ORIGINAL COMMUNICATION

Anatomy Journal of Africa. 2015. Vol 4 (1): 457 – 465

HUMAN PELVIS HEIGHT IS ASSOCIATED WITH OTHER PELVIS MEASUREMENTS OF OBSTETRIC VALUE

Munabi Ian G. *, **Mirembe Florence, Luboga Sam A**

*Corresponding author; Munabi Ian G, Department of Anatomy, School of Biomedical Sciences, Makerere University College of Health Sciences, P.O. Box 7072 Kampala Uganda East Africa Telephone: +256772485474 Email: imunabi@chs.mak.ac.ug

ABSTRACT

In low resource settings, perinatal death remains a major challenge, yet some of the key anthropometric measures used for screening have been found to be inappropriate. These calls for additional anatomically related measurements to act as a basis for the design of: easy-to-use, low technology accurate tools to enhance obstetric care quality in these settings. This study set out to determine the associations between the various pelvis anthropometric measurements of obstetric importance with pelvis height. The study made use of 30 complete rearticulated Adult pelvic bonesets of known sex. The some of the thirteen measurements made on each boneset included: Pelvis height, Sacral Anterior Orientation (SAO), pubic bone length, total pelvis height and inlet medial-lateral diameter. All measurements were taken thrice and the average used for comparisons with pelvis height. The non-parametric Mann-Whitney test and multilevel regression analysis test to control for gender was used. Pelvis height had significant associations with SAO (-0.36, P<0.01), pubic bone length (0.41, P<0.01), total pelvis height (0.21, P=0.04) and inlet medial-lateral diameter (0.46, P=0.02). Additional significant associations were observed with the diameters of the mid and outlet diameters of the birth canal. Pelvis height had significant associations with: total pelvis height and inlet medial-lateral diameter of the pelvis and the measurements related to the mid and outlet diameters of the birth canal. This study provides initial evidence to support further evaluation of pelvis height as an additional tool for the assessment of the human birth canal.

Key words: Pelvis height, Pelvimetry, Childbirth low resource settings

INTRODUCTION

From an evolutionary point of view the female pelvis in Homo sapiens, is a compromise adaptation between stability during bipedal locomotion requiring a narrow pelvis and giving to birth a large brained infant, the obstetric dilemma [OD] (Pfeiffer et al., 2014). Depending on the environmental pressures, the high variability of the pelvis can lead to a small maternal birth canal and later increased risk of developing cephalopelvic disproportion (Kurki, 2013). According to Kurki 2011, there is very little difference between the dimensions of the birth canals with respect to gender (Kurki, 2011). In this paper we focus on Pelvis Height which is used by motor vehicle engineers in test crash human models to delineate the contribution of the pelvis to total body height [Figure 1] (Reed et al., 1999). There has been no study seeking to relate pelvis height to the other pelvis measurements of obstetric importance in Ugandans. In this paper we set out to answer the research question what are the associations between the various pelvis anthropometric measurements of obstetric importance with pelvis height in a sample of bones from the Ugandan population?

MATERIALS AND METHODS

This was a pilot cross sectional study, done in the Makerere University College of Health Sciences, School of Biomedical Sciences, Department of Anatomy Galloway Bone Collection Archive, on a sample of 30 complete pelvis bones (20 male and 10 females according to the records made at the time of preparation). The Galloway bone collection consists of defleshed skeletons. Each skeleton is stored in its own box with all the bones marked with an identification number, which corresponds to the record of the individual's gender and cause of death at the time of defleshing.

A search was made for complete female and male pelvis bone skeleton sets that were rearticulated using strong rubber bands. A purposive sampling strategy was adopted to match each identified female pelvis bone set with a corresponding randomly selected two complete male pelvis bone sets. This approach was adopted because of the current poor state of the collection that over the years left many of the bone sets incomplete as a result of student use. Each of the above mentioned measurements was made and recorded immediately on a sheet of paper. This was done three times for each measurement using a digital vernier caliper with an accuracy of 0.01 mm (Draper Expert Hants, UK) by an anatomist master's level research assistant. For the curved surfaces a string was used to obtain the length then also measurement made with the aid of a divider and the digital caliper.

