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BMI MAY UNDERESTIMATE THE SOCIOECONOMIC GRADIENT IN TRUE OBESITY

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ABSTRACT

Background

Body mass index (BMI) does not make a distinction between fat mass and lean mass. In children, high fat mass appears to be associated with low maternal education, as well as low lean mass because maternal education is associated with physical activity. Therefore, BMI might underestimate true obesity in children of low-educated mothers.

Objective

To investigate the associations of maternal education with fat mass index (FMI), lean mass index (LMI) and BMI.

Methods

In total, 1965 Dutch children from a prospective cohort, aged 5.7 years (standard deviation 0.5), had available data on body composition based on bioelectrical impedance analysis.

Results

Maternal education was not associated with BMI after adjustment for confounders. In contrast, children of low-educated mothers had a higher FMI (β 0.28; 95% CI 0.07 - 0.49) and a lower LMI (β -0.18; 95% CI -0.33 - -0.03) compared with children of high-educated mothers.

Conclusions

This suggests that BMI underestimates the educational gradient of childhood obesity.

INTRODUCTION

While childhood obesity appears to plateau in recent years, prevalence is still high particularly in low socioeconomic status children.^{235,236} Childhood obesity is usually measured with body mass index (BMI), which is a simple and widely accepted proxy measure of obesity. However, BMI has several limitations, including that it does not distinguish between fat mass and lean mass, while obesity is, by definition, excess body fatness. For example, Wells et al²³⁷ showed that individuals of the same age and gender have a twofold range of body fat mass for a given BMI value and some children within the normal BMI range had a high fat mass. Ness et al⁴¹ showed that high fat mass at 9-10 years of age was associated with lower social class. However, there was no association between social class and lean mass, which include muscles. They suggested that BMI may underestimate social gradients in childhood obesity in populations where lean mass is socially patterned. Lean mass may be socially patterned since a low socioeconomic status is associated with physical inactivity,²³⁸ less sport participation,²³⁹ and lower muscular strength,²⁴⁰ which suggest that children with a low socioeconomic background have lower muscle mass. It is interesting whether the findings by Ness et al⁴¹ might be present at an earlier age and could be confirmed in another cohort. Therefore the objective of this study was to examine the association between maternal education and body mass index, fat mass index, as well as lean mass index in a large cohort of 5-6 year olds: the ABCD study.

METHODS

The ABCD study is a population-based cohort study from fetal life onwards and has been described previously.⁴³ At age five-six, various health measurements were performed in 3321 children. As body composition differs by ethnicity,²⁴¹ the 2038 children with a Dutch mother and Dutch grandmother were selected for the present study. Appropriate study approval was obtained and all participants gave written informed consent for themselves and their children. Socioeconomic status (SES) was indexed using maternal education,³⁵ which was reported in the childhood questionnaire and was categorized as: low (no education or primary school only; lower vocational secondary education or technical secondary education); mid (higher vocational secondary education, intermediate vocational education); high (higher vocational education, university education). To calculate BMI, height (HT) was measured to the nearest millimetre using a Leicester height measure (Seca), and weight (WT) was measured to the nearest 100 gram using a Marsden weighing scale, model MS-4102. Arm-to-leg bioelectrical impedance analysis (BIA) was measured twice using the Bodystat 1500MDD system (Bodystat Inc, Douglas, UK) to obtain fat mass (FM) and lean mass (LM).⁴⁶ The outcome measures were BMI (WT/HT^2), FMI (FM/HT^2), and LMI (LM/HT^2). Univariate analyses were conducted with ANOVAs for continuous variables and Chi-Square tests for categorical variables. Linear

regression analyses were performed, adjusting for the child's age (continuous) and sex,⁴¹ maternal BMI (continuous, based on self-reported weight and height),^{35,174,215} maternal age (continuous),²⁴² and maternal smoking during pregnancy (yes/no, based on self-report).²¹⁵ As maternal BMI could be in the causal pathway and might therefore be a mediator instead of a confounder, we performed a model with and without maternal BMI. In total, 1965 children aged 5.7 years (SD 0.5) had available data on all variables.

RESULTS

In univariate analyses, children with low-educated mothers had a higher BMI, and higher FMI compared to children with high-educated mothers, while there were no educational differences in LMI (Table 8.1). After adjustment for child's age, sex, maternal age, and maternal smoking, children with low-educated mothers had a 0.32 (95% CI 0.07 - 0.56) higher BMI, and a 0.44 (95% CI 0.22 - 0.65) higher FMI, compared to children with high-educated mothers. The low-educated group had on average a lower LMI (β -0.12; 95% CI -0.27 - 0.03), but this did not reach significance. After adjustment for confounders including maternal BMI, there were no educational differences in BMI, but children with low-educated mothers had a higher FMI (β 0.28; 95% CI 0.07 - 0.49) and a lower LMI (β -0.18; 95% CI -0.33 - -0.03) compared to children with high-educated mothers (Figure 8.1). Educational related differences in FMI were more than two fold higher than these differences in BMI. Although boys had on average less fat mass and more lean mass compared to girls, separating the analysis by sex did not affect the main results.

