The relationship between stunting and overweight among children from South Africa: Secondary analysis of the National Food Consumption Survey – Fortification Baseline I

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Background. Globally, in children the prevalence of overweight and obesity is increasing, and this is associated with an increased risk of non-communicable diseases in adulthood. There is a need to examine the growing trends of overweight and obesity in children and their consequences in low- and middle-income countries.
Objectives. To describe the prevalence of, and determine the relationship between, stunting and overweight among children in two provinces of South Africa.
Methods. Secondary data analysis was conducted on anthropometric measurements of 36 - 119-month-old children from Gauteng and Mpumalanga provinces (N=519) participating in the South African National Food Consumption Survey – Fortification Baseline I (2005). The International Obesity Task Force (IOTF) body mass index (BMI) reference percentiles were used to determine overweight and obesity. The World Health Organization standards were used to derive z-scores.
Results. The prevalence of overweight was 12.0% (IOTF BMI ≥25 kg/m^2), including 3.7% obesity (IOTF BMI ≥30 kg/m^2). The predominantly urban Gauteng Province had a significantly higher prevalence of overweight children (14.1%) compared with Mpumalanga (6.3%) (p=0.0277). The prevalence of stunting was 17.0% (16.5% Gauteng, 18.2% Mpumalanga; p>0.05). There was a significant correlation (r=−0.32) between BMI and height-for-age z-scores (p<0.0001). In the obese group, 68.4% were stunted, while in the normal and underweight group only 13.6% were stunted.
Conclusions. Stunted children were more likely to be obese. Further research is necessary for clarity on the physiological mechanisms of this relationship. In the interim, prevention of stunting requires priority.

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Early nutrition has been identified as an important contributing factor to long-term health. Undernutrition, i.e. underweight, stunting, wasting and deficiencies of essential micronutrients, during this period has short-term consequences (i.e. increased risk of morbidity, mortality and disability) as well as long-term consequences (influencing adult size, intellectual ability, economic productivity, reproductive performance and metabolic and cardiovascular disease).[1] Stunting, specifically in the first 2 years of life, is associated with shorter adult height, lower achievements at school, reduced adult income, and decreased birth weight in offspring.[2]

The other side of the malnutrition coin is the effect of overnutrition, which includes overweight and obesity. According to the Centers for Disease Control and Prevention,[3] the short-term health consequences of childhood obesity include an increased risk of cardiovascular disease (CVD), impaired glucose tolerance, insulin resistance, type 2 diabetes, respiratory morbidity, musculoskeletal discomfort, hepatic steatosis, gallstones and gastro-oesophageal reflux, as well as impaired psychological and social function. In the long term, obese children are at a substantially higher risk of becoming obese adults,[3] with the attendant higher risk of developing non-communicable diseases (NCDs) in adulthood. A systematic review[4] highlighted the complexity of the relationship between childhood (including adolescent) body mass index (BMI) and adult disease risk, and concluded that: (*i*) obese children growing into obese adults were at higher risk of NCDs in their adult years; (*ii*) obese children growing into normal-weight adults were not at greater risk of CVD in adulthood; and (*iii*) interestingly, children at the bottom range of BMI who became obese adults seemed most susceptible to the risks associated with adult obesity, in particular hypertension. Similarly, children who experienced undernutrition in the first 2 years of life and who thereafter rapidly gained weight during childhood or adolescence had an increased risk of chronic disease related to nutrition.[2] It is therefore crucial to understand the relationship between early childhood undernutrition and obesity in the ensuing life stages to ultimately reduce the risk of chronic diseases. This article therefore aims to determine the prevalence of, and the relationship between, stunting and overweight among a specific group of children in South Africa (SA).

Methods

The second SA National Food Consumption Survey – Fortification Baseline I (NFCS-FB-I), conducted in 2005, provided the opportunity for secondary data analysis. This analysis included data of two neighbouring provinces that are geographically the smallest provinces in the country. Ethics approval (Ref No. 2003/107/N) from Stellenbosch University was obtained, and each participant's next of kin was informed of the purpose of the study to obtain informed consent.

