ORIGINAL ARTICLE

The Association of Early Life Factors with Body Composition in Peripubertal Jamaican Children

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ABSTRACT

Objective: *To explore the relationships among early life factors (*ie *maternal weight, height and body mass index, child's birthweight, birth length and ponderal index) and body composition in peripubertal Jamaican children.*

Methods: *One hundred and seventy-six healthy Jamaican children, 9–12 years of age were recruited from a longitudinal cohort. Their birth anthropometric and maternal anthropometric data during pregnancy were available for analysis. Measurements of anthropometry and body composition using bioelectrical impedance analysis were made. Pubertal stage was also recorded. Multiple linear regression analyses were performed.*

Results: *Adjusting for age and gender of the children, maternal weight and birthweight were positively associated with child's weight, height, body mass index (BMI) and lean body mass (LBM); maternal height was positively associated with child's height and LBM; and maternal BMI was positively associated with BMI and LBM of the child. Also, birth length was positively related to child's height. When child's current height was further added to the models, child's LBM was no longer associated with weight and height of mothers and birthweight but was related to child's current height (*$p = 0.00$*). Adjustment for pubertal stage in all models did not significantly change these associations.*

Conclusion: *In this Afro-Caribbean cohort, we found that higher maternal weight, height and birthweight are associated with greater height and LBM in the peripubertal period.*

Keywords: Birth length, birthweight, body composition, children, Jamaica, maternal size

Asociación de los Factores de los Primeros Años de Vida con la Composición Corporal de los Niños Jamaicanos Peripúberes

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RESUMEN

Objetivo: *Explorar las relaciones entre los factores de los primeros años de vida (ie el índice de masa corporal materno (IMC) y la altura, el peso al nacer del niño, su longitud al nacer y el índice ponderal) y la composición corporal en niños jamaicanos peripúberes.*

Métodos: *Ciento setenta y seis niños jamaicanos sanos, de 9 a 12 años de edad fueron reclutados de una cohorte longitudinal.*

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Sus datos antropométricos de nacimiento y los datos antropométricos maternos durante el embarazo estaban disponibles para el análisis. Las mediciones de la antropometría y la composición corporal se realizaron usando el análisis de impedancia bioeléctrica. El período de pubertad fue también registrado. Se hicieron análisis de regresión lineal múltiple.
Resultados: *El ajuste por edad y el género de los niños, el peso materno y el peso al nacer estuvieron positivamente asociados con el peso del niño, la altura, IMC, y la MCM; la altura materna estuvo positivamente asociada con la altura y la MCM del niño; y el IMC materno estuvo positivamente asociado con el IMC y la MCM. Asimismo, la longitud al nacer estuvo relacionada positivamente con la altura del niño. Cuando la altura actual del niño se añadió a los modelos, la MCM del niño no se relacionó ya con el peso y la estatura de las madres y el peso al nacer, sino con la altura actual del niño (p = 0.00). El ajuste por etapa puberal en todos los modelos no cambió significativamente estas asociaciones.*
Conclusión: *En esta cohorte afrocaribeña, encontramos que un mayor peso materno, altura, y peso al nacer se asocian con mayor altura y MCM en el período peripuberal.*

Palabras clave: Longitud al nacer, peso al nacer, composición corporal, niños, Jamaica, tamaño materno

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INTRODUCTION

The increasing prevalence of overweight and obesity is currently a worldwide problem (1). At least 41 million children younger than five years are overweight or obese. Most of them reside in low-income and middle-income countries [LMIC] (2). The prevalence of obesity in the under-five age group in LMIC has increased by 54% since 1990 (3, 4). Jamaica is a middle-income country in which overweight and obesity in children are also increasing at an alarming rate. This is reflected in data from 6–10-year-old rural schoolchildren in Jamaica where only 1% was moderately overweight and 4% mildly overweight in the 1990s, but less than 20 years later 11% of similarly aged children were overweight and 7% obese (5, 6).

This increase in prevalence of obesity is of great concern because of associated adverse consequences such as hypertension, coronary heart disease, ischaemic stroke, Type 2 diabetes mellitus and certain types of cancers (7). Obese children and adolescents are more likely to be obese adults (8, 9) and therefore, be at more risk for adverse health consequences in later life (10). Obesity also results in impaired social functioning, reduced productivity and increased economic burden on the healthcare system (11).

