Title:

Current socio-economic measures, and not those measured during infancy, affects bone mass in poor urban South African children

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None

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Mini-Abstract

Understanding the impact of poverty on bone development in children is important, especially in developing countries where inequalities persist. This study indicates that higher socio-economic status results in greater bone area and mineral content in Black South African children. Poverty alleviation policies may significantly improve growth and bone development.

Abstract:

Introduction: Understanding the impact of socio-economic status (SES) on physical development in children is important, especially in developing countries where considerable inequalities persist. This is the first study to examine the association between SES on bone development at the whole body, femoral neck, and lumbar spine, in Black children living in Soweto and Johannesburg, South Africa. *Methods:* Linear regression models were used to investigate associations between SES during infancy, and current SES, anthropometric and DXA-derived bone mass in 9/10 year old children (n=309). *Results:* Findings suggest that current SES measures, rather than SES during infancy, are stronger predictors of current whole body bone area (BA) and whole body bone mineral content (BMC) after adjusting for body size and composition. SES had no significant effect on either hip or spine bone mass. Caregiver's marital/cohabiting status (indicator of social support) and whether or not there was a television in the home (indicator of greater income) at age 9/10 years were the most important socio-economic determinants of whole body BA and BMC. *Conclusion:* SES has a significant independent effect on whole body BMC through its impact on BA. This suggests that poverty alleviation policies in South Africa could have a positive effect on bone health.

Keywords:

Bone mass, children, poverty, socio-economic status, South Africa

Introduction

According to the United Nations (2007), sub-Saharan Africa is not on track to reach the Millennium Development Goals target of halving the people in poverty by 2015 [1]. There is a critical need for health inequality research to unpack the potential that social and economic interventions may have on health and development in African children. It has been established that adverse childhood socio-economic conditions are associated with poor physical and cognitive development in children [2], higher adult mortality [3; 4], and increased risk of obesity and cardiovascular disease [5; 6]. Socio-economic status (SES) impacts child development through its association with nutrition, sanitation and hygiene, infection risk, maternal education, maternal stress and depression, physical activity, and stimulation in the home [7; 8]. In addition to SES affecting physical growth and body composition, it may also impact bone development. A UK cohort study demonstrated that higher SES at birth was indirectly associated with increased whole body bone mass in late childhood as a consequence of improved growth [9].

Under *Apartheid* legislation, the South African government fostered income inequalities in the country by denying large sections of the Black population access to land ownership and services [10]. In 1990, still under *Apartheid* conditions 3273 Black, White, Asian and Mixed Ancestral Origin infants born in Johannesburg-Soweto and their mothers were enrolled as part of a birth cohort study called Birth to Twenty (Bt20). This group of children represents a cohort born into an adverse social and political time in South Africa's history, but who would grow up through the transition to democracy in a post-*Apartheid* South Africa.

No study has explored the association between SES during infancy and childhood and skeletal development of children within a developing country where considerable inequalities exist within the population. The Bt20 cohort affords a unique opportunity to explore such associations. The aim of this paper is to examine the impact of SES at infancy and later in childhood on bone mass at the whole body and critical bone development sites, the femoral neck and lumbar spine, in a cohort of young South African Black children living in Johannesburg/Soweto. We included two SES time points as we hypothesised that there would be changes in SES over time due to South Africa's transition to democracy and that current SES factors may have a greater impact on bone health, because they were more proximal to the bone measures being observed.

Materials and Methods

Participants

The Bt20 cohort was defined by the timing of a singleton birth within a specified period (late April to early June) in 1990, as well as continued residence within the metropolitan area of Johannesburg, South Africa for at least 6 months after the birth of the child. This region covered approximately 100 square miles at that time, and included close to 3.5 million people with about 400 000 informal housing units. The enrolment methods and profile of the Bt20 cohort have been well documented in several publications [11; 12]. At age 9 years, a purposive sub-sample of Black (*n*=409) and all participating White (*n*=114) children stratified by sex, who were enrolled in the Bt20 cohort, were recruited into a longitudinal study assessing factors influencing bone

mass acquisition during childhood and adolescence (Bone Health study; BH). Statistical cross checks were conducted to ensure that there were no significant differences between the Bt20 and BH cohorts for key demographic variables (residential area at birth, maternal age at birth, gravidity, gestational age and birth weight).