Study design and subject selection
This cross-sectional national survey was descriptive in the quantitative research paradigm. The data used for this secondary analysis were extracted from the original data set (non-weighted) of the NFCS-FB-I for Gauteng and Mpumalanga provinces. It should be borne in mind that the two provinces included are neither 100% urban nor 100% rural, as in any natural setting. The number of rural enumerator areas (EAs) was much lower (n=12) than the number of urban EAs (n=52), and therefore rural/urban conclusions cannot be drawn. The details of the sampling strategy can be found elsewhere.[5] The inclusion criteria used in this secondary analysis were as follows: all children aged 3 - 9 years (36 - 119.9 months of age) from Gauteng and Mpumalanga provinces; children from households with at least one woman of reproductive age (16 - 35 years); and complete data on gender, date of birth, and weight and height measurements of the child. This total extracted sample consisted of 64 EAs (n=41 urban formal, n=11 urban informal, n=8 tribal, n=4 rural formal).[5] The total number of children with informed consent and included in this secondary analysis was 561.

Data collection
Validated questionnaires for the collection of sociodemographic data were administered by trained fieldworkers. The sociodemographic factors investigated for this secondary analysis were for descriptive purposes.

Each child was anthropometrically assessed (weight and height) by a trained fieldworker using standardised and internationally described procedures. Each fieldworker was equipped with a portable electronic scale and a standard weight for calibration purposes (Precision Health Scale, model UC-321, A&D Company, Japan; maximum capacity 150 kg) as well as a stadiometer for carrying out the measurements. Each child was weighed (preferably with an empty bladder) with minimum clothing. The average of two readings was used. The standing height of the children was taken using a stadiometer (without shoes). Two readings were taken and the measurement was repeated if the readings varied by >0.5 cm.[5]

Data analysis
We derived BMI (weight divided by height squared), and z-scores for BMI-for-age (BAZ), weight-for-age (WAZ) and height-for-age (HAZ) by using the World Health Organization (WHO) AnthroPlus software for the applicable ages (Department of Nutrition, WHO, Geneva). For each child, a z-score (i.e. the number of standard deviations (SD) from the reference population median) was calculated for BAZ, WAZ and HAZ. If the WAZ was <−6 SD or >+5 SD, the HAZ <−6 SD or >+6 SD, or the BAZ <−5 SD or >+5 SD, the record was first verified for accuracy of data entry. Where an error had occurred on data entry, this was corrected; where no error could be detected, the indicator with such an extreme z-score was set to missing and therefore excluded from the analysis (according to WHO standards). The number of records with such extreme z-scores was 42, of which 19 were for HAZ, 10 for BAZ, 2 for WAZ and 11 for both HAZ and WAZ, leaving 519 subjects' data for analysis.

The International Obesity Task Force (IOTF) recommended age- and sex-specific cut-offs for BMI to determine overweight and obesity in children aged 2 - 18 years were used, which were based on adult BMI cut-offs at 25 kg/m^2 and 30 kg/m^2 for overweight and obesity, respectively.[6] In explanation of the data analysis, Table 1 indicates the anthropometric operational definitions for this secondary analysis.

The statistical analyses were done using SAS 9.1.3 (SAS Institute, USA). The PROC Survey Means, which is part of the SAS program, was used to calculate confidence intervals (CIs). Descriptive statistics and frequency distributions were calculated as appropriate for recorded sociodemographic data. The secondary analyses included the χ^2 test, which is a test of independence and assesses whether two variables are independent of each other. It also included the Pearson's correlation coefficient, used to establish the strength of linear relationships between variables. Statistical significance was set at a p-value of <0.05.

Results
Sociodemographic profile of the children
More than two-thirds of the 519 children were from Gauteng (72.5%). The study subjects lived mainly in urban settings (81.5% v. 18.5% rural), and Gauteng represented mainly urban respondents (96.0%). Mpumalanga, on the other hand, had a closer to equal representation of urban- and rural-dwelling subjects (43.4% urban v. 56.6% rural). Of the 519 children, 46.4% were male.

The total household income per month indicated that these children were mainly (75.1%) from poor families (household income ≤ZAR1 000 per month; ~USD157.50 per month in 2005). In the majority of cases (60.0%) the father or mother was the head of the household, and in 16.9% of cases the husband of the responding woman was the head of the household. The mother (42.9%) and other female adults (26.7%) were mainly responsible for deciding what types of food to buy for the household, while in 14.7% of cases

Table 1. Operational definitions for anthropometric classifications

Anthropometric classification	WHO 2005/7 WAZ	WHO 2005/7 BAZ	IOTF cut-off points[6]	WHO 2005/7 HAZ
Underweight	<−2 SD	N/A*	N/A	N/A
Normal weight	−2 - 1 SD	N/A	N/A	N/A
Overweight	1 - 2 SD	2 - 3 SD (<5 years) 1 - 2 SD (5 - 19 years)	BMI 25 - 29.9 kg/m^2	N/A
Obese	≥2 SD	≥3 SD (<5 years) ≥2 SD (5 - 19 years)	BMI ≥30 kg/m^2	N/A
Stunting	N/A	N/A	N/A	<−2 SD

