Predictors of adolescent weight status and central obesity in rural South Africa

Elizabeth W Kimani-Murage[1,2,*], **Kathleen Kahn**[1,3,4], **John M Pettifor**[5], **Stephen M Tollman**[1,3,4], **Kerstin Klipstein-Grobusch**[6], and **Shane A Norris**[5]

[1]MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[2]African Population and Health Research Centre (APHRC), PO Box 10787, 00100 Nairobi, Kenya

[3]Umeå Centre for Global Health Research, Department of Public Health and Clinical Medicine, Umeå University, Sweden

[4]INDEPTH Network, Accra, Ghana

[5]MRC Mineral Metabolism Research Unit, Department of Paediatrics, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[6]School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Abstract

Objective—To investigate predictors of adolescent obesity in rural South Africa.

Design—Cross-sectional study. Height, weight and waist circumference were measured using standard procedures. Overweight and obesity in adolescents aged 10–17 years were assessed using the International Obesity Taskforce cut-offs, while the WHO adult cut-offs were used for participants aged 18–20 years. Waist-to-height ratio of >0·5 defined central obesity in those at Tanner stages 3–5. Linear and logistic regression analysis was used to evaluate risk factors.

Setting—Agincourt sub-district, rural South Africa.

Subjects—Participants (*n* 1848) were aged 10–20 years.

Results—Combined overweight and obesity was higher in girls (15%) than boys (4%), as was central obesity (15% and 2%, respectively). With regard to overweight/obesity, fourfold higher odds were observed for girls and twofold higher odds were observed for participants from households with the highest socio-economic status (SES). The odds for overweight/obesity were 40% lower if the household head had not completed secondary level education. For central obesity, the odds increased 10% for each unit increase in age; girls had sevenfold higher odds *v.* boys; post-pubertal participants had threefold higher odds *v.* pubertal participants; those with older

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*Corresponding author: lizmurage@gmail.com; ekimani@aphrc.org.

mothers aged 50+ years had twofold higher odds *v.* those whose mothers were aged 35–49 years; those in highest SES households had twofold higher odds *v.* those in lowest SES households.

Conclusions—In rural South Africa, adolescent females are most at risk of obesity which increases with age and appears to be associated with higher SES. To intervene effectively, it is essential to understand how household factors influence food choice, diet and exercise.

Keywords

Adolescent; Obesity; Low- to middle-income countries; South Africa; Rural areas

Obesity is increasingly a public health concern in both high-income and low- to middle-income countries (LMIC), but the prevalence is expected to increase more rapidly in LMIC[1,2]. Obesity in these countries is associated with a rise in chronic diseases such as hypertension, CHD, type 2 diabetes and certain types of cancer, which contribute substantially to the burden of disease[2]. Childhood and adolescent obesity is of particular concern, as obese children and adolescents are more likely to become obese adults and hence are at a higher risk of metabolic diseases[3,4]. In South Africa, high levels of overweight/obesity have been documented among adults[5]. There is also some evidence of high levels of overweight/obesity among children and adolescents[6,7]. In a recent study in Agincourt, rural South Africa, we described patterns of overweight/obesity and central obesity among children and adolescents aged 1–20 years. The prevalence of combined overweight and obesity was high in adolescent girls, reaching a peak of 25% at age 18 years, while central obesity was also high in adolescent girls, increasing with pubertal development and reaching a peak of 35% in girls at Tanner stage 5[8].

Predictors of child and adolescent obesity have been described in various studies[9,10] and seem to involve a complex array of influential domains: community, family/household, individual and genetic. In a literature review conducted in 2001, Davison and Birch[10] described an ecological model of predictors of child weight status. In this model, child characteristics interact with familial/household and societal/community factors to influence weight status in a child. The child's behavioural patterns including dietary intake, sedentary behaviours and physical activity predict his/her weight status. Furthermore, child characteristics including sex, age and genetic susceptibility to gaining weight moderate the impact of child behavioural patterns on the development of obesity. Family/household factors such as socio-economic factors, parenting styles, parental dietary patterns and sibling interactions influence a child's weight status through shaping the development of child behavioural patterns[9,10]. Community and wider societal and environmental factors influence the weight of the child through influencing the child's behavioural patterns and family factors[10].

There are limited studies describing the predictors of child and adolescent obesity in rural South Africa[11]. The present study aimed to assess associations between child-, maternal-, household- and community-level factors and weight status and central obesity among adolescents aged 10–20 years, randomly selected from a rural South African setting.

Study setting and population

The study was conducted in the Agincourt sub-district of Mpumalanga Province in rural north-east South Africa, close to the country's border with Mozambique. It was nested within the Agincourt health and sociodemographic surveillance system (HDSS). The Agincourt HDSS is a multi-round prospective community study established in 1992, covering the entire Agincourt sub-district. Until 2007 when the site was extended, the HDSS followed some 70 000 people living in 11 500 households in twenty-one villages, about 30%

of whom were of Mozambican origin. The Mozambicans entered South Africa mainly as refugees in the early to mid-1980s following the civil war in Mozambique. Despite voluntary repatriation programmes, most elected to remain as so-called self-settled former refugees. They are also Tsonga-speaking, have much in common culturally and have integrated to large extent with the host South African population. Despite this, the Mozambicans remain a vulnerable subgroup within the broader community[12,13].