For each articulated pelvis bone measurements were made as shown in figure 2 (Kurki, 2011). Additional measurements for each set of bones included the pelvis height (Reed et al., 1999) and the Sacral Anterior Orientation (SAO) obtained using the manual method as described by Peleg et al 2007 (Peleg et al., 2007). It is important to note that Pelvis Height used here is not the same as Total Pelvis Height which is the total distance from the highest point on the iliac crest to the lowest point on the ischial spines (Milne, 1990; Schroeder et al., 1997).

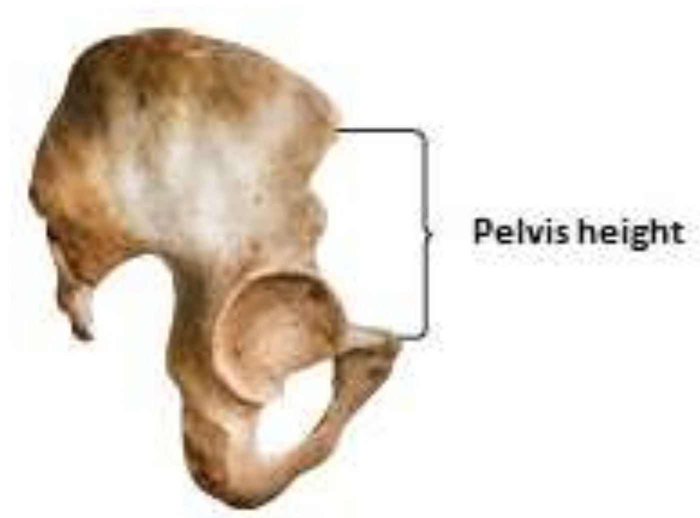

Figure 1: Lateral view of the articulated human pelvis showing the pelvic height

Once all the measurements were done the raw data was entered into an excel sheet from which an average measure for each parameter was computed. The final average values for each measurement per bone set were then exported to STATA 12 (STATA Corp LP, Texas, USA) statistical software for detailed analysis. The mean and non parametric Mann-Whitney tests were used to generate descriptive statistics and identify differences in measurements due to gender. The variation between pelvis height and each of the above pelvis measurements was determined by multilevel regression analysis using the xtmixed function in STATA with maximum likelihood estimation and grouping by gender (Carle, 2009).