*For the purpose of this study, BAZ <−2 SD were not reported since such values reflect wasting and not underweight *per se*. Underweight children were therefore defined as those with WAZ <−2 SD.

the father had this responsibility. A similar pattern was seen regarding the household member deciding how much money was spent on food procurement (42.9%, 21.8% and 16.3%, respectively). In 77.4% of cases, the mother was responsible for feeding or serving the food to the child. The majority of mothers had education up to grade 11 or 12 (48.8%) while 18.4% of mothers had primary or no education, and only 4.3% had tertiary education.

Prevalence of overweight, obesity and stunting

Of the total group of children (N=519), 8.3% were overweight and 3.7% obese (IOTF cut-offs). For these two provinces, at least 1 in every 10 children (12.0%; 95% CI 8.9 - 15.0) was therefore overweight/obese (IOTF BMI ≥25 kg/m^2) (Table 2). Gauteng had a significantly higher prevalence of overweight and obese children (14.1%) compared with Mpumalanga (6.3%) (p=0.0277) (p-values indicated in Table 3). Furthermore, Gauteng also had a significantly higher prevalence (4.8%) of obese children compared with Mpumalanga (0.7%). Girls had a significantly higher prevalence of overweight and obesity (15.8%) compared with boys (7.4%) (p=0.0034). Stunting was prevalent in 17.0% (95% CI 13.8 - 20.1) of the total group (Gauteng 16.5%, Mpumalanga 18.2%; p>0.05) (Table 2).

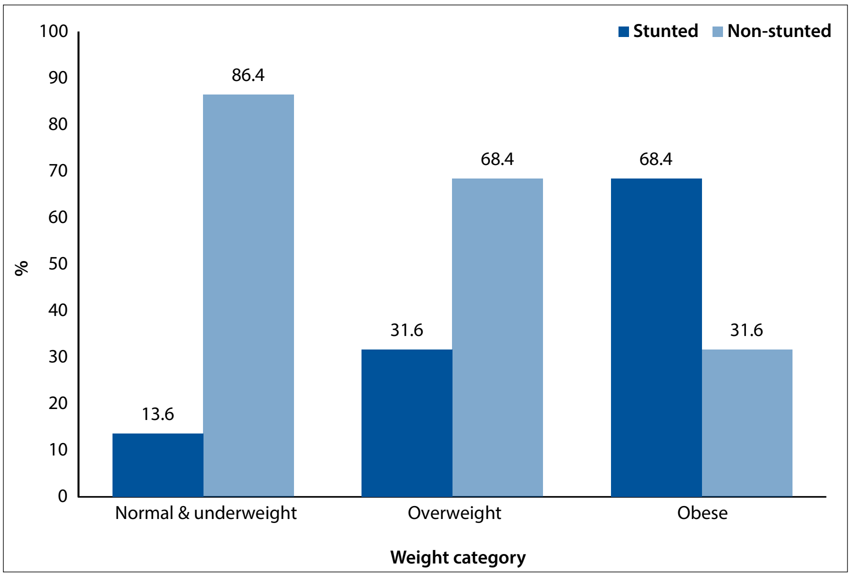

Fig 1. Relationship between stature and body weight in 3- to 9-year-old children from Gauteng and Mpumalanga (N=519) (p<0.0001).

Table 2. Weight and height status of the children by province and gender (*N*=519*)