While there have been government development initiatives, infrastructure remains limited in Agincourt. The area is dry with household plots too small to support subsistence farming. The poverty level is high[14] and labour migration is widespread, involving up to 60% of working age men and increasing numbers of women[15,16]. The Agincourt HDSS and study area have been described in detail previously[8,17].

Data and methods

We conducted a growth survey between April and July 2007. The survey targeted 4000 children and adolescents aged 1–20 years – 100 males and 100 females for each year of age – comprising about 12% of the total Agincourt HDSS population within this age spectrum. Participants had lived in the study area at least 80% of the time since birth, or since 1992 when enrolment in the Agincourt HDSS began. A total of 3511 children and adolescents (close to 80% of the sample) participated in the study[8]. All survey participants aged 10–20 years (*n* 1848) were included in the present analysis.

Measurements

Anthropometric measurements were carried out on all participants while pubertal assessment was obtained from those aged 9–20 years. Height was measured using a stadiometer (Holtain, Crymych, UK) calibrated in millimetres. Weight in kilograms (to one decimal point) was determined using a mechanical bathroom scale (Hanson; Bathroom Trends Limited, Epsom, UK), and waist circumference was measured in millimetres using an inelastic tape measure. All measurements were taken according to standard procedures[8,18]. Adolescents self-rated their pubertal stage using the Tanner 5-point pubertal self-rating scale that reflects physical development based on external primary and secondary sex characteristics[19]. This self-rating scale has been validated for black South Africans[20]. Genital development in boys and breast development in girls were used to define the stages in the present study. Data collection procedures are detailed in a previous publication[8].

Explanatory variables

Explanatory variables used in the study were obtained from the Agincourt HDSS. This involves systematic annual recording of all births, deaths and migration events occurring in the Agincourt sub-district since 1992. Additional data are collected as special census modules nested within the annual update rounds. These include education, child social grant uptake, union status and food security. An asset survey conducted in each household every two years provides a relative measure of household socio-economic status (SES)[17].

Child-level factors included age, sex and pubertal development stage; maternal-level factors included mother's age, nationality, highest education level, marital/union status and co-residence with the child; household-level factors included age, sex and highest education level of the household head and his/her relationship to the child, household food security and household SES; area of residence (predominantly South African or Mozambican) was used as a proxy for community-level characteristics.

Definitions of the explanatory variables are provided in Table 1. Pubertal stage was constructed with Tanner stage 1, 2–4 and 5 defined as pre-pubertal, pubertal and post-pubertal, respectively. Food insecurity was defined as reporting not having enough food to eat in either the last month or the last year, whereas food-secure households were those households reporting sufficient to eat both in the last month and last year. Household wealth index was constructed from household assets[21] including type and size of dwelling; water and sanitation facilities; electricity; modern assets such as a fridge and television; transport assets such as a car; communication assets such as a telephone; and livestock such as cattle. A composite score for the wealth indicator was constructed. Household wealth tertiles were generated from the composite SES score using STATA's xtile command and labelled as 'lowest' (lowest third), 'medium' and 'highest' (highest third).

Outcome measures

Outcome measures included BMI-for-age Z-score, waist-to-height ratio Z-score, combined overweight and obesity, and central obesity. BMI-for-age Z-scores were generated using the WHO 2007 reference, using the WHO AnthroPlus software (WHO, Geneva, Switzerland)[22]. Age- and sex-specific waist-to-height ratio Z-scores were sample specific. Overweight and obesity in children aged 10–17 years were determined using the absolute age- and sex-specific cut-offs for BMI recommended by the International Obesity Taskforce[23]. These are defined to pass through BMI of 25 and 30 kg/m^2 at 18 years for overweight and obesity, respectively. For adolescents aged 18–20 years, adult cut-off points for BMI of 25 and 30 kg/m^2 for overweight and obesity, respectively, were used. Overweight and obesity were combined in the analysis owing to the limited number of participants who were classified as obese. Waist-to-height ratio cut-off of >0·5 was used to determine the presence of central obesity in both boys and girls in Tanner stages 3–5[24].

Underweight status was determined among the participants to assess its influence on the outcomes. This was defined by the 5th percentile using the WHO 2007 reference for BMI-for-age Z-scores[22,25]. About 4 % of the study participants were classified as underweight. However most of those underweight were in lower ages and were in pubertal stages 1 and 2, indicating that they were still growing. Exclusion of these children altered the results only marginally; thus they were retained in the final analysis.

Ethical clearance

For the growth study, signed informed consent was obtained from the parent/caregiver for children and adolescents aged less than 18 years and from the adolescents aged 18–20 years themselves, while assent was also obtained from adolescents aged less than 18 years. Verbal informed consent is routinely obtained from participants in the Agincourt HDSS. Ethical clearances for the growth survey (# M070244) and the Agincourt HDSS (# M960720) were granted separately by the University of the Witwatersrand Committee for Research on Human Subjects (Medical).

