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ORIGINAL ARTICLE

VALIDATION OF MATERNAL ANATOMICAL ANTHROPOMETRIC MEASUREMENTS TO PREDICT CEPHALOPELVIC DISPROPORTION AMONG PRIMIGRAVID WOMEN

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ABSTRACT

Background*: Detection of women at risk for cephalopelvic disproportion will allow physicians to make preparations and treatment decisions that can minimize maternal and neonatal morbidity. In developing countries, a significant number of maternal deaths are attributable to the complications of obstructed labor typically cephalopelvic disproportion. Maternal height reflecting maternal pelvic size has been shown to be predictive for obstructed labor.*

Objective: *This study assessed the validity of maternal anatomical anthropometric measurements to predict cephalopelvic disproportion.*

Methods*: Hospital based prospective descriptive (observational) study was carried out in three hospitals. The sample size was 384.The data collected included socio-demographic characteristics such as age, residence, level of education and occupation of mothers. Data for gestational age, socio demographic and mode of delivery were collected from antenatal care follow up charts.*

Results: *A total of 384 nulliparous mothers where 337 of them delivered through spontaneous vaginal delivery and 47 gave birth by cesarean section (CS) due to cephalopelvic disproportion, were included in the present study. Height, foot length, Michaelis horizontal diagonal and head circumference of the mothers were significantly smaller ($p<0.0001$) in the mothers with CPD compared to mothers without CPD. In addition, a statistically significant decrease ($p<0.05$) in the mean maternal age was observed in mothers with CPD.*

Conclusions: *Foot length, Michaelis horizontal diagonal and head-circumference of the mothers may be used in predicting cephalopelvic disproportion, especially in rural areas where facilities are limited.*

Key words: *Cephalopelvic disproportion, Spontaneous vaginal delivery, anthropometric measurements.*

INTRODUCTION

CPD (Cephalopelvic Disproportion) is defined as a mismatch between the maternal birth canal (the pelvis), and the fetal head(1) . Detection of women at risk for CPD will allow physicians to make preparations and treatment decisions that can minimize maternal and neonatal morbidity.

In developing countries, a significant number of maternal deaths are attributable to the complications of obstructed labor typically CPD, which leads to birth canal trauma, postpartum hemorrhage, and genital infections. In patients with CPD, delay in decision to seek care or delay in arrival to an appropriate medical care facility is common in rural hospitals(2). Numerous investigators have attempted to find indexes to identify high risk women during pregnancy.

The advanced pelvimetry techniques such as pelvimetry through computer-based tomography, Magnetic Resonance Imaging, radiography and ultrasound are expensive and scarce in the developing countries(4). Anthropometric measurements of mother are simple, inexpensive and available for patients which had been introduced as the first technique to predict CPD(5).

As a result of the present study, it might be easier to manipulate different maternal anthropometric measurements to diagnose CPD and the measurements are simple, inexpensive and available techniques to predict CPD of labor. Since the study was the first of its kind conducted in Ethiopia and East Africa, it may be used as a base line for further investigation.

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PATIENTS AND METHODS

The study was conducted in Addis Ababa governmental hospitals involving Gandhi Memorial, Zewditu Memorial and Tikur Anbessa Specialized Hospitals from June 2017 – Oct. 2017. The following data collection tools were used: Checklist, weight scale, non-elastic tape meter, wooden centimeter and Standiometer. These standardized instruments were sponsored by department of Nutrition of the Ethiopian Public Health Institute. Data were collected by principal investigator and three assistant data collectors.