We have previously reported racial SES disparities in that all the White families participating in the BH cohort were in the highest quartile using an SES asset indicator [13]. In this study we specifically investigated SES variation within a low SES strata and its concomitant effect on bone mass. Therefore, we included only Black participants from the BH study who had SES data during infancy (between birth and up to 2 years) and SES, anthropometric, bone mass and pubertal data during late childhood (between 9 and 10 years; *n*=309; 161 (52.1%) males). All participants and their caregivers provided written informed consent and ethical approval was obtained from the University of the Witwatersrand Committee for Research on Human Subjects.

SES questionnaire

Household measures of SES were assessed using an interviewer-administered questionnaire (which has been shown to be valid for a South African sample [14]) with the caregiver within the first two years after birth (0/2), and again at 9/10 years. The questionnaire captured both social and economic aspects of SES and included: marital status, education (grouped grade category responses at 0/2 years and single grade categories at 9/10 years), types of dwelling, water source and toilet facilities, whether or not

there was a range of consumer durables in the home (television, refrigerator, washing machine and telephone) and whether or not the family owned a motor vehicle. Whether or not there was a video machine and microwave in the home was introduced into the questionnaire at 9/10 years to reflect the changing technology available. Furthermore, at 9/10 years, caregivers were also asked whether the child was covered by South Africa's private medical insurance (medical aid). An SES index was created by summing the product of the binary SES variables multiplied by the proportion having each of the SES measures at each time point. Therefore, the ownership of goods in the sample was used to provide a relative weighting by giving more weight to those items more commonly owned.

DXA-derived body composition and bone mass

Whole body composition (total fat mass minus head fat mass (g); lean tissue mass minus head lean tissue mass (g); bone mineral content (BMC) minus head BMC (g)) and whole body bone area minus head bone area (BA, cm^2) was used in the analyses as recommended for DXA-derived body composition and bone mass for this age group [15], and site-specific (femoral neck of the non-dominant hip and mean lumbar spine (L1-L4) BMC (g) and BA (cm^2)) were measured at ages 9/10 years using a fan-beam DXA model (QDR 4500A; array mode; Hologic Inc, Bedford, MA).

Anthropometry, pubertal development, physical activity and dietary calcium intake

Height and weight at 9/10 years were measured with participants wearing light clothing using standard techniques [16]. Pubertal development was assessed by a trained expert of the same sex using Tanner's Sexual Maturation Scale to determine breast/genital/pubic hair development [17, 18]. Total physical activity (PA) was estimated by using a structured, detailed, retrospective interview taking into consideration all PA and inactivity over the previous 12 months. The questionnaire was based on questionnaires validated in previous studies [19; 20] and modified appropriately for South African children. The intensity, frequency, and duration of all PA [at school, after school, at home, and commuting (actively and passively) to and from school] were taken into account. Intensities of activities were classified as multiples of one metabolic equivalent (the ratio of the associated metabolic rate for the specific activity to the resting metabolic rate). PA was scored from the questionnaire as metabolic PA (METPA) by weighting the intensity [multiples of basal metabolic rate (metabolic equivalents) and duration (h/wk)] [21] . Dietary calcium intakes were assessed through a quantitative food frequency questionnaire, this questionnaire has been shown to be reproducible in assessing the dietary intakes of adults and children among the Black population in South Africa [22; 23].

Statistical analyses

T-tests and chi-square tests were used to investigate whether there were any differences by sex of the child for the anthropometric, DXA, METPA, dietary calcium intakes and pubertal data in the BH sample. Descriptive statistics for the measures of SES at 0/2 and 9/10 years were produced. To

enable the representativeness of the SES profile of the BH cohort to be assessed, the 9/10 year SES data were compared using chi-square tests with similar data available in the South African 1998 Demographic and Health Survey (DHS) since the survey was conducted at a similar time point. Cases selected from the DHS dataset were Black urban females, aged 15-49 years, residing in the capital/large cities within the province of Gauteng (n=619). Linear regression models were used to investigate the association of measures of SES at 0/2 and 9/10 years with fat mass, height, BMC and BA at the whole body, femoral neck and mean lumbar spine at 9/10 years in the BH sample. Height and body composition measures were included in the analyses because of their impact on bone mass. Fat mass was log transformed as this variable was not normally distributed. Each binary measure of SES was entered *independently* into separate regression models for outcome measures of fat mass (logged) and height controlling for age and sex, as well as outcome measures of BA and BMC controlling for age, sex and height (step one). This approach allowed the effect of each measure of SES on each of the outcomes to be assessed whilst controlling for potential confounding factors in the relationship.

