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# INFLUENCE OF MATERNAL PELVIS HEIGHT AND OTHER ANTHROPOMETRIC MEASUREMENTS ON THE DURATION OF NORMAL CHILDBIRTH IN UGANDAN MOTHERS

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## ABSTRACT

In low resource settings, maternal anthropometry may complicate time based monitoring of childbirth. We set out to determine the effect of maternal anthropometry and foetal birth weight on the duration of childbirth. Birth related secondary data from 987 mothers with pregnancies of ≥ 37 weeks, singleton baby and a normal childbirth were obtained. This data was analysed for regression coefficients and Interclass correlations coefficients (ICCs). The mean duration of childbirth was 7.63hours. Each centimetre increase in maternal pelvis height led to a 0.56hours increase for the first stage ($P<0.01$), 0.05hours reduction for second stage ($P<0.01$), and 0.46hours increase in total duration of childbirth ($p<0.01$). For each centimeter increase in maternal height there was a 0.04hours reduction in the first stage ($P=0.01$) and a 0.005hours increase in second stage ($P=0.03$). The ICCs with respect to geographical site were 0.40 for stage 1, 0.27 for stage 2 and 0.21 for stage 3. Additional modeling with tribe of mother did not change the ICCs. Maternal pelvis height and maternal height were found to have a significant effect on the duration of the different stages of normal childbirth. Additional study is needed into the public health value of the above measurements in relation to childbirth in these settings.

**Key words:** Humans; anthropometry; childbirth; pelvis height;

## INTRODUCTION

In sub-Saharan Africa and other resource-limited settings, the low access/utilization of birth related health care support (Shiferaw et al., 2013) and poor nutrition(Dewey et al., 2011a) are among the key factors that determine the outcomes of childbirth. Some of the other factors include: the age of the mother (Zaki et al., 2013), maternal height, maternal weight and newborn infants birth weight (Adeyemi et al., 2014). For this study we picked the Uganda population because of its multi-ethnic sample of African populations with representation from the: pygmy, Niger-Congo, Ethiopic and Nilo Saharan ethnic groups of sub-Saharan Africa (Campbell et al., 2008; Excoffier et al., 1987). In such populations variations in individual genetics may work with the above-mentioned factors to create a unique maternal phenotype. This unique phenotype in turn creates a need for population specific measures to monitor the outcomes of childbirth.

The absence of population specific measures of the duration of childbirth may in certain clinical situations act as an additional source of confusion and even lead to inaction. This confusion and or inaction may manifest as delays leading to some of adverse birthing experiences and poor outcomes of childbirth for mothers in these low resource settings (Kiguli et al., 2016; Munabi et al., 2016b; Stone, 2016). In more developed settings, differences

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in the accepted duration of childbirth have been linked to inappropriate interventions and unfavorable birth experiences of mothers (Nystedt et al., 2014). This makes having a uniform understanding of the duration of childbirth, one of the critical steps towards improved management of childbirth in any setting. This step to develop a uniform understanding of the duration of childbirth aids the development of appropriate screening tools. These screening tools should preferably rely on proven associations between the duration of childbirth and various easy to use anthropometric measurements. Defining such associations thus aids the development of population level screening guidelines to identify individuals at risk and action time cut offs for safe childbirth in these settings. Also the use of easy to use anthropometric measurements is important in these low resource settings where there is poor electricity distribution and deployment of low carder staff in predominantly hard to reach health facilities. Such screening tools when used during the antenatal period in these low resource settings may help in the process of birth planning and over time lead to reduction in the delays associated with adverse events of pregnancy (Kiguli, Munabi, Ssegujja, Nabaliisa, Kabonesa, Kiguli and Josaphat, 2016; Munabi et al., 2015a; Munabi, Luboga, Luboobi and Mirembe, 2016b; Munabi et al., 2015c).

A core assumption for this study was that small maternal stature is associated with small maternal birth canal dimensions (Kozuki et al., 2015; Munabi, Luboga, Luboobi and Mirembe, 2016b). These small or reduced birth canal dimensions in the presence of a normal sized or large baby set up a mother for a difficult childbirth that if not identified early may end in an adverse outcome for either mother or newborn. This study set out to determine the effect of maternal: pelvis height, ethnicity, height, weight, and foetal birth weight on the duration of the different stages of spontaneous childbirth in a cohort of Ugandan mothers with normal births.

