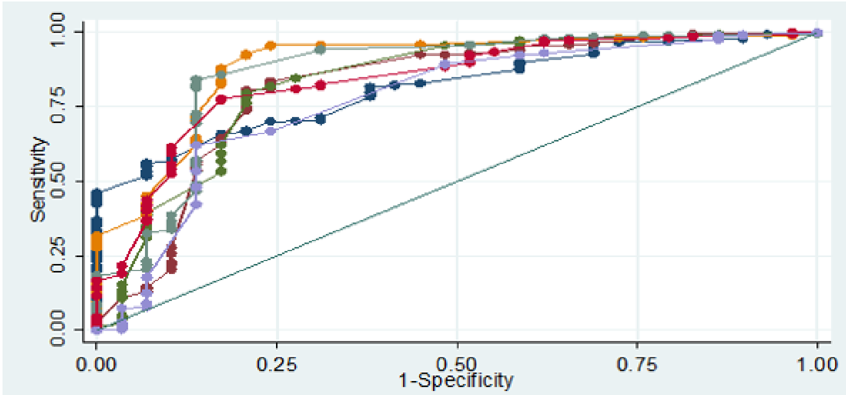


Figure 1

Flow chart showing recruitment process of newborns



This graphical plot illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied.

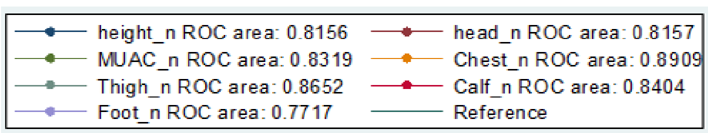


Figure 2

ROC curve for anthropometric parameters of Newborns at Mbarara Regional Referral Hospital