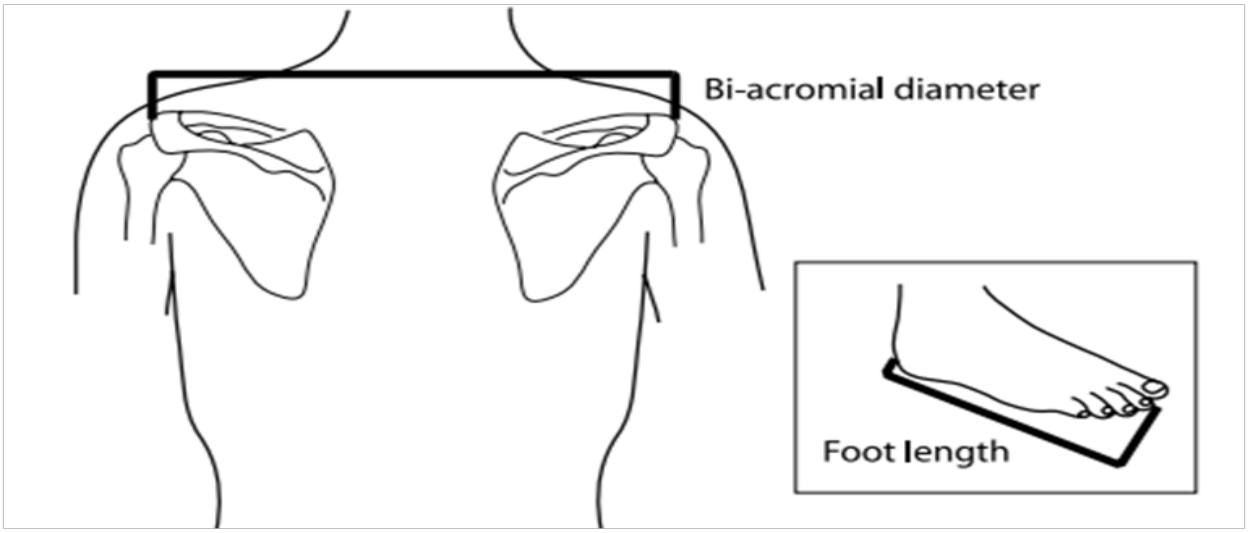
Data Collection: The study was a hospital-based cross -sectional descriptive. The data included socio-demographic characteristics such as age, residence, level of education and occupation of mothers. Data for gestational age, socio demographic and mode of delivery were collected from ante natal care follow up chart. Every data was collected before delivery and data which did not fulfill the inclusion criteria were rejected.

Data for CPD cases were collected after CPD was confirmed by a physician. he inclusion criteria were: primigravid mother, full term pregnancy, mothers with singleton pregnancy and mothers with IUFD due to CPD. Mothers who undergo CS for: non-vertex presentation, obvious congenital abnormalities of fetus, abruptio placenta, preeclampsia, eclampsia, placenta previa, women who had hip fractures, asymmetrical pelvis, multiple pregnancy, polyhydroamnions, preterm delivery, elective CS, instrumental delivery and repeat caesarean section were excluded from the study.

In this study, the outcome measures of interest were maternal anatomical anthropometric measurements.

Maternal height was measured in the standing position following standards of measuring height by using standardized standiometer (mothers stood next to a wall with their feet and knees together, knees straight, heels, legs, hip, shoulders, back of the head parallel to the wall, their body completely flat and stretched, hands hanging on both sides, and looking straight ahead. The horizontal plate of the standiometer was placed over the mother's head and standing height was measured) and foot length is measured by wooden centimeter from heel to the tip of longest toe.
The distance between the two acromial ends was taken by using standardized non elastic tape meter. Michaelis transverse diameter (distance between two depressions of superior posterior spines at two horizontal ends of the sacral bone) and Michaelis vertical diameter (distance between L5 and carina ani) was measured using a centimeter non elastic tape measure with the mother in the standing position. Head circumference-is the distance between the highest occipital peak and mid fore head line (6) measured by standard non elastic tape meter.

All measurements were taken three times and the average was taken. Every measurement was recorded to the nearest 0.5 cm interval. Data for mode of delivery was collected from delivery report recorded in patient card and subjects were divided into two groups: normal delivery and subjects with CPD.