## MATERIALS AND METHODS

This was an analysis of secondary data obtained from a multi site cross-sectional study carried out at selected health facilities from different geographical regions and levels of Uganda's health care system as described in more detail else where (Munabi, Luboga and Mirembe, 2015a). In this parent study the purposive selection of hospitals was made to cater for geographical clustering of known major ethnic groupings within Uganda and accompanying tribal differences in feeding practices (Baingana et al., 2014; Campbell and Tishkoff, 2008). There were 1146 mothers from all the study sites during the study period of whom the childbirth records of 987 (86.13%) mothers that had spontaneous vaginal deliveries with normal foetal outcomes were used for this study.

For this analysis the following data was extracted from each record: maternal age in years, maternal height in centimeters and maternal weight in kilograms, gravidity, symphysio-fundal height in centimeters, a proxy for gestational age on clinical examination to the nearest 0.1 centimetre, babies birth weight in kilograms and the duration of each of the first (active phase), second and third stages of childbirth. In addition the record of pelvis height in centimeters that had been measured as described in more detail elsewhere was included in the extracted data (Munabi et al., 2015b). Reported tribe of maternal tribe was used as a proxy for each mothers genotype during the analysis. In the sub analysis using maternal tribe the group in West Nile, which represents the Lugbara, Alur and kakwa tribes of the Nilo Saharan ethnic group was used as the reference group. STATA 12 (StataCorp LP, Texas, USA) was used for analysis to obtain output both the descriptive and inferential statistics summarized here in the results section. Multilevel linear regression using the xtmixed function in STATA was used to calculate the regression and Intraclass correlation (ICC) coefficients (Weir, 2005). Any observation found with a missing value was dropped from analysis. A $p<0.05$ was considered significant for all tests. The parent study received ethical approval from Makerere University School of Biomedical Sciences IRB and Uganda National of Science and Technology as previously described (Munabi, Luboga and Mirembe, 2015b). No identifier marks of personal information were used in the analysis and subsequent reporting of the study results.

## RESULTS

Table 1 provides a summary of the characteristics of the included participant mothers, duration of the different stages of parturition and neonatal birth weight. In Table 2, note that the means for each of the study variables were significantly different with respect to study sites. For example the duration of the first (1st) stage of childbirth was longer at 5 of the participating sites when compared with what was observed at site 1(Mulago hospital). The remaining two sites, (site 5, mean difference-0.86 hours, P=0.03 and site 7, mean difference -2.53 hours, P<0.01. had a shorter duration of childbirth when compared to site 1. Similar trends were observed for the other summarized information in table 2 for the other stages of childbirth.

**Table 1: Descriptive statistics of participant mothers**

| Variable | Records | Mean | Std. Dev. |
|---|---|---|---|
| Age (years) | 958 | 25.33 | 5.74 |
| Height (Cm) | 942 | 159.09 | 9.53 |
| Weight (Kg) | 952 | 64.14 | 9.76 |
| Gravid | 931 | 3.01 | 1.99 |
| Fundal height (Cm) | 968 | 38.19 | 0.71 |
| Birth weight (Kg) | 973 | 3.17 | 0.50 |
| Pelvis height (Cm) | 959 | 7.28 | 1.85 |
| Stage 1 (hours) | 861 | 7.81 | 3.81 |
| Stage 2 (hours) | 886 | 0.70 | 0.66 |
| Stage 3 (hours) | 872 | 0.15 | 0.17 |
| Total duration (hours) | 986 | 7.63 | 3.81 |

Table 3 provides a summary of regression analysis of all the study variables against the total duration of childbirth. In this table it was only neonatal birth weight and the gravidity of the mother that lacked significant coefficients. Also in table 3 note that, mothers from the other tribal groupings experienced significantly shorter total duration of childbirth than the reference group.