	Province and gender				
	GP	MP	Male	Female	All
Weight indicators					
Children, *n*	376	143	241	278	519
Underweight (WAZ <−2 SD), % (95% CI)	6.1 (3.7 - 8.6)	10.5 (3.9 - 17.1)	8.3 (5.1 - 11.5)	6.5 (3.3 - 9.7)	7.3 (4.8 - 9.9)
Normal weight, % (95% CI)					
WAZ −2 - 1 SD	87.2 (83.5 - 91.0)	84.6 (79.0 - 90.2)	86.3 (81.7 - 90.9)	86.7 (82.6 - 90.8)	86.5 (83.4 - 89.6)
BAZ†	75.8 (71.2 - 80.4)	77.6 (70.5 - 84.8)	77.2 (72.6 - 81.7)	75.5 (69.9 - 81.2)	76.3 (72.4 - 80.2)
Overweight, % (95% CI)					
WAZ 1 - 2 SD	4.8 (2.5 - 7.1)	4.9 (2.0 - 7.8)	4.6 (1.8 - 7.4)	5.0 (2.5 - 7.6)	4.8 (3.0 - 6.6)
BAZ†	13.0 (9.6 - 16.4)	9.8 (4.1 - 15.5)	11.6 (7.5 - 15.7)	12.6 (8.3 - 16.9)	12.1 (9.2 - 15.1)
IOTF BMI 25 - 29.99 kg/m^2	9.3 (7.0 - 11.6)	5.6 (1.0 - 10.2)	6.6 (3.8 - 9.5)	9.7 (6.9 - 12.5)	8.3 (6.2 - 10.4)
Obese, % (95% CI)					
WAZ ≥2 SD	1.9 (0.2 - 3.5)	0.0	0.8 (0.0 - 2.0)	1.8 (0.2 - 3.4)	1.4 (0.1 - 2.6)
BAZ†	6.9 (4.2 - 9.6)	2.1 (0.0 - 4.5)	3.7 (1.2 - 6.3)	7.2 (4.2 - 10.2)	5.6 (3.5 - 7.7)
IOTF BMI ≥30 kg/m^2	4.8 (2.4 - 7.2)	0.7 (0.0 - 2.1)	0.8 (0.0 - 2.0)	6.1 (3.3 - 9.0)	3.7 (1.9 - 5.5)
Overweight and obese, % (95% CI)					
WAZ ≥1 SD	6.7 (3.6 - 9.7)	4.9 (2.0 - 7.8)	5.4 (2.5 - 8.3)	6.8 (3.7 - 10.0)	6.2 (3.8 - 8.5)
BAZ ≥1 SD	20.0 (15.4 - 24.5)	11.1 (6.2 - 17.6)	15.4 (10.8 - 19.9)	19.8 (14.5 - 25.0)	17.7 (14.0 - 21.4)
IOTF BMI ≥25 kg/m^2	14.1 (10.3 - 17.8)	6.3 (1.8 - 10.8)	7.4 (4.3 - 10.6)	15.8 (11.4 - 20.2)	12.0 (8.9 - 15.0)
Height indicators					
Stunted (HAZ <−2 SD), % (95% CI)	16.5 (13.0 - 20.0)	18.2 (11.6 - 24.7)	15.4 (11.0 - 19.7)	18.3 (13.6-23.1)	17.0 (13.8 - 20.1)
BMI <25 kg/m^2	10.9 (7.9 - 14.0)	14.7 (9.8 - 19.6)	12.0 (8.2 - 15.8)	11.9 (8.1 - 15.6)	11.9 (9.3 -14.6)
BMI ≥25 kg/m^2	5.6 (3.1 - 8.1)	3.5 (0.2 - 6.8)	3.3 (1.1 - 5.6)	6.5 (3.4 - 9.6)	5.0 (3.0 - 7.0)

GP = Gauteng Province; MP = Mpumalanga Province.
*With quality assurance measures, 42 entries were excluded.
†Refer to Table 1 for BAZ cut-off values per age group.

With regard to body weight *per se* (WAZ criteria), there was an almost equal prevalence of the two extremes of weight status, namely 7.3% of children being underweight and 6.2% being overweight. However, when considering the children's BMI, which includes height (BAZ criteria), more children were classified as being overweight and obese (17.7%) than when considering weight only (WAZ) criteria (6.2%). The disparity in the findings between the weight (WAZ) and BMI (BAZ) criteria was supported by the high prevalence of stunting (HAZ of <−2 SD 17.0%) among the total group of children. A statistically significant negative correlation ($p<0.0001$; Pearson correlation coefficient r −0.32) was found between IOTF BMI and HAZ. Of the obese children, 68.4% were stunted, while 31.6% of overweight children and only 13.6% of the normal and underweight children were stunted (Fig. 1). Almost a third of the stunted group of children were overweight/obese (BMI ≥25 kg/m^2) (Table 2).

Table 3. Chi-square values for the different relationships tested (*N*=519)

Factors tested	Provinces, *p*-values	Gender, *p*-values
WAZ ≥1 SD group	0.1415	0.6716
BAZ ≥1 SD group	0.0074*	0.2038
IOTF BMI ≥25 kg/m^2 group	0.0277*	0.0034*
Stunted group	0.6462	0.3649
Stunted normal-weight group	0.2354	0.9546
Stunted overweight group	0.3298	0.1003

*Significant.