Although behavioural and environmental factors (sedentary lifestyle and excess energy intake) are important factors responsible for the increase in obesity seen over the past two decades, early life factors have emerged as important contributing factors (12). Adverse *in utero* conditions resulting from maternal over- or under-nutrition may lead to permanent alterations in physiological systems of the developing fetus (13–15) with a lifelong propensity to developing obesity. Birthweight is the most commonly used indicator of prenatal exposures and body mass index (BMI) for assessment of adiposity. Most studies have demonstrated that higher birthweight is associated with higher BMI in children and adults in a variety of ethnic groups and is linear in some and U-shaped or J-shaped in others (16). Body mass index correlates strongly with both lean body mass (LBM) and fat mass [FM] (17) and as such it is unclear whether it is LBM or FM that is programmed by adverse *in utero* conditions. Some studies show a positive association between birthweight and LBM in later life (18–20) whereas studies relating birthweight to FM are less consistent (20–22). In a larger group of children from this Vulnerable Windows Cohort, maternal size in the first trimester was shown to be positively correlated with waist circumference (an indirect measure of fat mass) at mean age 11.5 years (23).

To our knowledge, the relationship between early life factors and markers of body composition in Afro-Caribbean children has not been clearly explored. We hypothesized that inadequate maternal nutritional state (as evidenced by maternal anthropometry) and lower birth size are related to higher body fat in peripubertal children. This study therefore, aims to explore the relationships among early life factors (*ie* maternal weight, height and BMI, child's birthweight, birth length and ponderal index) and body composition in peripubertal Jamaican children.

SUBJECTS AND METHODS

Participants

Participants were recruited from a birth cohort [Vulnerable Windows Cohort] (24) at the peripubertal stage. This is a cohort of 569 Afro-Jamaican mothers and their offspring. Mothers were recruited from the first trimester. They were recruited from the antenatal clinic at the University Hospital of the West Indies. Women with systemic illnesses (*eg* pre-eclampsia, diabetes and sickle cell anaemia) were excluded. This cohort serves to examine the effects of pre-natal factors on the development of chronic non-communicable diseases. We serially recruited 176 healthy children, aged between nine and 12 years from the cohort.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by The University of the West Indies Ethics Committee, Mona, Jamaica. Written informed consent was obtained from a parent or guardian of each child enrolled.

Study Design

Upon arrival at the metabolic ward of the Tropical Metabolism Research Unit, measurements of anthropometry and body composition were made. Pubertal stage was also recorded. At the end of the measurements, the children were given a light meal.

Measurements

Birth records of these children were available for analysis. Data abstracted included their mother's weight, height and BMI at their first antenatal visit, as well as the child's weight and length at birth. Birthweight and crown heel length were measured within 24 hours of delivery. Ponderal index (PI) was calculated as: PI = birthweight (kg)/ birth length $(m)^3$.

Anthropometric measurements were obtained with the children dressed in light clothing with shoes and socks removed using a standardized protocol (24). The children were weighed using an electronic scale (Tanita Solar Powered Scale, Model 1632) to the nearest 100 g and standing height was measured using a Harpenden Portable Stadiometer to the nearest millimeter. The scale was calibrated each morning with a known weight and the stadiometer checked against a calibrated reading.

Body composition was estimated using bioelectrical impedance analysis (BIA). For BIA measurements, subjects were barefooted, wore light clothing and in the supine position. Measurements were made with the subject's feet shoulder-width-apart and their arms at a 45-degree angle to their bodies. Electrodes were placed on the dorsum of the right hand and foot (tetrapolar placement). Before all measurements, the analysers were calibrated using a 500-ohm resistor. Using a single frequency (50 kHz) battery-operated bio-impedance analyser (model Quantum X; RJL Systems, Clinton Township, MI, USA) a low-voltage, painless, alternating current was applied to the body. Resistance and reactance were determined on the right-side of the body. Two measurements were taken and the mean was used in the analysis of body composition. Resistance values obtained from our subjects were used to determine total body water (TBW) using validated equations given by Luke *et al* for children of similar age and ethnicity (25, 26).

The pubertal stages of pubic hair and breast development were recorded according to the method of Marshall and Tanner (27, 28). Testicular volume was measured with a Prader orchidometer.

Statistical Methods

All statistical analyses were performed with SPSS (Statistical Package for the Social Sciences, version 19, Chicago, Illinois) for Windows. We obtained means and standard deviations for participant characteristics and anthropometric and body composition variables.