Table 2: Showing variation in Means of the study variables with respect to study site

| **Variable** | **Mean (Std. Dev.)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Age (years) | 25.51(4.67) | 22 (4.76) | 25.86 (5.59) | 26.20 (6.76) | 26.45 (5.67) | 24.51 (6.19) | 25.78 (6.39) | **<0.01** |
| Height (Cm) | 160.32 (7.71) | 0 | 160.88 (5.93) | 164.38 (6.92) | 163.13 (5.43) | 153. 91 (11.29) | 162.78 (8.49) | **<0.01** |
| Weight (Kg) | 67.63 (9,86) | 62.6 (8.56) | 63.82 (7.14) | 61.14 (8.10) | 65.94 (8.36) | 61.24 (8.29) | 62.67 (14.33) | **<0.01** |
| Gravid | 2.39 (1.21) | 1.92 (1.29) | 3.70 (2.22) | 3.85 (2.52) | 3.60 (2.37) | 2.92 (1.72) | 3.80 (2.87) | **<0.01** |
| Birth weight (Kg) | 3.21 (0.48) | 2.92 (0.63) | 3.12 (0.44) | 3.23 (0.72) | 3.13 (0.39) | 3.22 (0.49) | 2.96 (0.57) | **<0.01** |
| Pelvis height (Cm) | 5.78 (1.48) | 8.38 (1.10) | 6.39 (0.49) | 6.58 (0.84) | 7.77 (1.36) | 8.01 (1.66) | 9.48 (1.29) | **<0.01** |
| Stage 1 (hours) | 7.07 (3.05) | 10.43 (4.37) | 8.41 (3.52) | 10.35 (2.52) | 6.61 (3.75) | 9.07 (3.86) | 4.54 (2.27) | **<0.01** |
| Stage 2 (hours) | 0.37 (0.34) | 0.63 (1.00) | 0.53 (0.41) | 0.61 (0.34) | 0.37 (0.29) | 1.18 (0.77) | 0.48 (0.24) | **<0.01** |
| Stage 3 (hours) | 0.09 (0.05) | 0.10 (0.06) | 0.13 (0.08) | 0.34 (0.57) | 0.11 (0.11) | 0.19 (0.12) | 0.19 (0.09) | **<0.01** |
| Total duration (hours) | 5.86 (4.29) | 9.51 (5.38) | 8.84 (3.83) | 8.25 (5.44) | 6.16 (4.11) | 10.34 (4.01) | 4.10 (2.96) | **<0.01** |
| Records | 284 | 27 | 76 | 52 | 143 | 315 | 90 | |

Key site: 1-Mulago hospital, 2-Kilembe hospital, 3-Nyakibaale, 4-Anaka Hospital, 5-Kitgum hospital, 6-Arua hospital 7-Kumi hospital, 8-ANNOVA test Value

In table 4, Pelvis height was the only variable that had a significant effect across all the stages of childbirth. Each centimetre increase in pelvis height was associated with a 0.56 hours (33.6minutes) increase in the duration of the first stage (P<0.01), 0.05 hours (3 minutes) reduction in the duration of second stage (P<0.01), 0.02 hours (1.2 minutes) reduction in the duration of the third stage, and a 0.46 hours (27.6 minutes) increase in the total duration of childbirth (p<0.01). Each centimetre increase in maternal height was associated with a significant 0.04 hours (2.4 minutes) reduction in the duration of the first stage (P=0.01) and a 0.005 hours (18 seconds) increase in the duration of the second stage (P=0.03) keeping all the other variables constant. The adjusted regression coefficients of all the other variables were not significant. Note that the first stage had the highest ICC of 0.40, followed by stage 2 with an ICC of 0.27 and stage 3 with the lowest ICC of 0.21. In table 4 observe there is no difference in the ICCs for site and the combination of site and tribe with the exception of the total duration of childbirth.