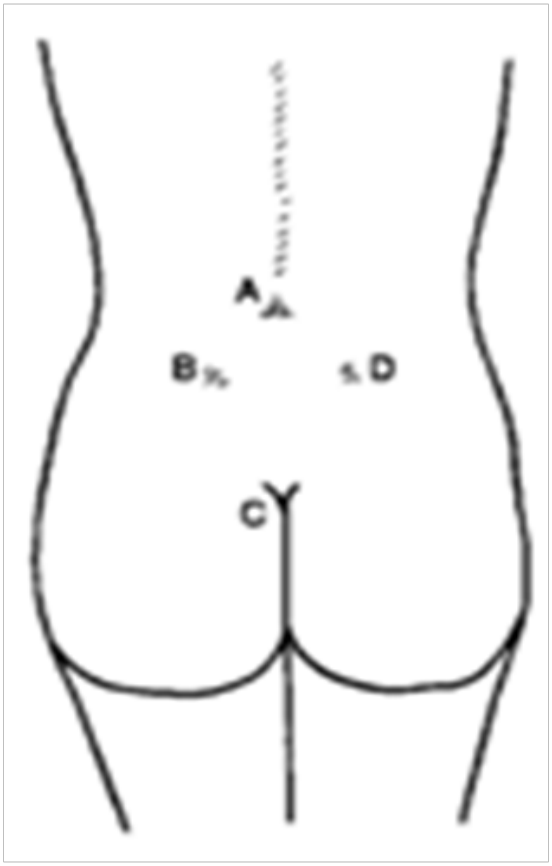


Figure1:-Various anthropometric measurements made in this study. Bi-acromial diameter is measured between the two acromial ends. Foot length is measured from heel to tip of longest toe. The transverse diameter of the Michaelis sacral rhomboid was measured between the two posterior superior iliac spines (**B** to **D**). The vertical diameter of the rhomboid was measured between the L5 spine (one space below the L3–L4 disc which is in line with the uppermost point of the iliac crest) and the upper limit of the natal cleft (**C**) (taken and modified from Benjamin, et al. 2012) (7)

To maintain data quality, properly designed data collection materials were developed. The principal investigator checked whether the data assistant data collectors were using the right data collection procedures and techniques .

Supervision was carried out by the principal investigator on a daily basis to maintain consistency of measurements and to assure completeness of data. In addition, cross checks between client card number and check list were performed to validate the accuracy of collected data and whenever an error occurred at any level, the investigator would trace back and manages accordingly. Data entry, cleaning and analysis was done by the principal investigator.

Data were checked for values that were inconsistent with other information gathered in the study. The data were also checked for missing item and check list with missed data's were discarded. Finally data were entered and analyzed with SPSS version 23 statistical package. SPSS version 23, analysis of variance (ANOVA) followed by Tukey, 95%CI and P-values less than 0.05 were used to examine significant association between dependent and independent variables. Cut off values for maternal age and anthropometric measurements were defined as the values closest to the 10th percentile of our population. Sensitivity, specificity and positive predictive values with their 95% confidence intervals (CI) were calculated using these thresholds. The data were presented by using statements, frequency tables, figures and percentages.

Ethical considerations: Ethical clearance was obtained from Institutional Review Board of College of Heath Science, Addis Ababa University and from Addis Ababa Public Health Research and Emergency Management Core Process. The same document and letter from department of medical anatomy was used to secure written permission from the administration of Gandhi Memorial Hospital, Zewditu Hospital and Tikur Anbessa Hospital. All the study participants were briefed on the research activities and confidentiality of the information to be collected was assured. Written consent was obtained from each participant. The participants were told that they had the right not to participate or could even exclude themselves from the study, for any reason, at any time during the study.

RESULTS

***Socio-demographic Characteristics*:** In this study, a total of 384 primigravid women were recruited based on established inclusion criteria. Among these, 337 of them were mothers who delivered through spontaneous vaginal delivery and the rest, 47 mothers, gave birth by CS due to confirmed CPD. The socio-demographic characteristics of the women who gave birth through spontaneous vaginal delivery and by CS is shown in table-1.