Step two of the regression analyses focussed on whole body outcomes (BA and BMC) since this was the only bone mass site that had significant associations with SES ($p<0.05$) from step one of the analyses. In step two, linear regressions were used to assess the *combined* effects of the different significant dimensions of SES from step one while considering the pathways through which SES might operate to influence bone and controlling for potentially confounding factors. Variables were entered into the model in

blocks. Model A included the measures of SES that were significant ($p<0.05$) in the regression models from step one for whole body BA and BMC, whilst controlling for sex, age and height of the child. Including only the significant SES measures reduced potential problems of co-linearity between the measures of SES. The use of an SES index was not used in step 2 of the regression analysis because we aimed to investigate which *dimensions* of SES, at which ages, were associated with bone development and this would not have been possible using such an index as opposed to the individual SES measures. Assessment of co-linearity between the significant SES measures entered into the regression models revealed no concerns (tolerance of <0.05). Model B further controlled for pubertal status, whilst Models C and D also controlled for physical activity and habitual dietary calcium intake respectively. Model E controlled for both physical activity and dietary calcium intake. Models F and G further controlled for lean mass and fat mass respectively. Model H controlled for both lean and fat mass together, and Model I, further controlled for whole body bone area (BA) in the case of whole body BMC. SPSS version 14.0 (Chicago, USA) was used for the statistical analyses.

Results

Cohort characteristics

Table 1 compares the mean and standard deviation for each of the variables by the sex of the child. Boys had a significantly higher femoral neck BA and BMC, mean lumbar spine BA, mean lean tissue mass, and calcium intake. Girls had a significantly higher mean fat mass, and more were in stage 2 of puberty.

[Insert Table 1 here]

SES over time

The measures of SES at 0/2 and 9/10 years for the cohort and comparable measures in the 1998 South African DHS are presented in Table 2. There were some marginal improvements in SES over time with more households having indoor running water, inside flush toilets, televisions, refrigerators, washing machines and telephones by 1999/2000 compared to 1990. In addition, more caregivers were married or cohabitating, but had lower education levels which probably reflect shifts in primary care-giving from biological mothers to other caregivers, for example grandmothers and aunts between 1990-1999/2000.

In comparison with the DHS, the BH sample was similar with regard to the proportion of married/cohabiting families and indoor running water source. However, the BH sample caregivers were better educated and households owned a greater proportion of consumer durables.

[Insert Table 2 here]

SES associations with height, body composition and bone mass

Table 3 presents the unstandardised coefficients and significance levels of the SES measures entered *individually* into step one of the regression models for fat mass (logged) and height (controlling for age and sex). Several individual SES items as well as the SES index at birth and 9/10

years were positively associated with fat mass. Only living in a house, cottage or flat at 9/10 years was significantly associated with height.

[Insert Table 3 here]

There were more SES measures at ages 9/10 associated with whole body BA and BMC outcomes than at 0/2 years (Tables 4 and 5). None of the SES measures were significantly associated with femoral neck and lumbar spine BA and BMC (data not shown). The caregiver's marital status at 9/10 years was a particularly significant predictor as it was associated with three of the outcome variables (fat mass and whole body BA and BMC). Other SES measures that were highly significantly ($p<0.01$) associated with whole body BA and BMC were whether or not the household had a television or refrigerator and the SES index at ages 9/10 years.

[Insert Table 4 and 5 here]

Table 6 presents the unstandardised regression coefficients and significance levels for the regression models that considered the *combined* effects of the significant SES variables on BA. Model A included the measures of SES controlling for sex, age and body size (height) of the child. A positive association was found between SES and whole body BA. Children whose caregiver was married or cohabiting had a whole body BA that was on average 26cm^2 larger than those whose caregivers were not married or cohabiting. The caregiver's marital/cohabiting status was significantly

associated with whole body BA until fat mass was controlled for in Model G. Television ownership was significantly associated with whole body BA once all of the confounders were controlled for in Model H.