Table 8.1. Covariates and outcomes by maternal education

	Maternal education				p-value*
	Total	High	Mid	Low	
	(n=1965)	(n=1518)	(n=328)	(n=119)	
Age, yr (SD)	5.7 (0.5)	5.7 (0.5)	5.7 (0.5)	5.7 (0.4)	0.18
Sex (% boys)	51.0	51.8	48.5	48.7	0.49
Maternal age, yr (SD)	32.8 (3.8)	33.1 (3.4)	31.9 (4.3)	30.9 (5.2)	<.001
Maternal BMI, kg/m ² (SD)	22.6 (3.5)	22.3 (3.1)	23.2 (3.9)	24.8 (5.3)	<.001
Smoking during pregnancy (%)	5.8	2.4	12.5	30.3	<.001
Body composition					
Height, cm (SD)	116.8 (5.7)	116.7 (5.6)	117.2 (5.7)	117.4 (6.1)	.16
Weight, kg (SD)	21.0 (2.9)	20.9 (2.7)	21.3 (3.3)	21.9 (3.7)	<.01
Body mass index, kg/m ² (SD)	15.4 (1.3)	15.3 (1.2)	15.4 (1.5)	15.8 (1.7)	<.001
Fat mass index, kg/m ² (SD)	3.1 (1.1)	3.0 (1.0)	3.2 (1.3)	3.5 (1.5)	<.001
Lean mass index, kg/m ² (SD)	12.3 (0.8)	12.30 (0.8)	12.3 (0.8)	12.2 (0.7)	0.62
Fat percentage (%)	19.7 (5.7)	19.4 (5.3)	20.0 (6.4)	21.8 (7.3)	<.001

*p-values are based on one-way ANOVAs for continuous variables and Chi-square tests for categorical variables

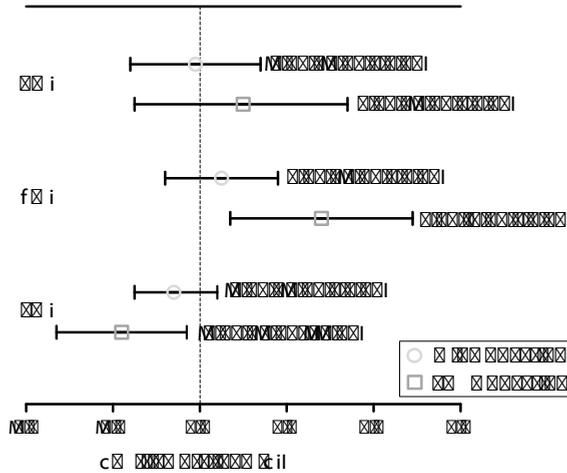


Figure 8.1. Linear regression analysis adjusted for age, sex, maternal age, maternal BMI, and smoking during pregnancy. Reference: high maternal education

DISCUSSION

This study showed that a low maternal education was associated with greater FMI and with lower LMI as measured by BIA, and not with BMI in children 5–6 years of age. Our observations suggest therefore, that BMI may underestimate the socioeconomic gradient in obesity. Although the absolute differences may be low, tracking (and even increase) of these differences with age is probable. As reviewed, earlier studies to SES differences in childhood BMI showed conflicting results,³⁵ which might partly be due to the limitations of BMI. The limitations of BMI are that it is stature dependent, is also affected by relative leg length, and reflects both lean tissue and fat tissue.^{243,244} It has been suggested that BMI underestimates the true prevalence of high body fatness in children from a ‘lower income’ background to a greater extent than it did in the higher income group. This was explained by height differences since children from lower income backgrounds were shorter and heavier, with a greater proportion of weight being accounted for by body fat,²⁴⁵ as BMI is not independent of height.²⁴⁶ In our sample, there were no height differences. Therefore a lower lean mass index in the low-educated group might be due to muscle mass or bone density differences, suggesting that the low-educated group may be less physically active. Our result emphasizes the limitations of BMI as a marker of obesity among children of low-educated mothers. BMI might not only underestimate the socioeconomic gradient in the prevalence of true obesity, but might also underestimate the adverse consequences of obesity that is measured by BMI in low socioeconomic groups. Our results are comparable to Ness et al⁴¹ with education related differences in BMI and FMI. However, after adjustment for confounders the education

related differences in BMI disappeared, and LMI became significant in our sample. Since LMI increased with increasing maternal BMI, adjustment for maternal BMI affects the association between maternal education and childhood BMI to a greater extent than the association between maternal education and childhood FMI. It can be discussed whether maternal BMI is in the causal pathway and should be considered as a mediator rather than a confounder. Most studies that examined the association between socioeconomic status and adiposity adjust for maternal BMI,³⁵ so we also have adjusted for this variable in the final model. Future research regarding the role of maternal BMI in this relation is needed. As percentage fat mass increases with age and percentage lean mass decreases with age,²⁴⁷ which might – partially – act through a decline in physical activity with age,^{248,249} socioeconomic differences in FMI and LMI might change with age as well. The BIA-measurements have some limitations, as BIA predicts body fatness using an algorithm based on a number of variables including height, whole-body impedance, and hydration constants. However, BIA appears an accurate tool for epidemiologic studies⁴⁶ and we have no reason to assume that the prediction of fat mass and lean mass systematically differs between educational groups. As the current study sample is in general higher educated and has lower BMI (i.e. healthier) than the initial sample of the cohort, selective loss to follow-up is present. The association between BMI and maternal education was by far not significant ($p=0.44$), and it is therefore not likely that BMI would become associated with maternal education if the low-educated group was larger. In conclusion, we demonstrated for the first time that children with low-educated mothers had a higher FMI and a lower LMI compared to children with high-educated mothers, while BMI did not differ between educational groups. This suggests that BMI underestimates the socioeconomic gradient of childhood obesity and therefore caution is needed for interpreting BMI in children across socioeconomic groups.