Table 1:- Socio-demographic characteristics of the women who gave birth through spontaneous vaginal delivery and by cesarean section due to cephalopelvic disproportion

		Frequency (percentage)	
Variables	**Category**	**ND (n=337)**	**CPD (n=47)**
Residence	Urban	321(95.3%)	33(70.2%)
	Rural	16(4.7%)	14(29.8%)
Age range	≤20	25(7.4%)	10(21.3%)
	21-25	207(61.4%)	24(51.1%)
	26-30	93(27.6%)	8(17.0%)
	31-35	12(3.6%)	5(10.6%)
Level of education	Cannot read and write	32(9.5%)	3(6.4%)
	Can read and write	79(23.4%)	14(29.8%)
	Primary school	100(29.7%)	7(14.9%)
	Secondary school	68(20.2%)	5(10.6%)
	College and above	58(17.2%)	18(38.3)
Occupation	House wife	158(46.9)	18(38.3%)
	Government employed	48(14.2%)	16(34%)
	Self employed	128(38%)	11(23.4%)
	Others	3(.9%)	2(4.3%)

Results of maternal age and anthropometric measurements: As shown below in table 2, about 384 primigravid mothers were included in the present study. Based on their mode of delivery, these mothers were grouped into two groups: - (spontaneous vaginal delivery (SVD) and CPD group). According to this study, SVD was defined as women who gave birth spontaneously through vaginal canal without the use of forceps or vacuum to assist delivery. The mean fetal weight who delivered through spontaneous vaginal delivery was 2.96with standard deviation of 0.55 (table 2).

The mean fetal weight delivered by CS was 3.38 with standard deviation of 0.4 as shown in table 2.In the present study, statistically significant decrease (p=0.013) in the mean fetal weight was observed in mothers who gave birth through SVD.

Several measurements were lower in mothers who had cesarean delivery for CPD when compared with mothers who delivered vaginally.

The mean maternal height, foot length, Michaelis horizontal diameter and maternal head circumference also were smaller in the CPD group than in the SVD group. Statistically significant differences were observed for height, foot length, Michaelis horizontal and head circumference of mothers with and without CPD. The mean of Michaelis vertical diagonal and bi-acromial diameter did not have significant difference between the SVD and CPD groups as shown in Table 2.

Table 2:- Comparison of maternal characteristics between Spontaneous Vaginal delivery and cephalopelvic disproportion group.

Variables	**Normal delivery (n=337)**	**Cephalopelvic disproportion (*n*=47)**	***P-v*alues**
Height (cm)	1.65±0.06	1.53±0.06	0.000*
Foot length (cm)	23.7±0.92	22.6±0.72	0.000*
Michaelis Horizontal diagonal(cm)	9.1±0.83	8.5±0.56	0.000*
Michaelis vertical diagonal(cm)	9.3±0.92	9.3±0.52	0.883
Head circumference (cm)	53.4±2.91	48.9±4.90	0.000*
Bi-acromial diameter (cm)	33.6±3.11	33.2±2.84	0.428
Fetal Birth weight (kg)	2.96±0.55	3.38± 0.40	0.013*

Values are expressed as mean ±SD,fetal birth weight is in kilogram

*: *P-v*alues<0.05 were considered significant (ANOVA).