[Insert Table 6 here]

Table 7 presents the unstandardised regression coefficients and significance levels for the regression models that considered the *combined* effects of the significant SES variables on BMC. Model A included the measures of SES controlling for sex, age and height of the child. Again, a positive association was found between SES and whole body BMC. Children whose caregiver was married or cohabiting had a whole body BMC that was on average 30g higher than those whose caregivers were not married or cohabiting. Similarly, children who had a television in their home had a whole body BMC that was on average 50g higher than those who did not. The caregiver's marital status and whether or not there was a television in the home at 9/10 years were the SES measures that remained significantly associated with whole body BMC when other SES measures were also included in the models. The caregiver's marital status was significantly associated with whole body BMC until fat mass was controlled for in Model G. Whether or not there was a television in the home remained significantly associated with whole body BMC until whole body BA was controlled for in Model I.

[Insert Table 7 here]

Discussion

This is the first study to analyse longitudinal SES data with respect to body composition and bone mass in Black South African children in order to further understand the potential impact of modifiable environmental factors on skeletal development. The study found that several SES factors showed marginal improvement over the ten years of the study which extended through South Africa's transition to democracy. This probably reflects a general improvement in household living standards, but also the maturation of the family unit over the 10 years of study. Furthermore, in comparison with the DHS, this study sample is probably more representative of families who are residentially stable and have been living in Johannesburg-Soweto for more than 10 years than the DHS sample which also includes recent migrants who are more likely to be of lower SES.

SES was higher in this study sample than that of the average urban Black family living in the province of Gauteng, but, the overall SES of these families is still considerably lower than that of urban inhabitants in more economically developed countries like the USA [14]. Cameron (2003) argues that even marginal improvements in SES can have dramatic effects on biologically sensitive markers of social change such as growth [24]. Comparing 1978 growth data from Black girls in Soweto [25] with the growth data from Birth to Twenty cohort, a positive secular trend is evident with significant increases of approximately 5-10 cm in height during this time, or alternatively, 4-5cm per decade.

In these analyses, current SES measures were more significantly associated with body composition and whole body BA and BMC than those

measured in infancy. Despite the relationship with whole body BA and BMC, SES had no significant effect on either hip or lumbar spine bone mass. This is not too surprising as the overall impact of SES on the skeleton would be distributed throughout the skeleton and small differences might not be detected at specific regional sites.

Caregiver's marital/cohabiting status (an indicator of improved social and household financial support), and whether or not there was a television in the home (which in the South African context would be an indicator of greater household disposable income), were the most important socio-economic determinants of whole body BA and BMC. These findings illustrate the importance of both social and economic dimensions of SES for bone health. It appears that the effect of marital/cohabiting status on BA is through its effect on the child's fat mass as the association disappeared once this was controlled for. The effect of marital/cohabiting status on whole body BMC is also through its effect on the child's fat mass as the association disappeared once fat mass was controlled for. The relationship between the presence of a television in the home and whole body BA only became significant once all potential confounders were for. The relationship between the presence of a television in the home and whole body BMC was significant until BA was controlled for. It would appear that television ownership is directly related to BA (bone size) independent of height, and fat and lean mass, but is indirectly related to BMC through its impact on BA. This may seem counterintuitive in light of findings from Australia that suggest that television watching is negatively associated with bone mass and positively associated with fracture risk in children [26]. However, within the South African context owning a

television is more indicative of greater disposable income which may relate to better nutrition and not necessarily decreased physical activity. Indeed, we examined this with our data and there were no significant differences in physical activity scores between those who owned a television (median METPA=10.0; 4.6-20.6) and whose who did not (median METPA= 8.1; 5.8-19.0).