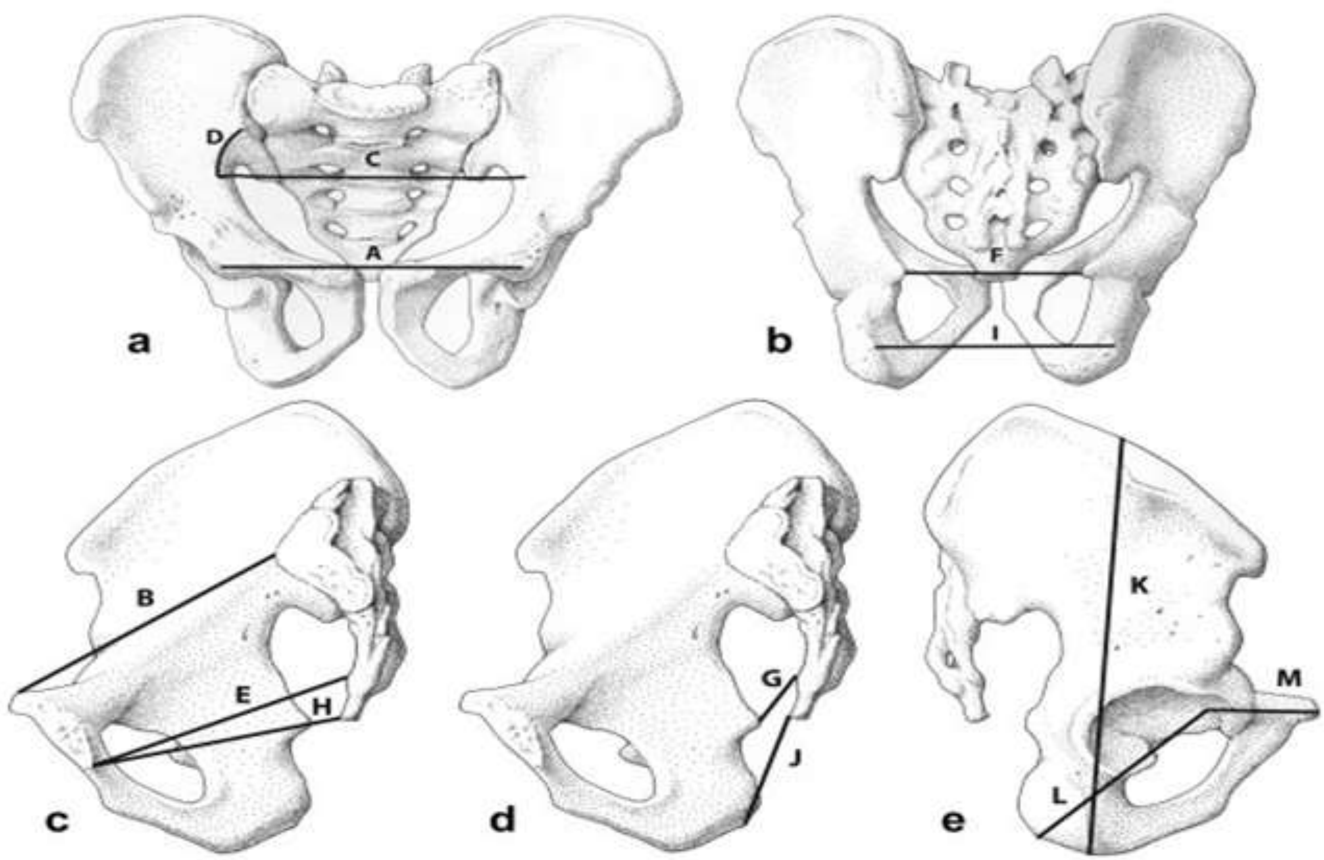

Figure 2: Measurements of the pelvis and hip bone (see Table 1 for descriptions). Measurements of the pelvis and hip bone (see Table 1 for descriptions): a) anterior view of pelvis; b) posterior view of pelvis; c) and d) medial view of right hip bone with sacrum; e) lateral view of right hip bone. A: bi-acetabular breadth; B: inlet A-P; C: inlet M-L; D: inlet posterior; E: midplane A-P; F: midplane M-L; G: midplane posterior; H: outlet A-P; I: outlet M-L; J: outlet posterior; K: hip bone length; L: ischial length; M: pubic length. Reprinted from Publication Journal of human evolution, Vol 61: Kurki HK: Pelvic dimorphism in relation to body size and body size dimorphism in humans page: 635, http://dx.doi.org/10.1016/j.jhevol.2011.07.006 (2011), with permission from Elsevier.

RESULT

The pelvis height ranged from 94.8 mm to 133.9 mm with a mean of 112.3 mm (SD 8.95). The male pelvis bonesets had smaller pelvis height measurements compared to the females. This difference was not significant (P=0.50). The differences in gender for the other measurements are summarized in table 1. Significant differences in measurements with respect to gender were observed with: Pubic length Distance, Outlet posterior Apex distance, Outlet M-L Distance, Outlet A-P, Mid plane posterior S4-S5 distance, Mid plane M-L Between ischial spines and the Bi-acetabular distance. For all the above the female pelvis bonesets were observed to have significantly larger measurements (p<0.01).

