HOMO - Journal of Comparative Human Biology 67 (2016) 273–293

Contents lists available at ScienceDirect

HOMO - Journal of Comparative Human Biology

journal homepage: www.elsevier.com/locate/jchb

Age related changes in pelvis size among adolescent and adult females with reference to parturition from Naraingarh, Haryana (India)

Krishan Sharma*, Puneet Gupta, Shailza Shandilya

Department of Anthropology, Panjab University, Chandigarh 160014, India

ARTICLE INFO

Article history:
Received 29 October 2014
Accepted 2 October 2015

ABSTRACT

This research examines the ontogenic patterns of changes in growth during adolescence, pelvis variations and growth during twenties and thirties of age, structural remodeling of pelvis related to childbirth and relationship of pelvis area with physique based on the cross-sectional data on 391 females from the state of Haryana. Peak growth velocity for body height and breadths of skeletal traits occurred between 11 and 12 years, much before mean age of menarche at 13.5 years; while for body weight and body mass index (BMI) occurred between 14 and 15 years, after the mean age of menarche. Untill the age 11 years, 11.87% of growth in stature was remaining, 19.37% for bi-cristal breadth, 25.96% for bi-ischial breadth and 35.82% for pelvic area. The hypothesis of critical value of pelvic width of 240 mm at *iliocristale* for menarche to occur has been only a statistical association. Higher prevalence of malnutrition during pubertal phase than pre- and post-pubertal phases was due to greater nutritional needs during puberty.

Among adult females, BMI was very poorly correlated with stature but very strongly correlated with body breadths, body breadth-stature indices and body weight. The body mass and pelvis size continued to change during 20s and first half of 30s. The continued increase of BMI was due to increase in body fat and muscle mass in females 18 years and older. To tease apart age and parturition effects on pelvis variations, the analysis showed that pelvic bones remodeling took place after the first child was born and not after

* Corresponding author. Tel.: +91 9417092610.
E-mail address: kdsharmalibra@yahoo.co.in (K. Sharma).

http://dx.doi.org/10.1016/j.jchb.2016.04.002

the subsequent births, and it was a sign of childbirth phenotypic plasticity rather than age. Pelvis area was strongly associated with stature, BMI and age. Mean pelvic area of tall females was greater than those of medium and short stature. Females with broad shoulders had significantly greater mean pelvis area than those with narrow shoulders and medium shoulders. Females having thin/lean physique had the smallest mean pelvis area compared to those having medium and obese types of physiques. The stepwise multiple regression analysis revealed that BMI was the major determinant factor (multiple $r = 0.37$) of pelvis area; addition of stature component increased the value of multiple r to 0.50, while addition of age marginally increased multiple r to 0.53.

Introduction

The investigations of human pelvis have been of immense interest to biological anthropologists because of peculiar evolutionary responses of a human pelvis to accommodate erect posture. This favored narrow pelvis that increases locomotor efficiency (Gruss and Schmitt, 2015; Rosenberg, 1992; Schultz, 1949). This change even preceded the origin of the genus *Homo* (DeSilva et al., 2013; Lovejoy, 2005). Other responses include meeting the competing demand of obstetrical requirements. In order to maintain adequate space for a safe delivery of a large skull sized fetus the female requires a wide sacrum tilted backward (Schultz, 1969; Washburn, 1960), a wider bi-acetabular diameter (Lovejoy, 1974) and more elongated pubic rami (Leutenegger, 1972) that reduce the risk of abductor labor. The action of these two antagonistic evolutionary selection pressures on Pleistocene hominins resulted in having the difficult childbirth process in humans due to a large-brained neonate despite having a birth-canal space constrained by bipedality. It was called a "scar of evolution" by Krogman (1951) and Washburn (1960) described it "obstetric dilemma", making midwifery obligatory to facilitate childbirth. This hypothesis has been subjected to tremendous scrutiny over the years (Berge, 1984; Brown, 2015; Plunkett et al., 2011; Rosenberg, 1992; Ruff, 1995; Sharma, 2012; Schultz, 1949; Trevathan, 2011; Weiner et al., 2008; Wells et al., 2012). Gruss and Schmitt (2015) have estimated that the narrow, anatomically modern pelvis, with a circular birth canal and further encephalized neonate, requiring fetal rotation during birth, with narrow body shape to enhance locomotion and to meet thermoregulatory demands, evolved about 200,000 years ago in Africa and the Middle East. So, the different functional requirements in males and females in relation to the intensity of obstetrical selection pressures have been often emphasized for the observed sexual dimorphism in pelvis (Brown, 2015). This sexual dimorphism resulted in decreased height and increased lateral breadth of pelvis in females. However, Warrener et al. (2015) has argued that pelvic width has no role in predicting hip abductor mechanics or locomotor costs in either men or women, and both are equally efficient at both walking and running even if they have wider pelves. She attributes birth complications, caused by a neonate too large to fit through the birth canal, to other factors affecting pelvic and fetal size.

Significant ethnic differences in pelvis morphology have been reported (Handa et al., 2008; Hoyte et al., 2005; Patriquin et al., 2002). For example, women of European ancestry were found to have statistically significantly wider pelvic inlet and outlet than African-American women ($p < 0.001$), while there were no significant ethnic differences for some other traits such as interspinous diameter, angle of the subpubic arch, anteroposterior conjugate, levator thickness and levator hiatus (Holland et al., 1982). These differences may be due to adaptive responses to various factors. For example, the thermoregulatory adaptations to different climates are known to shape the pelvis of extinct hominins and modern humans (Holliday and Hilton, 2010; Ruff, 1994). The biogeographic patterns of variations in body size and proportions between geographically widely spread human populations are referred to as Allen's and Bergmann's rules. Populations living in colder climates have relatively wider