Multiple linear regression analyses were used to determine the relationships between (1) maternal anthropometry at first antenatal visit and the child's body composition and (2) birth anthropometry and body composition in the children. Analyses were adjusted for children's age, gender, height and pubertal stage. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Similar proportions of boys and girls were present in the subset of the cohort studied compared to those not studied. However, those studied were 100 g heavier than those not studied (3.2 kg in those studied, 3.1 kg in those not studied, $p = 0.02$). Characteristics of the 176 mothers obtained at the first antenatal visit and also newborn anthropometry of the 176 subjects are shown in Table 1.

Also displayed are current anthropometric and body composition measurements of these 176 subjects. There were no significant differences in measurements between mothers of boys and girls. Boys were heavier and longer at birth. There were no significant gender differences in weight, height, BMI and LBM. Girls had higher fat mass and per cent fat mass.

Table: 1. Maternal and newborn anthropometric measurements and current anthropometric and body composition measurements for 176 Jamaican children

	Boys (n = 84)		Girls (n = 92)		
	Mean	SD	Mean	SD	*p*-value
Maternal measurements at first antenatal visit					
Weight (kg)	66.7	11.7	63.9	13.2	ns
Height (cm)	164.0	6.2	162.6	5.2	ns
Body mass index (kg/m^2)	24.8	4.3	24.2	5.0	ns
Birth measurements					
Weight (kg)	3.3	0.49	3.1	0.5	0.0
Length (cm)	50.6	2.53	49.1	2.9	0.0
Ponderal index (kg/m^3)	25.2	3.0	26.0	3.1	ns
Anthropometry and body composition measurements at mean age 11 years					
Age (years)	10.7	0.9	10.6	0.9	ns
Weight (kg)	40.1	10.7	42.1	12.0	ns
Height (cm)	146.2	7.65	147.6	8.1	ns
Body mass index (kg/m^2)	18.5	3.6	19.1	4.5	ns
Lean body mass (kg)	29.8	5.9	28.6	6.5	ns
Fat mass (kg)	10.3	5.4	13.5	6.1	0.0
Per cent fat mass (%)	24.5	6.2	30.8	5.7	0.0

p-value (Student's *t*-test) represents the difference between males and females; ns = not significant

The association between children's anthropometry or body composition at age 11 years and maternal anthropometry at the first antenatal visit, adjusting for age and gender of the children are given in Table 2. Maternal weight was positively associated with child's weight, height, BMI and LBM. Maternal height was positively associated with child's height and LBM. Maternal BMI was positively associated with child's BMI and LBM. When child's current height was further added to these three models, child's lean mass was no longer significantly related to mother's weight and height, but was related to child's current height ($p = 0.00$).

Table 2 also shows the relationship between the child's birth anthropometry and anthropometry and body composition at age 11 years, adjusting for age and gender of the child. Birth length was positively related to height at age 11 years. Birthweight was positively associated with weight, height, BMI and LBM at age 11 years. When child's current height was added to the latter model, lean mass was no longer significantly related to birthweight, but was related to child's current height ($p = 0.00$). Adjustment for pubertal stage in all models did not significantly change these associations (data not shown).

DISCUSSION

In this study, we found that mothers who were heavier in their first trimester and offspring with higher birthweight had higher weight, height, BMI and LBM at age 11 years. Contrary to our hypothesis, our data support the relationship of lean mass rather than fat mass with early life factors. The results suggest that maternal anthropometry and birthweight programs lean mass and height in the children.

It is known that maternal nutritional status as evidenced by weight, height, weight gain, BMI and dietary intake (29, 30) is a major determinant of newborn size. Maternal size also has implications for childhood size, acting through their birth size. These observations are supported by our findings showing that both maternal weight in the first trimester and child's birthweight were positively related to child's weight, height, size and LBM at age 11 years. The mean BMI of the mothers

Table 2: Multiple linear regression analyses showing predictors of anthropometry and body composition at mean age 11 years after adjusting for age and gender of the children

	Children at age 11 years											
	Weight		Height		Body mass index		Lean body mass		Fat mass		Per cent fat mass	
	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*
Maternal anthropometry at first antenatal visit												
Weight (kg)	0.18	0.01	0.16	0.01	0.15	0.05	0.20	0.004	0.14	0.06	0.05	0.49
Height (cm)	0.12	0.09	0.31	<0.001	-002	0.98	0.17	0.02	0.06	0.40	-0.05	0.48
BMI (kg/m^2)	0.14	0.06	0.04	0.49	0.15	0.05	0.14	0.04	0.12	0.11	0.07	0.34
Children's birth size												
Birthweight (kg)	0.17	0.02	0.14	0.02	0.15	0.05	0.18	0.01	0.14	0.07	0.09	0.22
Birth length (cm)	0.09	0.22	0.14	0.03	0.06	0.45	0.10	0.17	0.07	0.34	0.07	0.30
Ponderal index (kg/m^3)	-0.07	0.32	-0.08	0.19	-0.06	0.41	-0.07	0.32	-0.07	0.36	-0.09	0.18