**Table 3: Showing regression analysis of study variables on total duration of childbirth**

| Variable (unit) | Regression coefficient (95% CI, P value) | Constant (Std. Err, value) |
|---|---|---|
| Age (years) | -0.06 (-0.12 to -0.01, **0.02)** | 8.32 (0.31, **<0.01)** |
| Height (Cm) | -0.11 (-0.14 to -0.08, **<0.01)** | 13.37 (0.85, **<0.01)** |
| Weight (Kg) | -0.07 (-0.10 to -0.04, **<0.01)** | 10.50 (0.69, **<0.01)** |
| Gravid | -0.09 (-0.24 to 0.06, 0.22) | 7.84 (0.28, <0.01) |
| Birth weight (Kg) | 0.02 (-0.57 to 0.67, 0.95) | 7.64 (0.66, <0.01) |
| Pelvis height (Cm) | 0.41 (0.24 to 0.57, **<0.01)** | 4.68 (0.61**, <0.01)** |
| Tribe (Number of records) | -0.39 (-0.49 to -0.29, **<0.01)** | 8.79 (0.20, **<0.01)** |
| a. West Nile (308) | 1 | |
| b. Ganda (190) | **-**4.51 (-5.27 to -3.74**, <0.01)** | |
| c. Ankole (83) | **-**2.85 (-3.87 to -1.82, **<0.01)** | |
| d. Soga (12) | **-**2.42 (-4.86 to 0.21, 0.05) | |
| e. Gishu (5) | -2.65 (-6.39 to 1.09, 0.17) | |
| f. Acholi/Lango (194) | -3.59 (-4.35 to -2.83, **<0.01)** | |
| g. Nyoro/Toro (12) | -3.45 (-5.89 to -1.01, **0.01)** | |
| h. Iteso (93) | -5.85 (-6.84 to -4.87**, <0.01)** | |
| i. Konjo (23) | -1.00 (-2.80 to 0.79, 0.27) | |
| j. Others (49) | -3.00 (-4.27 to -1.72**, <0.01)** | |
| Site | 0.26 (0.18 to 0.33**, <0.01)** | 6.06 (0.27, **<0.01)** |
| 1. Mulago | 1 | |
| 2. Kilembe | 3.65 (2.02 to 5.29**, <0.01)** | |
| 3. Nyakibale | 2.99 (1.94 to 4.04**, <0.01)** | |
| 4. Anaka | 2.39 (1.16 to 3.62, **<0.01)** | |
| 5. Kitgum | 0.31 (-0.53 to 1.14, 0.47) | |
| 6. Arua | 4.48 (3.81 to 5.14, **<0.01** | |
| 7. Kumi | -1.75 (-2.73 to -0.76, **<0.01)** | |

**Table 4: The adjusted regression analysis for each stage of childbirth controlling for site and tribe**

| | Stage of childbirth (95% CI, P value) | | | |
|---|---|---|---|---|
| **Variable** | **Stage 1** | **Stage 2** | **Stage 3** | **Total duration** |
| Age (years) | -0.01 (-0.07 to 0.05, 0.80) | -0.0002 (-0.01 to 0.01, 0.97) | 0.001 (-0.002 to 0.004, 0.39) | 0.004 (-0.07 to 0.07, 0.91) |
| Height (Cm) | -0.04 (-0.06 to -0.01, **0.01)** | 0.005 (0.001 to 0.01, **0.03)** | 0.001 (-0.0003 to 0.003, 0.11) | -0.03 (-0.06 to 0.002**,** 0.07) |
| Weight (Kg) | -0.01 (-0.04 to 0.01, 0.35) | 0.001 (-0.003 to 0.01, 0.58) | -0.0004 (-0.002 to 0.001, 0.54) | -0.01 (-0.04 to 0.02, 0.56) |
| Gravid | -0.01 (-0.20 to 0.18, 0.91) | -0.01 (-0.04 to 0.02, 0.57) | -0.008 (-0.02 to 0.001, 0.09) | -0.10 (-0.31 to 0.10, 0.33) |
| Birth weight (Kg) | -0.15 (-0.68 to 0.38, 0.58) | 0.05 (-0.03 to 0.13, 0.20) | -0.004 (-0.03 to 0.02, 0.79) | -0.11 (-0.67 to 0.46, 0.72) |
| Pelvis height (Cm) | 0.56 (0.40 to 0.73, **<0.01)** | -0.05 (-0.08 to -0.03**, <0.01)** | -0.02 (-0.02 to -0.008**, <0.01)** | 0.46 (0.28 to 0.65, **<0.01)** |
| Constant | 10.64 (5.72 to 15.55, **<0.01**) | 0.05 (-0.82 to 0.73, 0.91) | 0.13 (-0.11 to 0.38, 0.29) | 9.59 (4.08 to 15.11, **<0.01**) |
| ICC site | 0.40 | 0.27 | 0.21 | 0.21 |
| ICC Site and tribe | 0.40 | 0.27 | 0.21 | 0.22 |