The study results confirm our hypothesis, at least at the whole body, that marginal improvement in SES would affect bone mass. The only other study to explore the association between SES and bone mass in childhood is the Avon Longitudinal Study of Parents and Children cohort in Bristol, UK. Clark et al (2005) showed that maternal education level at the time of pregnancy exerted two opposing influences on whole body BMC in late childhood (aged 9/10) [9]. On the one hand, better maternal education increased whole body BMC and BA as a result of improved growth (height). On the other hand, poorer maternal education resulted in shorter children, but their whole body BMC and BA were preserved as a consequence of their greater fat mass, which probably affects periosteal bone formation [9].

It would appear that the hypothesised complex interaction model between SES and height and fat mass, and consequent impact on bone size and bone mass postulated by Clark et al (2005) from UK data, is not borne out by our study set in a very different socio-economic and transitioning environment for several reasons [9]. In these analyses, current SES factors overshadowed historical SES factors during infancy; and secondly, higher SES (disposable income) was significantly associated with improved whole body BMC independently of height and fat mass, but mediated through a

larger BA. It is possible that in a homogenous and higher SES environment such as Bristol, UK, the independent effect of SES on bone mass is not apparent. However, the evidence from this study suggests that SES can influence BMC through height and bone size, and fat mass in a low SES environment.

A limitation of this study is that even though the study sample was demographically representative of the original Bt20 cohort, it was not socio-economically representative. This sub-sample was of significantly higher SES, thus under representing the poor. Nevertheless, findings show significant associations between SES and BA and BMC and it is unlikely that this pattern would change with a more representative sample. In fact, the magnitude of association would be expected to increase.

We have reported previously that on average pre-pubertal Black children are 4.5cm shorter (3.5%), consume 50 per cent less calcium (300-453 mg daily calcium intake) and engage in significantly less formal school physical activity than their White counterparts [27; 28]. Despite these critical racial differences in nutrition, physical activity and body size, Black children surprisingly have greater BMC at the femoral neck, total hip, and mid-radius than White children once body size is controlled for, and similar BMC at the whole body, lumbar spine and distal one-third of the radius [29]. These findings suggest a strong protective genetic disposition in Black South Africans for higher bone mass. The results from the present study also illustrates that SES has a significant independent effect on whole body bone size but not at skeletal sites such as the hip and lumbar spine in Black South African children. Consequently, poverty alleviation in South Africa could have

a positive effect on bone health. However, further longitudinal data are needed to tease out the ultimate effects of genetic and environmental factors on peak bone mass in South Africa, and how these in turn predict fracture risk.

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Table 1: Sample characteristics at 9/10 years of age

Variables	Boys (n=161) Mean (SD)	Girls (n=148) Mean (SD)	Significance
Whole body bone area (cm^2)	931.11 (122.16)	933.51 (161.28)	
Femoral neck bone area (cm^2)	3.58 (0.36)	3.47 (0.39)	**
Mean lumbar spine bone area (cm^2)	10.29 (1.03)	9.94 (1.01)	**
Whole body BMC (g)	673.41 (125.69)	655.11 (147.50)	
Femoral neck BMC (g)	2.62 (0.38)	2.31 (0.41)	***
Mean lumbar spine BMC (g)	5.52 (0.88)	5.59 (1.11)	
Height (cm)	133.26 (5.85)	134.14 (6.22)	
Lean mass (g)	18990.01 (2618.68)	18108.47 (3262.61)	*
Fat mass (g)[1]	6210.77 (3520.96)	8507.93 (4794.84)	***
Age (years)	9.65 (0.46)	9.66 (0.49)	
Metabolic physical activity score[1]	20.24 (26.66)	12.46 (12.88)	
Calcium intake (mg Ca)	527.59 (203.30)	463.14 (203.28)	**
Pubertal status	**%**	**%**	
Tanner stage 1 for breast, genitalia or pubic hair	78.90	66.20	*
Tanner stage 2 plus for breast, genitalia or pubic hair	21.10	33.80	

[1] t-tests performed using log transformations as data was skewed.
***p<0.001 **p<0.01 *p<0.05

Table 2: Descriptive measures of SES at 0/2 years and 9/10 years and comparable SES measures from the South African DHS (1998)