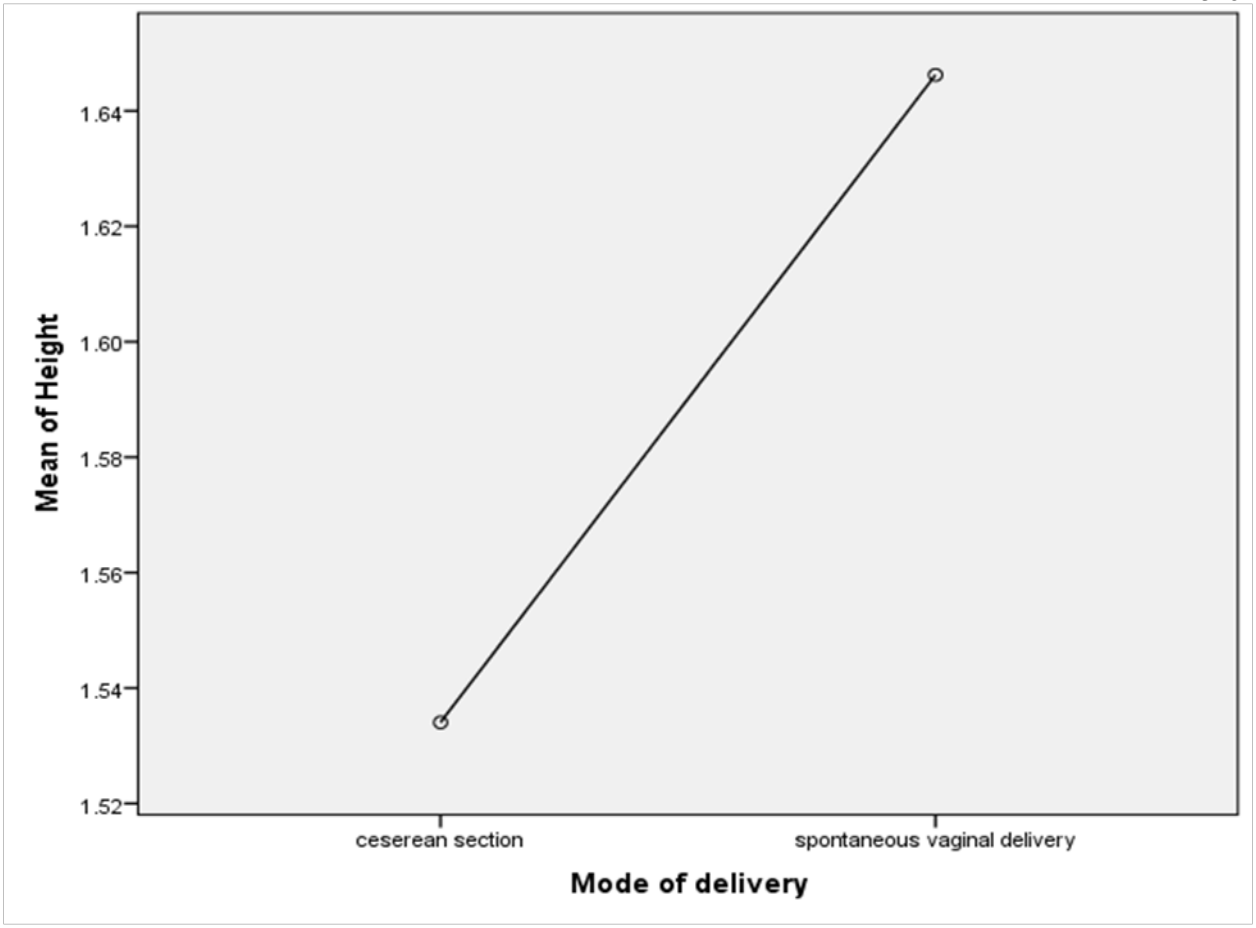


Figure 2: A plot of mean height among spontaneous vertex delivery and cephalopelvic disproportion (who gave birth by cesarean section)

As shown below in table 3,maternal height, Michaelis transverse diameter, maternal head circumference and foot length had the highest sensitivity, specificity and positive predictive value respectively (Table 3).

The results in table 3 were computed by using 10^{th} percentile of age and all measurements as Cut-off values. After cut-off values were determined sensitivity percentage, specificity percentage and Positive Predictive Value (PPV) percentage were calculated.

