Journal of Clinical Densitometry: Assessment of Skeletal Health, vol. 12, no. 2, 219−223, 2009

1094-6950/09/12:219−223/$36.00
DOI: 10.1016/j.jocd.2009.01.001

Original Article

Postpartum Bone Status in Teenage Mothers Assessed Using Peripheral Quantitative Computed Tomography

Kate A. Ward,[*,1] *Judith E. Adams,*[1] *Stephen A. Roberts,*[2] *Zulf Mughal,*[4] *and Mourad W. Seif*[3]

[1]*Clinical Radiology, Imaging Sciences Research Group, University of Manchester, Oxford Road, Manchester M13 9PT, UK;* [2]*Health Methodology Research Group, University of Manchester, Oxford Road, Manchester M13 9PT, UK;* [3]*Obstetrics and Gynaecology and Reproductive Health, University of Manchester, St Mary's Hospital, Hathersage Road, Manchester, M13, 0JH UK; and* [4]*Paediatric Medicine, Central Manchester & Manchester Children's Hospitals NHS Trust, Hathersage Road, Manchester M13 0JH, UK*

Abstract

Teenage pregnancy occurs during a time when the maternal skeleton may still be accruing mineral. We hypothesized that teenage mothers would have reduced amounts of bone mineral and altered bone geometry compared with controls. This cross-sectional, observational compared teenage mothers (n = 18) to age- and ethnicity−matched controls (n = 52). The main outcomes were peripheral quantitative computed tomography and dual-energy X-ray absorptiometry to measure bone geometry, bone mineral density (BMD) at radius, lumbar spine and hip, and whole body bone mineral content (WBBMC). In teenage mothers, cortical BMD was reduced at the radial diaphysis (mean difference: −1.3%; $p = 0.03$). Size-adjusted WBBMC was reduced (mean difference: −4.0%; $p = 0.004$) and was lower for a given amount of lean mass (mean difference: −5.8%; $p = 0.02$). No other significant differences between groups were found. The recruitment and retention of participants to this study were extremely difficult and disappointing. Teenage mothers had lower BMD at cortical sites compared with age−matched controls. These data suggest that pregnancy might have a detrimental effect on teenage mothers' future skeletal health. The results of this study require confirmation and provide pilot data for further investigations.

Key Words: Bone mineral density (BMD); dual energy X-ray absorptiometry (DXA); peripheral quantitative computed tomography (pQCT); recruitment; teenage pregnancy.

Introduction

The UK has the highest teenage pregnancy rates in Europe (30 births per 1000 individuals), second only to USA (52 births per 1000 individuals) in the developed world *(1)*. A reduction in teenage pregnancy remains a UK government priority *(2)*.

Adolescence is a crucial period for skeletal development, at the end of which peak bone mass is attained *(3)*. Within the 2 yr pre- and post-menarche females accrue approx 30−40% of their total adult bone mineral content (BMC) *(4−6)*. On the onset of puberty in girls additional mineral is laid down on the endosteal surfaces of the long bones, the function of which is thought to be a ''store'' for increased calcium demand during pregnancy and lactation *(7)*. At birth the newborn skeleton contains on average 30 g calcium and most of this calcium is accrued during the 3rd trimester of pregnancy. Calcium is supplied to the fetus by increasing calcium absorption, mobilization of skeletal calcium stores and reduction in renal calcium excretion in the mother *(8)*.Therefore, given that puberty is a critical period for mineral accrual, and that this continues, albeit to a lesser extent, until adulthood it is likely that teenage mothers will still be accruing calcium into their own skeletons, whilst ensuring adequate calcium provision to the fetus. Also, the accrual of muscle

Received 07/21/08; Revised 01/09/09; Accepted 01/09/09.
*Address correspondence to: Kate A. Ward, PhD, Nutrition and Bone Health Research Group, MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge CB1 9NL, UK. E-mail: Kate.Ward@mrc-hnr.cam.ac.uk

mass precedes bone mass accrual, and therefore any loss of bone or early cessation of bone accrual is likely to negatively impact on the muscle bone relationship *(9)*. Given that peak bone mass is a determinant of future fracture risk the impact of teenage pregnancy on maternal skeletal development requires investigation.