SES measure	0/2 years (%)	9/10 years (%)	SADHS 1998 (%)	Significance
Caregiver married/cohabiting	23.60	45.00	46.70	
Caregiver has Grade 11-12 or higher at 0/2 years /Grade 12 or higher (completed High School or Secondary education) at 9/10 years	44.30	33.00	26.70	*
Lives in house/flat/cottage	90.90	87.10	-	
Indoor water source	47.60	50.50	54.30	
Inside flush toilet	23.90	37.20		
Has television in home	78.30	90.90	73.50	***
Has motor vehicle in home	28.20	26.50	19.40	*
Has refrigerator in home	75.40	91.30	66.20	***
Has washing machine in home	10.70	29.10	-	
Has telephone in home	60.20	65.00	-	
Has video machine in home	-	40.50	-	
Has microwave in home	-	24.90	-	
Child covered by medical aid	-	17.80	-	
n	**309**	**309**	**619**	

To assess the representativeness of the SES profile of the BH cohort at 9/10 years comparisons were conducted with the South African 1998 DHS. Cases selected from the DHS dataset were Black urban females, aged 15-49 years, residing in the capital/large cities within the province of Gauteng. ***p<0.001 **p<0.01 *p<0.05

Table 3: Unstandardised linear regression coefficients and significance levels to show the independent effects of each of the SES measures on fat mass (logged) and height, controlling for sex and age

Parameter	Fat mass (logged) (g)	Height (cm)
SES measures at 0/2 years		
Caregiver married/cohabiting	0.04	0.61
Caregiver has Grade 11-12 or higher education	0.05	-0.25
Lives in house/flat/cottage	-0.08	-0.38
Indoor water source	0.04	-0.12
Inside flush toilet	0.03	-0.64
Has television in home	0.12	-0.29
Has motor vehicle in home	0.13*	-0.09
Has refrigerator in home	0.14*	-0.23
Has washing machine in home	-0.05	-1.67
Has telephone in home	0.15**	0.37
Categorised SES index		
Low (reference category)	0.00	0.00
Mid	0.11	-0.43
High	0.18**	-0.56
SES measures at 9/10 years		
Caregiver married/cohabiting	0.22***	1.22
Caregiver has Grade 12 or higher education	0.06	-0.06
Lives in house/flat/cottage	-0.13	-3.04**
Indoor water source	0.08	-0.17
Inside flush toilet	0.08	1.03
Has television in home	0.15	1.24
Has motor vehicle in home	0.13*	0.26
Has refrigerator in home	0.11	0.55
Has washing machine in home	0.09	-0.08
Has telephone in home	0.05	0.60
Has video machine in home	0.14*	0.93
Has microwave in home	0.10	-0.46
Child covered by medical aid	0.10	-0.64
Categorised SES index		
Low (reference category)	0.00	0.00
Mid	0.01	-0.48
High	0.16*	1.14
n	**309**	**309**

SES measures entered individually into the regression models, controlling for sex and age.
***p<0.001 **p<0.01 *p<0.05

Table 4: Unstandardised linear regression coefficients and significance levels to show the independent effects of each of the SES measures on whole body, femoral neck and mean lumbar spine BA, controlling for sex, age and height

Parameter	Whole body BA (cm^2)	Femoral neck BA (cm^2)	Mean lumbar spine BA (cm^2)
SES measures at 0/2 years			
Caregiver married/cohabiting	-1.82	0.05	0.08
Caregiver has Grade 11-12 or higher education	6.07	0.06	-0.08
Lives in house/flat/cottage	1.64	-0.02	-0.11
Indoor water source	13.84	-0.03	0.03
Inside flush toilet	16.45	-0.03	-0.002
Has television in home	22.11	0.002	-0.04
Has motor vehicle in home	19.14	0.03	-0.07
Has refrigerator in home	19.28	-0.003	-0.15
Has washing machine in home	4.48	0.03	0.01
Has telephone in home	23.16*	0.02	-0.12
Categorised SES index			
Low (reference category)	0.00	0.00	0.00
Mid	25.47*	0.001	-0.10
High	33.02**	0.01	-0.10
SES measures at 9/10 years			
Caregiver married/cohabiting	26.38**	0.05	0.06
Caregiver has Grade 12 or higher education	6.04	-0.01	-0.14
Lives in house/flat/cottage	-7.97	-0.05	0.03
Indoor water source	22.01*	0.01	-0.02
Inside flush toilet	18.88	0.02	0.08
Has television in home	50.89**	0.003	-0.01
Has motor vehicle in home	16.42	-0.04	0.07
Has refrigerator in home	49.96**	-0.01	-0.16
Has washing machine in home	16.13	-0.05	-0.01
Has telephone in home	14.78	-0.03	0.04
Has video machine in home	21.85*	-0.03	-0.04
Has microwave in home	21.75	-0.02	0.03
Child covered by medical aid	18.54	0.01	-0.15
Categorised SES index			
Low (reference category)	0.00	0.00	0.00
Mid	21.47	-0.01	0.01
High	37.38**	-0.02	-0.03
n	**309**	**309**	**309**