Different methods are applied to decide the cut-off points for maternal anthropometric measurements. The use of ROC curves to determine the cut-off limits is recommended by Ferguson, et al. (2000) (8).

Another method of determining a cut-off limit for an anthropometric measurement to predict CPD has been identifying the 10^{th}percentile of the measurements for the study population (Liselele, et al., 2000) (5). In the current study, the 10^{th} percentiles was used as cut-off value for all maternal anthropometric measurements (Table 3).

Table 3: Cut-off value, sensitivity, specificity and PPV percentage of maternal anatomical anthropometric measurements and fetal birth weight as predictors of cephalopelvic disproportion

Variables	Cut-off value	Sensitivity percentage	Specificity percentage	PPV Percentage
Height (cm)<10^{th} percentile	1.53	86.1	95.4	65.9
Foot length (cm)<10^{th} percentile	22.2	27.8	89.6	21.7
Michaelis rhomboid–transverse (cm)<10^{th} percentile	8.0	50.0	89.0	12.8
Michaelis rhomboid–vertical (cm) <10^{th} percentile	8.0	25.0	87.9	2.13
Head circumference(cm)<10^{th} percentile	49.0	33.3	89.7	23.4
Bi-acromial diameter (cm)<10^{th} percentile	31.0	18.4	88.7	14.9
Fetal Birth Weight	2.20	0	53.4	0

Table 4:- Validity of combining maternal height with other anthropometric measurements f or prediction of cephalopelvic disproportion

Combined Variables	Sensitivity percentage	Specificity percentage	PPV Percentage
Height<10^{th}percentile+foot length<10^{th} percentile	56.9	92.5	44.1
Height<10^{th} percentile +Michaelis vertical<10^{th} percentile	80.0	91.5	34
Height<10^{th} percentile +Michaelis horizontal<10^{th} percentile	77.1	92.1	39.4
Height<10^{th}percentile+head circumference<10^{th} percentile	60.9	92.2	44.7
Height<10^{th}percentile+bi-acromial diameter<10^{th} percentile	57.6	90.7	40.4
Head circumference<10^{th} percentile +bi-acromial diameter<10^{th}percentile	28.6	89.2	19.1

According to the present study, combined anthropometric measurements showed increment in sensitivity, specificity and PPV. Foot length alone has a sensitivity percentage of 27.8, specificity percentage 89.6 and a PPV of 21.7%. When foot length is combined with other anthropometric measurements such as height, Michaelis horizontal and maternal head circumference its sensitivity increased to 59.6%, 33.3% and 30.4% respectively.

As shown in Table 4, when height is combined with other anthropometric measurements it did not show increment in sensitivity, specificity and PPV.

Table 5:- Validity of combining maternal foot length with other maternal anthropometric measurements for prediction of CPD

Combined Variables	Sensitivity percentage	Specificity percentage	PPV percentage
Foot length<10th percentile + Michaelis vertical<10th percentile	27.5	89.1	11.8
Foot length<10th percentile + Michaelis horizontal<10th percentile	33.3	89.3	17.2
Foot length<10th percentile +head circumference<10th percentile	30.4	89.7	22.6
Foot length<10th percentile +bi-acromial diameter<10th percentile	25.7	89.1	18.3
Michaelis vertical<10th percentile + Michaelis horizontal<10th percentile	43.7	88.4	7.4
Michaelis vertical<10th percentile + head circumference<10th percentile	32.4	88.8	12.8
Michaelis vertical<10th percentile + bi-acromial diameter<10th percentile	23.5	88.3	8.5
Michaelis horizontal<10th percentile + head<10th percentile circumference	16.0	89.7	18.1
Michaelis horizontal<10th percentile +bi-acromial diameter<10th percentile	30.9	88.9	13.8

DISCUSSION

Cephalopelvic disproportion is a major risk factor for maternal and perinatal morbidity and mortality. Accurate prediction of women at risk for cephalopelvic disproportion is not predicted by health centers which are not equipped to perform a caesarean section, long referral distances and poor local transport may lead to obstructed labour and uterine rupture (4,9,10). Conversely, in a resource limited setting, prediction of cephalopelvic disproportion in women at risk must be sufficiently specific to avoid unnecessary referral.