## DISCUSSION

We set out to determine effect of maternal: pelvis height, ethnicity, height, weight, and foetal birth weight on the duration of the different stages of spontaneous childbirth in a cohort of Ugandan mothers with normal births. We found that only maternal pelvis height had a significant effect on each of the stages of spontaneous childbirth ($P<0.01$). We have previously observed that pelvis height had significant associations with both pelvic inclination and the mid and outlet dimensions of the birth canal (Munabi et al., 2015d). We now posit that the above observations may also explain the significant effect of maternal pelvis height on the different stages of childbirth seen in this study. Also the use of maternal pelvis height as a screening tool is supported by the fact that maternal height, which is currently used for screening mothers in these setting, reaches its maximum at the age of 16-17 years of age (Dewey and Begum, 2011a; Dewey et al., 2011b). Maternal pelvis height continues changing, through out the reproductive period of most mothers in these settings, till the 30$^{th}$ year of life when the growth of the pubis bone ceases in women(Pfeiffer et al., 2014; Rissech et al., 2007). These observations provide additional support for our previously made assertion that use of maternal pelvis height in combination with maternal height and maternal weight improves the screening for mothers with potential adverse outcomes of pregnancy (Munabi, Luboga and Mirembe, 2015a).

It is important to note the significant differences in the means of maternal height for each of the study sites in table 2. Maternal height, one of the key anthropometric measurements used for screening mothers in our settings, is recognized as a useful indicator of exposure to chronic malnutrition(Özaltin et al., 2010; Pfeiffer, Doyle, Kurki, Harrington, Ginter and Merritt, 2014). For communities with typically small statured women, the extent of each woman's bone growth is dependent on the quality of nutrition within such communities (Kurki, 2011). Nutrition is to a large extent determined by the available food supply, which in Africa is turn determined by climate and culture of a population occupying a given geographical location. In table 4 observe that the ICCs for the first stage of childbirth were the greatest of all four calculated ICCs. This could be due to the common practice of using birth-monitoring tools like the partogram to monitor the first stage of childbirth, which increases the uniformity and thus the reliability of the observations across the sites. In comparison the stages 2 and 3 which in practice rely more on expectant waiting have an almost 50% reduction in reliability. The observed very low reliability compared to the recommended 0.95 minimum (Lance et al., 2006; Weir, 2005), points to a set of geographical site specific factors as previously described in observations made in more developed settings (Laughon et al., 2012). The focus on a geographical site specific factor is further emphasised by the negligent contribution of maternal tribe to the size of the model ICCs for site and tribe compared to site only ICCs (see table 4). For this analysis maternal tribe was used a proxy of the mothers genetic variability, thus the observed absence of the effect on site with inclusion of the tribe ICCs. This holds true despite our earlier observed mild effect of maternal tribe on the associations between maternal pelvis height and maternal height (Munabi et al., 2016a). This absence of effect on the duration of childbirth due to tribe is also supported by observations made in previous studies looking at immigrant populations in the United Kingdom (UK) found no difference in duration of childbirth for Chinese (Shah et al., 2011), Somali (Yoong et al., 2005), and Turks (Kanthasamy et al., 2013) compared with native white British women. Similar conclusions were drawn from a multiyear American study where was lengthening of the duration of childbirth in the more modern cohorts of mothers attributed to changes in practice patterns (Laughon, Branch, Beaver and Zhang, 2012). Thus as has been suggested elsewhere, the observed racial/ethnic differences in duration of childbirth may actually be the result of differences in practice patterns (Walsh et al., 2011).

In this study maternal age, maternal weight, number of pregnancies carried by mother and foetal birth weight had no significant effect on the duration of childbirth. One of the study limitations is the fact that most mothers in Africa prefer home childbirth to facility-based childbirth(Shiferaw, Spigt, Godefrooij, Melkamu and Tekie, 2013). This particular limitation may on the one hand have reduced the representativeness of the study; the findings still provide a glimpse into the factors affecting the duration of childbirth in these settings.

In conclusion, maternal pelvis height and maternal height were found to have a significant effect on the duration of the different stages of normal childbirth. Maternal tribe had a negligible effect on the duration of the different stages of normal childbirth. In comparison, the site where childbirth occurred had a significant effect on the recorded duration of normal childbirth. Additional study is needed into the public health value of the above measurements in relation to childbirth in these settings.

**Competing interests**
No competing interest to declare

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