SES measures entered individually into the regression models, controlling for sex, age and height. ***p<0.001 **p<0.01 *p<0.05

Table 5: Unstandardised linear regression coefficients and significance levels to show the independent effects of each of the SES measures on whole body, femoral neck and mean lumbar spine BMC, controlling for sex, age and height

Parameter	Whole body BMC (g)	Femoral neck BMC (g)	Mean lumbar spine BMC (g)
SES measures at 0/2 years			
Caregiver married/cohabiting	-3.92	0.002	-0.01
Caregiver has Grade 11-12 or higher education	0.29	0.05	-0.14
Lives in house/flat/cottage	-4.42	0.02	-0.04
Indoor water source	16.66	-0.01	-0.01
Inside flush toilet	17.20	-0.01	0.02
Has television in home	15.77	0.02	0.03
Has motor vehicle in home	14.24	0.01	-0.07
Has refrigerator in home	17.68	-0.0004	-0.09
Has washing machine in home	2.28	0.03	-0.01
Has telephone in home	17.85	0.02	-0.09
Categorised SES index			
Low (reference category)	0.00	0.00	0.00
Mid	24.29	0.05	0.04
High	27.11*	0.02	-0.03
SES measures at 9/10 years			
Caregiver married/cohabiting	29.61**	-0.01	0.15
Caregiver has Grade 12 or higher education	0.37	-0.02	-0.11
Lives in house/flat/cottage	-8.83	-0.01	-0.14
Indoor water source	21.34*	0.04	0.09
Inside flush toilet	19.41	0.05	0.14
Has television in home	64.76***	0.04	0.15
Has motor vehicle in home	14.72	-0.05	0.06
Has refrigerator in home	51.70**	0.05	0.08
Has washing machine in home	7.18	-0.06	0.002
Has telephone in home	11.44	0.02	0.01
Has video machine in home	19.23	-0.01	0.002
Has microwave in home	16.17	0.03	0.04
Child covered by medical aid	2.29	-0.04	-0.13
Categorised SES index			
Low (reference category)	0.00	0.00	0.00
Mid	30.57*	0.06	0.16
High	36.88**	0.05	0.16
n	**309**	**309**	**309**

SES measures entered individually into the regression models, controlling for sex, age and height. ***p<0.001 **p<0.01 *p<0.05

Table 6: Unstandardised linear regression coefficients and significance levels to show the combined effects of the different SES measures on whole body BA (cm^2)

Parameter	Model A	Model B	Model C	Model D	Model E	Model F	Model G	Model H
SES measures at 0/2 years								
Has telephone in home	13.62	10.80	11.08	10.71	10.91	10.30	2.15	2.22
SES measures at 9/10 years								
Caregiver married/cohabiting	25.78**	24.69*	25.04*	24.68*	25.01*	19.94*	6.50	3.41
Indoor water source	11.25	8.67	9.86	8.60	9.73	8.00	5.53	4.33
Has television in home	30.55	27.82	27.37	27.83	27.39	27.82	26.78	27.19*
Has refrigerator in home	32.88	34.50	34.15	34.39	33.93	18.64	22.24	9.92
Has video machine in home	3.23	3.47	3.03	3.36	2.82	4.05	-0.48	0.81
Control variables								
Female child	-9.80	-12.61	-10.93	-12.52	-10.75	13.11	-39.00***	-16.58*
Age (years)	25.16*	17.47	17.06	17.52	17.15	2.84	13.49	1.45
Height (cm)	17.80***	17.48***	17.57***	17.47***	17.57***	10.87***	14.58***	9.04***
Tanner stage 2 plus for breast, genitalia or pubic hair	-	25.99*	26.26*	26.00*	26.29*	18.19	6.18	0.61
Metabolic physical activity score	-	-	0.25	-	0.25	0.19	0.35*	0.30*
Calcium intake (mg Ca)	-	-	-	0.001	0.003	0.01	-0.02	-0.01
Lean mass (g)	-	-	-	-	-	0.20***	-	0.02***
Fat mass (g)	-	-	-	-	-	-	0.01***	0.01***
Adjusted R square	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	**0.74**	**0.80**	**0.85**
n	**309**	**309**	**309**	**309**	**309**	**309**	**309**	**309**