The number of mothers who gave birth through CS appears to be high in the present study. However, the higher number of deliveries by way of CS may have been because in this study non-probability sampling method that did not involve random sampling was used. That is, the sample was recruited continuously until the required sample size (384) was obtained.

The present study compared fetal birth weight, different maternal anthropometric measurements (height, foot length, Bi-acromial diameter, maternal head circumference, Michaelis horizontal diameter and Michaelis vertical diameter) in mothers who gave birth through spontaneous vaginal delivery and those who undergo CS for confirmed CPD. Anthropometric measurements are routinely taken in most of antenatal care clinic services even at the junior level (health visitor). They are simple, none invasive and inexpensive.

Maternal height and mode of delivery were observed to be significantly associated in the current investigation. This finding is in line with the findings of several studies that demonstrated mothers with CPD were significantly shorter than those who have normal vaginal deliveries, even though the sensitivity related to a maternal height cut-off for risk set at 150 cm was low(5)

In a study conducted in Congo, a univariate analysis revealed that height, intertrochanteric diameter and the transverse diagonal of Michaelis sacral rhomboid area were associated with CPD. Logistic regression analysis showed that maternal height less than 150 cm and/or transverse diagonal of Michaelis less than 9.5 cm were the body dimensions most associated with CPD.

However, their findings were not in agreement with those reported by Kara et. al., (2005) (11) and Wongcharoenkiat and Boriboonhirunsarn (2006) (12)which documented maternal height as a risk factor for caesarean section.

The study conducted in Congo also failed to document a significant association between short stature and mode of delivery. The observed discrepancy on lack of significant association may have been due to racial differences as these investigations were carried out among participants with different racial profiles. The studies which reported significant association between maternal height and mode of delivery were conducted in Ethiopia, Asia, (Thailand and Turkey) while the study which failed to show significant association was carried out in Africa (Congo). Several studies have used a cutoff value of 150cm for height to predict CPD(16). However, this cut off point may not be appropriate for use in different populations because of variations in genetic factors as well as environmental factors such as nutritional status of the mother(13).

In the present study, Michaelis horizontal diameter also was significantly associated with mode of delivery (P=0.000). However, in the study conducted in Democratic Republic of Congo, the transverse diagonal of sacral area was identified as the strongest anthropometric predictor for CPD(16). In addition, the clinical algorithm obtained by the addition of this risk factor to the maternal height was found to be the best model to identify women at risk for CPD. According to the findings of this study, the model identified more than half of the cases of CPD among nulliparous women. These authors concluded that it is important to note that in order to achieve a similar sensitivity using only maternal height, a cut off value of 159 cm should be used. Using this cut off value, however, will lead to referral of 31% of nulliparous women, which may not be acceptable in most settings, especially, in resource limited settings. However, a lower cut off may be chosen, for instance the 5th percentile, (for both measures) to minimize the number of women referred(16).

In the present study, Michaelis vertical diameter and mode of delivery were not associated. The absence of significant association between Michaelis vertical diameter and mode of delivery also has been reported by Rahele, et al. (2014) (17). However, other investigations have reported that Michaelis vertical diameter could identify more than 50% of abnormal labor progresses (Rozenholc, et al., 2007) (14) and that it had significant association with mode of delivery (Liselele, et al., 2000 (5); Alijahan, et al., 2012 (15) and Hubert, et al., 2000) (16). This inconsistency could be explained by the racial differences in the study participants of these investigations.

