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# Shorter mothers have shorter pregnancies

José G B Derraik<sup>1,\*</sup>, Tim Savage<sup>1,2</sup>, Paul L Hofman<sup>1,2</sup>, Wayne S Cutfield<sup>1,2</sup>

<sup>1</sup>Liggins Institute, University of Auckland, Auckland, New Zealand

<sup>2</sup>Gravida: National Centre for Growth and Development, Auckland, New Zealand

\* Correspondence to: Dr José Derraik, Liggins Institute, University of Auckland, Private Bag 92019, Auckland, New Zealand; Phone: +64.9.923.3794; E-mail: j.derraik@auckland.ac.nz

The factors determining gestational length in humans have not been adequately described. In the case of preterm births, maternal nutrition in the periconceptional period has been described as a possible causative factor. Recently, maternal stature has been also been linked to preterm birth, with a number of studies showing that shorter women are at a greater risk of delivering preterm babies (Han et al., 2012, Myklesstad et al., 2013).

However, no studies seem to have examined whether maternal height also affects length of gestation among children born at term, which extends across a range from 37 0/7 to 41 6/7 weeks of gestation. In light of the above findings, we aimed to assess for the first time whether maternal height is associated with gestational age in a cohort of children born at term.

## METHODS

We assessed 157 boys and 137 girls who were the control cohort recruited for a study examining the impact of conception with ovarian stimulation drugs on growth and metabolism in childhood (Savage et al., 2012). All children were of New Zealand European ethnicity, relatively high socioeconomic status, naturally conceived, from singleton pregnancies, and born at term (37 0/7 to 41 6/7 weeks of gestation). Exclusion criteria were being born small-for-gestational-age (birth weight <-2 standard deviation scores (SDS)), or born to mothers with gestational diabetes, chronic illness, or maternal drug use (including tobacco) during pregnancy.

Gestational age was determined by ultrasound scans performed <20 weeks of gestation. Maternal and paternal heights were measured using a Harpenden stadiometer to the nearest

mm. Birth weight data were transformed into standard deviation scores (SDS) (Niklasson et al., 1991).

Associations with maternal height were assessed using linear regression mixed models in SAS v.9.3 (SAS Institute, Cary, NC, USA), which included family identification number as a random factor. Models also accounted for infant's gender, birth order, maternal age, and paternal height. Stratified analyses were carried out subdividing the study cohort into three groups: shorter (<165 cm), average (165–170 cm), and tall (>170 cm) women. Pregnancy length was compared using multivariate models, and the proportion of children born early term (37 0/7 – 38 6/7 weeks of gestation) were compared using Fisher's exact tests. Demographic data are provided as means  $\pm$  SD; other data are means and 95% confidence intervals adjusted for confounders in multivariate models.

The Northern Y Regional Ethics Committee provided ethics approval. Written informed consent was obtained from parents/guardians, and verbal or written consent from each child.

## RESULTS

We studied 294 children (53.4% boys) born of 213 mothers and 213 fathers (as all siblings were born to the same mother and father). Mean maternal height was 167.3  $\pm$  6.1 cm (range 151.4–183.0 cm), slightly higher than the estimated average height of New Zealand women at 165 cm. Increasing maternal height was associated with longer pregnancy duration ( $\beta=0.036$ ;  $p=0.002$ ). There was also a progressive increase in birth weight SDS with increasing maternal height ( $\beta=0.045$ ;  $p<0.0001$ ).

Stratified analyses showed that the main effect on pregnancy length appears to occur among shorter mothers (<165 cm tall), whose pregnancies were ~0.6 and ~0.7 weeks shorter than pregnancies of mothers 165–170 cm ( $p=0.0009$ ) and >170 cm ( $p=0.0002$ ) tall, respectively (Figure 1A). Further, 34% of children of shorter mothers were born early term compared to 19% of average height ( $p=0.021$ ) and 12% of taller ( $p=0.0003$ ) mothers (Figure 1B).

Paternal height was not associated with the gestational age ( $p=0.67$ ) or birth weight SDS ( $p=0.68$ ) of the offspring.

## DISCUSSION

This study shows that maternal height is positively associated with pregnancy length across the term 5-week window. As previously discussed, a number of studies have shown an association between shorter maternal stature and preterm birth (Han et al., 2012, Mykkestad et al., 2013). Our findings have extended these observations, showing that maternal short stature is associated with shorter gestational length within term pregnancies, so that shorter mothers are more likely to deliver early term babies.

The breakdown of term pregnancies into early term (37 0/7 – 38 6/7 weeks of gestation), full term (39 0/7 – 40 6/7 weeks), and late term (41 0/7 – 41 6/7 weeks) has been recently proposed (American College of Obstetrics and Gynecology, 2013). Studies have shown that early term infants have greater mortality and morbidity in the neonatal period and early infancy than those born full term (Zhang & Kramer, 2009, Reddy et al., 2011). There is also evidence from large studies that neurocognitive outcomes in childhood and adulthood are worse in those born early term (MacKay et al., 2010, Yang et al., 2010a, Yang et al., 2010b). As a result, maternal stature is likely to be a contributing factor influencing long-term outcomes in the offspring via its effect on pregnancy length.

The mechanisms underpinning the association of maternal stature and pregnancy length are still unclear. Ozaltin et al. proposed that mechanisms involved may be socioeconomic

factors, undernutrition *in utero*, and maternal anatomical constraints (Ozaltin et al., 2010). In our study, socioeconomic factors were not at play in light of the homogeneity of our cohort, and their relatively high socio-economic status also means that undernutrition *in utero* is most unlikely to have been a factor.

Anatomical constraints are more likely to explain the observed differences in pregnancy length. This hypothesis is supported by the strong positive association between offspring birth weight SDS and maternal height (but not paternal height). Further, the anatomical explanation is also supported by the lack of a paternal height effect on pregnancy length, as previously observed in another study (Mykkestad et al., 2013). However, further studies are necessary before the mechanisms underpinning the effects of maternal stature on pregnancy length can be elucidated.

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**Figure 1.** A) Gestational age among term children born to mothers whose heights were <165 (n=88), 165–170 (n=105), and >170 (n=101) cm. Data are means and 95% confidence intervals adjusted for confounding factors in the multivariate models. B) Percentage of children born early term (37 0/7 to 38 6/7 weeks of gestation) according to maternal height groups. \*p<0.05 and \*\*\*p<0.001 vs the shortest group.