Discussion

There is a need to address the growing trend of overweight and obesity in children and its consequences by means of appropriate interventions, especially in low- and middle-income countries.[7] This study documented that in Gauteng and Mpumalanga provinces, SA, 12% of children were overweight/obese (IOTF BMI ≥25 kg/m^2), which is somewhat lower than that reported at the national level for the entire 2005 survey (14%),[8] as well as for the1999 NFCS, in which 17.1% of children aged 1 - 9 years carried excessive weight.[7] No comparison could be made with the more recent South African National Health and Nutrition Examination Survey (SANHANES) conducted in 2012, which reported on an older group of children (aged 2 - 14 years).[9] The significance of these findings should be seen against the background that, in the settings of the present study, dietary patterns are lacking in variety and the foods most consumed were reported to be maize, sugar, tea, whole milk and brown bread.[10] Only one child from a household with at least one woman of reproductive age was the inclusion criterion for the national survey. It may be expected that children living in child- or elderly-headed households could have had worse nutritional status.

The global prevalence of overweight in developing countries was reported to be 6.1% for children 0 - 5 years of age.[11] Developing countries have shown a higher increase in prevalence relative to developed countries,[11] hence the concern regarding the results of overweight and obesity in the present analysis. In this study, urbanisation may be a major factor contributing to the overweight and obesity status, since children from Gauteng were more likely to be overweight than those from Mpumalanga. Generally in SA, urban children are more likely to be overweight.[9,12] SA has been shown to have an increasing urban population in which traditional diets are steadily being replaced by Western diets, characterised by decreases in fibre and increases in fat and added sugars. Recent work has confirmed dramatic increases in added sugars and sucrose-sweetened beverage consumption in both urban and rural areas of North West Province in SA.[13]

However, in the midst of the overnutrition phenomenon, 17.0% of children in this secondary analysis were classified as stunted. Although this is somewhat lower than the national data (21.5% in 1999 and 20.0% in 2005),[10,14] the figures are of concern. Chronic malnutrition and stunting, during early childhood[2] typically occur among children living in resource-limited settings (typically prior to urbanisation).[15]

The current analysis indicated a significant association between BMI and HAZ ($p<0.0001$), which supports the literature from SA indicating that children who are short for their age have a higher risk of being overweight.[8,12] The coexistence of stunting and overweight in a group of female children has been reported within a nutrition transition context.[15] Although Jinabhai *et al.*[16] did not confirm this association in 8 - 11-year-old SA children in 1994, this phenomenon has been studied in countries experiencing urbanisation and the nutrition transition, including SA, over a number of years.[12,17] In 2010, the coexistence of stunting and combined overweight and obesity in the same child (<5 years) was reported to be as high as 18% in a regional study in Mpumalanga.[17] Our study reported a lower prevalence of 3.5% in Mpumalanga, which may be explained by the age difference (<5 years and 3 - 9 years in the present study). However, it is noteworthy that this analysis revealed more stunted children (68.4%) in the obese group than in the normal-weight and underweight group (13.6%) (Fig. 1). Possible mechanisms related to this predisposition are that stunted children have impaired fat oxidation and impaired regulation of energy intake.[12] This association, however, raises the interesting possibility that the clinical interpretation of BMI is different between those who are stunted and those who are of normal height. Do the overweight stunted child and the overweight normal-height child have the same health risks? Although experiencing chronic undernutrition in early childhood and exposure to energy-dense diets (possibly with urbanisation) in later years could be argued as a cause of overweight, the broader social, environmental and dietary determinants of the association need to be better understood, as do the implication(s) of these findings in defining policy and appropriate interventions.

Conclusion

Of major concern in this study is the high prevalence of both overweight (12%) and stunting (17%) in the same cohort of mainly low socioeconomic groups of children. This study revealed a significant, negative association between BMI and HAZ, with more overweight children than normal-weight and underweight children being stunted. Even though the cause of overweight in these children cannot be determined by this cross-sectional set of data, the effects of an urbanised lifestyle within the nutrition transition could play a major role if children are less active and consume more convenience foods.

In the interest of public health, these results, in the context of other available data, should be considered as a high priority for the prevention of childhood obesity. Since malnutrition is preventable, policy and interventions should address inadequate early nutrition as well as high-energy, unbalanced nutrition during childhood and adolescence.

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