Model A controls for sex, age and height.
Model B controls for sex, age, height and pubertal status.
Model C controls for sex, age, height, pubertal status and physical activity
Model D controls for sex, age, height, pubertal status and calcium intake.
Model E controls for sex, age, height, pubertal status, physical activity and calcium intake.
Model F controls for sex, age, height, pubertal status, physical activity, calcium intake and lean mass.
Model G controls for sex, age, height, pubertal status, physical activity, calcium intake and fat mass.
Model H controls for sex, age, height, pubertal status, physical activity, calcium intake, lean mass and fat mass.
***p<0.001 **p<0.01 *p<0.05.

Table 7: Unstandardised linear regression coefficients and significance levels to show the combined effects of the different SES measures on whole body BMC (g)

Parameter	Model A	Model B	Model C	Model D	Model E	Model F	Model G	Model H	Model I
SES measures at 9/10 years									
Caregiver married/cohabiting	29.63**	28.57**	28.70**	28.43**	28.54**	24.21*	13.19	10.58	6.75
Indoor water source	12.09	9.07	9.57	8.56	9.02	7.69	4.26	3.46	-1.78
Has television in home	50.44*	47.01*	46.77*	46.81*	46.56*	47.16*	43.72*	44.46**	13.58
Has refrigerator in home	33.10	34.23	34.06	33.48	33.24	19.74	22.02	11.11	-0.43
Control variables									
Female child	-26.70*	-29.75**	-29.00**	-29.34**	-28.53**	-7.32	-52.04***	-31.79**	-13.55*
Age (years)	-2.54	-10.25	-10.45	-9.98	-10.17	-22.79	-12.58	-23.38*	-24.79***
Height (cm)	16.38***	16.05***	16.09***	16.03***	16.07***	10.13***	13.64***	8.64***	-1.36
Tanner stage 2 plus for breast, genitalia or pubic hair	-	26.76*	26.90*	26.78*	26.93*	19.63	9.44	4.42	3.41
Metabolic physical activity score	-	-	0.11	-	0.11	0.07	0.20	0.15	-0.18
Calcium intake (mg Ca)	-	-	-	0.01	0.01	0.01	-0.01	-0.01	0.004
Lean mass (g)	-	-	-	-	-	0.02***	-	0.02***	-0.003*
Fat mass (g)	-	-	-	-	-	-	0.01***	0.01***	-0.004***
Whole body bone area (cm^2)	-	-	-	-	-	-	-	-	1.11***
Adjusted R square	**0.57**	**0.58**	**0.58**	**0.58**	**0.58**	**0.63**	**0.67**	**0.71**	**0.91**
n	**309**	**309**	**309**	**309**	**309**	**309**	**309**	**309**	**309**

Model A controls for sex, age and height.
Model B controls for sex, age, height and pubertal status.
Model C controls for sex, age, height, pubertal status and physical activity
Model D controls for sex, age, height, pubertal status and calcium intake.
Model E controls for sex, age, height, pubertal status, physical activity and calcium intake.
Model F controls for sex, age, height, pubertal status, physical activity, calcium intake and lean mass.
Model G controls for sex, age, height, pubertal status, physical activity, calcium intake and fat mass.
Model H controls for sex, age, height, pubertal status, physical activity, calcium intake, lean mass and fat mass.
Model I controls for sex, age, height, pubertal status, physical activity, calcium intake, lean mass, fat mass and whole body bone area.
***p<0.001 **p<0.01 *p<0.05.