The present study was conducted in Ethiopia while the studies which reported significant association between Michaelis vertical diameter and mode of delivery were conducted in Cameroon and the Congo. In the current study, about 57.4%% of women with foot length <22.6cm and (p=0.000) gave birth by CS, indicating that foot length has a strong significant association with mode of delivery and this observation was in agreement with other reports. A study conducted in the Sudan (Omdurman maternity hospital) (18), for example, showed that women with foot length less than 18cm have a significantly less chance (P<0.001) of vaginal delivery compared to those with 18cm and more. However, Awonuga, et al. (2007) (19) and Tahir, et al. (1988) (20) did not observe a significant relationship between foot length and mode of delivery. The difference in the findings of these two studies and the present study may be explained by differences in sample size and methods of data collection.

In the investigation conducted by Awonuga et. al. and Tahir, et al., shoe size was used instead of the actual foot length and sample size used was lower compared to the current study. It appears that the measurement of shoe size is not useful as predictor of the mode of delivery. Maternal head circumference also was observed to be significantly associated with mode of delivery (P=0.000) in the present study. The finding agrees with the reports of other investigations (Connolly, et al., 2003) (6). Another maternal anthropometric measurement carried out in the current study was maternal Bi-acromial diameter. Bi-acromial diameter did not show any significant association with mode of delivery. This observation is in agreement with the study conducted in India, which reported that Bi-acromial diameter did not show significant association with mode of delivery (7).

To our knowledge, no definite cut off level between the estimated fetal weight and the likelihood of obstructed labor has been established until now. According to Papungkorn and Wiboolphan 2006 (21), the best cut off level of the estimated fetal weight was chosen to be 3000 gm. In this study, it was reported that fetal weight greater than 3,000 g increased the risk for cesarean section, due to CPD, by 3.96 folds. The findings of the current study also showed that fetal birth weight was significantly associated with mode of delivery.

Observation of the current study was comparable with findings of other investigations(7). which reported that fetal weight (fetal weight ≥3 000g), help predict CPD. Results of study conducted in Urban Nigeria and Malawi (22) showed the distribution of birth-weight for women with CPD was normal (probability plot) and the mean birth-weight increased significantly with maternal age (p<0.001) and parity (p<0.001).

The mean birth-weight of women with CPD was 3277 g to 3352 g and that of women without CPD was 2881 g which was significantly lower than that of CPD cases (p<0.001)(22). In the past, attempts have been made to combine more than one anthropometric measurements in the hope that the predictive value of the combined measurements would be greater(5). In the present study, when foot length was combined with other anthropometric measurements such as height, Michaelis horizontal diameter and maternal head circumference, its sensitivity increased from 27.8% to 59.6%, 33.3% and 30.4%, respectively. However, combination of maternal height with the other anthropometric measurements such as foot length, Michaelis horizontal diameter did not show a better prediction compared to mothers height alone. This finding was not consistent with the reports of a study carried out in Cameron (14) where a combination of maternal height less than or equal to the 5th percentile or a transverse diagonal of the Michaelis sacral rhomboid area less than or equal to the 10^{th} percentile resulted in a sensitivity of 53.1%, a specificity of 92.0%, a positive predictive value of 47.7% and a positive likelihood ratio of 6.6 with 13.5% of all women presumed to be at risk (14). This, inconsistent observation may be due to difference in the chosen cut-off values, that is, in the present study the tenth percentile was chosen as cut off value for height while the fifth percentile was used in the other studies.

Conclusion: Measurements of maternal height, foot length, head circumference and Michaelis transverse diameter using a measuring tape may represent a simple method to detect nulliparous women at risk of CPD. Being the first of its kind, the current investigation has generated a base line data for future studies. However, factors that may influence the decisions of mode of delivery, for example, use of oxytocin and fetal head size, were not investigated in the present study. In addition, the sampling method was not probabilistic and it may be difficult to generalize to the wider population.

It is, thus, recommended that meticulous research that assesses accuracy of maternal anthropometric measurements to predict CPD, involving larger sample size, should be conducted. Since there was scarcity of data from similar investigations, this same study should be repeated in other hospitals to see its reproducibility.

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