There were significant regression coefficients on univariate analysis were observed with the following measurements in respect to pelvis height: SAO, pubic length, Outlet posterior Apex distance, Outlet M-L Distance, Outlet A-P, Mid plane posterior S4-S5 distance, Mid plane M-L Between ischial spines, Mid plane A-P diameter, and the bi-acetabular distance (Table 2). On multivariate regression analysis, all the variables become non significant with the exception of the following four measurements. Pelvis height: reduced by 0.36mm for each degree increase the SAO; increased by 0.41mm for each mm increase in pubic length; increased by 0.21mm for each mm increase in total pelvis height and increased by 0.46mm for each mm increase in inlet medial-lateral diameter.

Table 1: Analysis of the measured pelvic parameters by gender

	Overall	**Segregated by gender (Mean (SD))**		**Mann-Whitney test**
Measurement	Mean (SD)	Female (10)	Male (20)	Z score (P value)
Sacral anterior Orientation (degrees)	51.49 (10.65)	49.27 (10.49)	52.6 (10.82)	1.06 (0.29)
Pubic length Distance (mm)	61.10 (9.10)	69.16 (8.17)	57.07 (6.58)	**-3.26 (<0.01)**
Ischial length Distance (mm)	72.58 (5.55)	73.34 (6.04)	72.20 (5.42)	-0.48 (0.63)
Pelvis height (mm)	112.32 (8,95)	115.73 (9.65)	110.61 (8.31)	-1.52 (0.13)
Total pelvis height (mm)	180.27 (11.81)	177.53 (13.64)	181.63 (10.91)	1.17 (0.24)
Outlet posterior Apex distance (mm)	76.56 (17.50)	84.45 (11.44)	72.62 (11.35)	**-2.64 (<0.01)**
Outlet M-L Distance (mm)	78.09 (17.50)	96.55 (15.37)	68.85 (9.29)	**-3.96 (<0.01)**
Outlet A-P (mm)	101.37 (13.38)	109.48 (10.52)	97.32 (13.00)	**-2.55 (<0.01)**
Midplane posterior S4-S5 distance (mm)	55.39 (11.46)	65.92 (8.41)	50.13 (8.92)	**-3.66 (<0.01)**
Midplane M-L Between ischial spines (mm)	83.14 (11.71)	94.92 (11.35)	77.25 (6.22)	**-3.39 (<0.01)**
Midplane A-P diameter (mm)	108.38 (12.91)	114.94 (9.52)	105.11 (13.32)	-1.87 (0.06)
Curved length of linea terminalis (mm)	28.72 (4.36)	27.81 (5.80)	29.18 (3.53)	1.10 (0.27)
Inlet M-L diameter (mm)	112.14 (5.78)	112.88 (6.39)	111.77 (5.59)	-3.08 (0.76)
Inlet A-P diameter (mm)	106.05 (9.64)	108.11 (9.19)	105.02 (9.91)	-0.92 (0.36)
Bi-acetabular distance (mm)	118.15 (7.59)	123.78 (6.80)	115.33 (6.40)	**- 2.90 (<0.01)**

Table 2: Summary of regression analysis for the various measurements with pelvis height

Measurement	**Regression coefficient (95% CI, P value)**	**Adj. Regression coefficient (95% CI, P value)**
Sacral anterior Orientation (degrees)	-0.30 (-0.59 to -0.003, **0.03)**	-0.36 (-0.60 to -0.13, **<0.01)**
Pubic length Distance (mm)	0.48 (0.17 to 0.79, **<0.01)**	0.41 (0.15 to 0.67, **<0.01)**
Ischial length Distance (mm)	0.36 (-0.20 to 0.92, 0.21)	-
Total pelvis height (mm)	0.12 (-0.14 to 0.39, 0.37)	0.21 (0.01 to 0.42, **0.04)**
Outlet posterior Apex distance (mm)	0.34 (0.12 to 0.57, **<0.03)**	**-**
Outlet M-L Distance (mm)	0.19 (0.02 to 0.36, **0.03)**	**-**
Outlet A-P (mm)	0.26 (0.04 to 0.48, **0.02)**	**-**
Midplane posterior S4-S5 distance (mm)	0.31 (0.06 to 0.57, **0.02)**	**-**
Midplane M-L Between ischial spines (mm)	0.31 (0.06 to 0.56, **0.02)**	**-**
Midplane A-P diameter (mm)	0.22 (-0.02 to 0.45, 0.07)	**-**
Curved length of linea terminalis (mm)	-0.16 (-0.89 to 0.58, 0.68)	-
Inlet M-L diameter (mm)	0.39 (-0.15 to 0.92, 0.15)	0.46 (0.06 to 0.87, **0.02)**
Inlet A-P diameter (mm)	0.07 (-0.26 to 0.40, 0.68)	-
Bi-acetabular distance (mm)	0.45 (0.05 to 0.83, **0.03)**	-