Notes

Each row and column correspond to a separate regression analysis; β = standardized regression coefficient; *p* = *p*-value

(Table 1) implies that they were adequately nourished. Well-nourished mothers are not expected to impose a nutritional constraint on the fetus. However, programming as reflected by the influence of birthweight on health in later life (31–33) has been observed within the range of normal birthweight.

Based on a previous report of the children (n = 296) in the same cohort as the present study showing that maternal size in the first trimester is positively correlated with waist circumference at mean age 11.5 years (23), we expected a similar association between maternal size in the first trimester and fat mass of the children. This was not supported by our data, possibly because waist circumference, like BMI is widely used as an index of adiposity but neither is a reliable indicator of the proportion of FM and LBM. Similar to other studies (34–36) we also showed a positive association between birthweight and child's BMI, but higher birthweight was related to greater lean mass at follow-up. Our results are consistent with many other studies in which direct measurements of body composition were made showing that higher birthweight was related to greater lean mass. In one of these studies, LBM was estimated by bioimpedance in nine-year-old Brazilian boys (22) and in another, LBM was determined using dual-energy X-ray absorptiometry (DXA) in nine to ten-year-old English boys and girls (18). Singhal *et al* also demonstrated in a group of seven-year-old children from the United Kingdom using DEXA that birthweight was positively associated with LBM and not fat mass (20). These findings are supported by evidence suggesting that there is early life programming of protein deposition (37) which is essential for lean tissue deposition. However, it is possible for a limitation in lean tissue synthesis to lead to more partitioning of nutrients to fat synthesis when there is long-term suboptimal nutrition and also, with exposure to an obesogenic environment. In such conditions, it may be possible to observe a consequential secondary significant effect of early life nutritional factors on fat mass. Furthermore, this might explain the different findings of early life factors predicting fat mass in children as reflected in different associations between birthweight and BMI [linear in some and U-shaped or J-shaped] (16).

Birthweight and length reflect the effects of *in utero* conditions. Birth length was associated with child's height. This finding plus the results showing that when child's height was added to the regression models, LBM was no longer associated with mothers weight, height, or child's birthweight, but was significantly related to child's length suggest that the association of birthweight with lean mass was mediated by height of the child. It seems that higher birthweight and length programmes taller children with a greater proportion of lean mass. This may explain in part the documented associations that infants with higher birthweights and lengths have a lower-risk of developing chronic diseases in later life (18) and lower birthweight infants are at greater-risk for obesity as adults (38). Using BIA to estimate body composition prevents us from determining the relative contributions of bone *versus* muscle to the observed associations. Also, in the two studies mentioned above in which DXA was used to determine body composition, only a two-compartment model was described. It is possible that birthweight influences both soft lean tissue and bone mass in later life.

A limitation may be that we did not control for current socio-economic status, which is a possible confounder. Our sample size was also modest. This study has significant strengths. We utilized standardized measurements for birth anthropometry in a birth cohort followed longitudinally. It is the first study in Afro-Caribbean children exploring the effect of early life factors on body composition. Based on our findings, we need to promote optimal maternal nutritional status to produce normal birthweight infants in order to promote adequate lean tissue synthesis and reduce adiposity in later life and a subsequent lower-risk of non-communicable diseases.

CONCLUSION

In this Afro-Caribbean cohort, we found that higher maternal weight, height and birthweight are associated with greater height and LBM in the peripubertal period. This implies that these early life factors programe body composition during growth primarily through influencing lean tissue deposition.

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Author contributions

CR Taylor-Bryan oversaw data collection, participated in interpretation of data, wrote manuscript and approved final version. AV Badaloo participated in study design, oversaw data collection, participated in interpretation of data, revision of manuscript and approved final version. MS Boyne participated in interpretation of data, revision of manuscript and approved final version. C Osmond participated in data analysis, interpretation of data and approved final version. TE Forrester conceived paper, participated in study design, provided oversight to study, participated in interpretation of data, revision of manuscript and approved final version. The authors declare that they have no conflict of interest.

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