To date studies on the effects of teenage pregnancy on maternal bone status have yielded inconclusive results *(10–15)*. Whilst some show no differences between teenage mothers and nulliparous controls *(13,14,16)*, others show reduced areal bone mineral density (BMDa *(17)*) or quantitative ultrasound parameters *(11,12)*. Most of the studies have used dual-energy X-ray absorptiometry (DXA) as their main outcome measure, which only provides integral BMDa, BMC, and projection bone area. A bone's strength is determined by its shape, size, and the distribution of mineral within it. As there is a working hypothesis that the additional mineral that females lay down on their medullary surface is for the demands of pregnancy and lactation, an outcome that can measure medullary area might provide further insight of how pregnancy affects the skeleton *(18–20)*. There have been no studies using peripheral quantitative computed tomography (pQCT) to study volumetric BMD *(17)* of the separate cortical and trabecular compartments, bone geometry, and strength in teenage mothers. As there were only limited pre-existing data on these endpoints and as any trial was likely to be difficult to conduct, a large-scale study was not feasible without preliminary data to power the study and to show that recruitment and retention of participants was practical. We therefore designed and implemented a proof of concept study to gain preliminary estimates of the effect sizes, study recruitment techniques, and determine the feasibility of conducting a definitive study. The main aim of the present study was to assess the effects of teenage pregnancy on bone geometry and BMD at the distal and diaphyseal radius. We also studied changes in spine, hip, and whole body using DXA. The hypotheses were that teenage mothers would have increased medullary area and thinner cortices, lower BMC, and BMD, and less BMC for their muscle mass in comparison to age-matched nulliparous controls.

Methods

Participants

Participants were recruited from specialist teenage pregnancy services—Central Manchester and Manchester Children's University Hospitals and Salford Hospitals NHS Trusts, Manchester, UK. Inclusion criteria were aged 13 to 19 yrs at booking, White-Caucasian, primiparous, ability to give informed consent (as determined by consultant obstetrician/teenage pregnancy midwife). Exclusion criteria were any personal or family history of inherited bone conditions, or use of medication that may affect bone status. An age–matched population of control subjects (n = 52) were drawn from the extended Manchester local reference database *(21,22)*. Recruitment for the study was done through advertisement in educational institutions and general practitioner (GP) surgeries within the Greater Manchester region. Detailed recruitment and relevant inclusion and exclusion criteria for the population have been described *(21)*.

Participants were recruited in the antenatal clinic at 20 wk or greater, gestation. The study received approval from relevant Local Research Ethics Committees and was carried out in accordance with the Declaration of Helsinki.

Sample Size

There were no pre-existing data using our primary endpoints, therefore a target sample size was chosen on the basis of BMDa. Lloyd et al *(12)* found a 10% decrease in the postpartum BMDa of the total hip in teenage mothers compared with controls. The mean BMDa (±SD) of the lumbar spine and total hip in healthy girls aged 16 years and over in our normative database were 0.94 mg/cm^2 (±0.09) and 0.92 mg/cm^2 (±0.09), respectively. Based on a conservative estimate of 5% difference between the 2 groups (5% of 0.93), a standard deviation (SD) of 0.09, 80% power, and a 2-sided significance level of 5%, the target sample size was 70 subjects in each group.

Anthropometric Measurements and Lifestyle Questionnaire

Anthropometric data were gathered at the time of the bone densitometry appointment. A more detailed methodology was reported previously *(23)*. Weight (Autoweigh Scales Ltd, UK), standing and sitting height (Leicester Height Metre, Child Growth Foundation, UK) were measured and body mass index (BMI) calculated. We also collected data on, age at menarche, contraceptive use, smoking and alcohol consumption.

Bone Densitometry

pQCT measurements of the nondominant radius were made using an XCT-2000 scanner (Stratec, Pforzheim, Germany). Total and trabecular BMD (mg/mm^3) and bone cross-sectional area (mm^2) were determined at the distal radius (4% site). At the midshaft (50%) radius, total and medullary areas (mm^2), cortical thickness, cortical vBMD (mg/mm^3), stress-strain index (mm^3), an in vivo measure of bone strength *(7,24)*, and muscle cross-sectional area (mm^2) were measured.

A Hologic QDR-4500A (Hologic, Waltham, MA) DXA scanner (software version 12.1) was used to measure lumbar spine (L1–L4), bone mineral apparent density (BMAD) (a size-adjusted BMD *(25)*, g/cm^3), femoral neck BMAD *(26)*; g/cm^3, and whole body bone mineral content (WBBMC; g (adjusted for whole body bone area [cm^2]), lean [g], and fat mass [g].

For DXA and pQCT detailed methodologies are given in previous articles *(21,23)*.