DISCUSSION

We set out to determine the associations between the various pelvis anthropometric measurements of obstetric importance with pelvis height of bones from the Ugandan population. We found that pelvis height significantly: reduces with SAO, while it increases with pubic length; total pelvis height and inlet medial-lateral diameter of the pelvis. According to Peleg et al. (2007) the SAO is also strongly correlated with pelvic incidence (Peleg et al., 2007). This implies that a decrease in the SAO would be accompanied by an increase in both pelvis incidence and pelvis height. This means that pelvis height increases proportionally with pelvis incidence as previously hypothesized from literature (Zivanovic, 1968).

Of the remaining three measurements: pubic length, total pelvis height and inlet medial-lateral diameter, the one of greatest interest in this study is pubic length. This is because while the growing points of all the other bones in the pelvis in both genders will fuse between the age of 16 and 18 years of age, the pubic bone of the human female pelvis keeps growing till the age of 28-30yrs leading to increased vertical and horizontal diameters of the birth canal (Rissech and Malgosa, 2007). This is especially important in our settings where the majority of the mothers give birth in their 2nd decade of life. This means that for subsequent deliveries in this 2nd decade in the life of a given mother will occur on a pelvis with changing dimensions till the age of 30 years. This may provide an additional explanations for the observed reduction in the SAO with increasing age (Peleg et al., 2007), reduction in length of labour with increasing parity (Zhang et al., 2010) and reduction of the duration of the second stage of labour with the use of the birthing stool (Gupta and Hofmeyr, 2004).

Since pelvis height is obtained using prominent easy to identify bony surface landmarks, it has the potential to support the development of a tool for pelvis assessment prior to childbirth in low resource settings. In these settings, the lack of universal access to expensive technologies like the ultrasound and the fact that most mothers attend antenatal care once makes the development of such tools a priority. A tool based on pelvis height will have to meet the following World Health Organization set of characteristics for an ideal diagnostic test for resource limited settings; Affordable, Sensitive, Specific, User friendly (simple to use), Rapid, Equipment free, and Delivered to those that need it (Mabey et al., 2004).

The study limitations were that the findings were based on a small sample size using bones of individuals who died more than 40 years ago. This small sample size may have also been the cause for the observed difference in gender which according to recent publications should not exist (Kurki, 2011). The use of multilevel regression techniques with additional computational simulations were used to address these two challenges with respect to the assumptions for regression analysis. Also changes in community nutrition have been observed to affect bone development and birth outcomes across generations (Dewey and Begum, 2011; Dewey and Mayers, 2011). There is thus a need for further confirmation of these measurements on an extant population to confirm the above observations before further attempts to evaluate the use pelvis height in the management of childbirth in low resource settings. Despite these identified shortcomings, the findings of this study provide baseline information to support initial generalizations regarding the use of pelvis height as a proxy measure for important obstetric measurements.

In conclusion pelvis height had significant associations with: total pelvis height and inlet medial-lateral diameter of the pelvis. Additional significant associations were observed with measurements related to the mid and outlet diameters of the birth canal. This study provides initial evidence to support further evaluation of pelvis height as a an additional tool for the assessment of the human birth canal.

Competing Interest

The authors declare no competing interest.

Acknowledgements

Mr. John Kukiriza and Mr. Kange, staff in the department of anatomy who assisted with the measurement of the bones and Ms Evelyn Bakengesa for editing the manuscript prior to submission. Mr. Mathew Mwenyi of Makerere University Medical Illustrations Department who did the art work. We also acknowledge the permission given from Elsevier to use figure 2 and Table 1 from Journal of human evolution, Volume 61: Kurki HK: Pelvic dimorphism in relation to body size and body size dimorphism in humans page: 635, (2011) http://dx.doi.org/10.1016/j.jhevol.2011.07.006 . This study was funded in part by the Carnegie Corporation of New York and Makerere University.

REFERENCES

1. Carle AC. 2009. Fitting multilevel models in complex survey data with design weights: Recommendations. BMC Med Res Methodol 9: 49.
2. Dewey KG. and K. Begum. 2011. Long-term consequences of stunting in early life. Matern Child Nutr 7 Suppl 3: 5-18.
3. Dewey, K. G. and D. R. Mayers. 2011. Early child growth: how do nutrition and infection interact? Matern Child Nutr 7 Suppl 3: 129-142.
4. Gupta, J. K. and G. J. Hofmeyr. 2004. Position for women during second stage of labour. Cochrane Database Syst Rev(1): CD002006.
5. Kurki, H. K. 2011. Pelvic dimorphism in relation to body size and body size dimorphism in humans. J Hum Evol 61(6): 631-643.

6. Kurki, H. K. 2013. Skeletal variability in the pelvis and limb skeleton of humans: does stabilizing selection limit female pelvic variation? Am J Hum Biol 25(6): 795-802.
7. Mabey, D., R. W. Peeling, A. Ustianowski and M. D. Perkins. 2004. Diagnostics for the developing world. Nat Rev Microbiol 2(3): 231-240.
8. Milne, N. 1990. Sexing of human hip bones. J Anat 172: 221-226.
9. Peleg, S., G. Dar, B. Medlej, N. Steinberg, Y. Masharawi, B. Latimer, L. Jellema, N. Peled, B. Arensburg and I. Hershkovitz. 2007. Orientation of the human sacrum: anthropological perspectives and methodological approaches. Am J Phys Anthropol 133(3): 967-977.
10. Pfeiffer, S., L. E. Doyle, H. K. Kurki, L. Harrington, J. K. Ginter and C. E. Merritt. 2014. Discernment of mortality risk associated with childbirth in archaeologically derived forager skeletons. International Journal of Paleopathology 7: 15-24.
11. Reed, M. P., M. A. Manary and L. W. Schneider. 1999. Methods for Measuring and Representing Automobile Occupant Posture. International Congress and Exposition, Detroit, Michigan, SAE Technical Paper Series. URl http://mreed.umtri.umich.edu/mreed/pubs/Reed_1999-01-0959.pdf [accessed March 2015]
12. Rissech, C. and A. Malgosa. 2007. Pubis growth study: applicability in sexual and age diagnostic. Forensic Sci Int 173(2-3): 137-145.
13. Schroeder, C. F., S. Z. Schmidtke and M. W. Bidez. 1997. Measuring the human pelvis: a comparison of direct and radiographic techniques using a modern United States--based sample. Am J Phys Anthropol 103(4): 471-479.
14. Tuck, S. M., L. D. Cardozo, J. W. Studd, D. M. Gibb and D. J. Cooper. 1983. Obstetric characteristics in different racial groups. Br J Obstet Gynaecol 90(10): 892-897.
15. Zhang, J., J. Troendle, R. Mikolajczyk, R. Sundaram, J. Beaver and W. Fraser. 2010. The natural history of the normal first stage of labor. Obstet Gynecol 115(4): 705-710.
16. Zivanovic S. 1968. The anthropological characteristics of the Ganda pelvis. East African Medical Journal 45(2).