Statistical analysis

Data analysis was undertaken using the STATA statistical software package version 10·0 (StataCorp LP, College Station, TX, USA). Student's t test was used to determine difference in means, while the χ^2 test was used to determine difference in proportions. Univariate and multiple linear and logistic regression analyses were conducted with outcome variables (BMI-for-age Z-score, waist-to-height ratio Z-score, overweight/obesity, central obesity) and explanatory variables as described above, respectively. Missing values for each variable were allocated an independent category in the regression models to maintain all participants in the analysis. The variables affected included: mother's age (9 %), nationality (9 %) and education (21 %); household head's education (11 %) and relationship with the child (<1%);

food security (4 %) and SES (2 %). Only explanatory variables significantly associated with the outcome variable at the 10 % significance level in the univariate analysis were included in the multiple regression analysis. A two-sided P value of <0·05 was considered statistically significant.

Results

The study sample comprised 903 (49·6 %) boys and 945 (50·5 %) girls aged 10–20 years; mean age was 14·6 (95 % CI 14·43, 14·83) years. There was no significant difference in mean age by sex.

Distribution of overweight/obesity and central obesity by explanatory variables

The prevalence of combined overweight and obesity among participants aged 10–20 years was 10 %, while that of central obesity among participants in Tanner stages 3–5 was also 10 %. The following categories had significantly higher prevalence of either combined overweight and obesity or central obesity: 15- to 20-year-olds v. 10- to 14-year-olds; girls v. boys; pubertal and post-pubertal v. pre-pubertal; those with older mothers; those with mothers of South African origin v. those with mothers of Mozambican origin or those who lived in villages inhabited predominantly by people of South African origin; those with the most educated household heads; and those from the highest SES households (all P<0·05; Table 1).

Multivariate analysis

Predictors of BMI-for-age Z-scores, waist-for-height ratio Z-scores, overweight/obesity and central obesity are presented in Tables 2 and 3. Only variables that were significantly associated with the outcome measures at the 10 % level of significance from univariate analysis are included in the tables. A test for collinearity among the variables included in the multivariate analysis was done; there was no significant collinearity. Additionally, interaction was tested between various variables significant at the univariate level; no significant interactions were found. Significant predictors of adolescent weight status and central obesity at the multivariate level were at child, maternal and household levels.

Child factors—All of the child-level factors examined (age, sex and pubertal development status) emerged as significant predictors of adolescent weight status and central obesity. After controlling for other covariates, for every increase in year of age, the odds of central obesity increased by 10 % (P=0·041). Compared with boys, girls had higher BMI-for-age and waist-to-height ratio Z-scores, had fourfold higher odds of being overweight or obese, and sevenfold higher odds of having central obesity (all P<0·001). Compared with pre-pubertal adolescents, pubertal and post-pubertal adolescents had higher BMI-for-age Z-scores and post-pubertal adolescents had higher waist-to-height ratio Z-scores; while post-pubertal adolescents had fourfold higher odds of overweight/obesity compared with pre-pubertal adolescents and threefold higher odds of having central obesity compared with pubertal adolescents (all P<0·001; Tables 2 and 3).

Maternal factors—Among maternal factors included, only the mother's age was a significant determinant. Adolescents of older mothers aged 50+ years had close to twofold higher odds of central obesity compared with adolescents whose mothers were aged 35–49 years (P=0·020; Table 3).

Household factors—After controlling for other covariates, significant household-level predictors included household head's highest education level, food security and SES. Compared with adolescents in households headed by someone with no formal education,

adolescents in households where the household head had education below secondary level certificate had lower BMI-for-age Z-scores and had 40 % lower odds of being overweight/obese (all $P<0.05$). Adolescents in food-secure households had higher waist-to-height ratio Z-scores ($P=0.046$). Compared with adolescents in the lowest SES households, those in the medium and the highest SES households had higher BMI-for-age Z-scores (both $P\ 0.001$), while those from the highest SES households had higher waist-to-height ratio Z-scores ($P=0.031$). Similarly, those from the highest SES households had about twofold higher odds of overweight/obesity and central obesity (both $P<0.05$; Tables 2 and 3).

Discussion

The present study has described key predictors of weight status and central obesity among adolescents aged 10–20 years living in rural South Africa. The study has demonstrated that significant predictors are at child level including age, sex and pubertal development; at maternal level including mother's age; and at household level including highest education of the household head, food security status and SES. Identifying context-specific predictors of the increasingly important problem of child obesity is an important step in its prompt containment given its link to the risk for paediatric metabolic diseases in LMIC[26,27].

The study reports a substantial prevalence of overweight/obesity particularly among girls, which is consistent with other findings in South Africa[28]. This is also consistent with findings in other LMIC undergoing a nutrition transition[26,29]. Substantial levels of child overweight/obesity have been reported in Africa particularly in North African countries such as Egypt, in other southern African countries, and even in countries as poor as Malawi[30].

Consistent with other studies[10], child-level factors emerged as key predictors of adolescent weight status and central obesity. Obesity increased with increase in age and was associated with pubertal development. This may reflect the effect of factors such as increased sedentary behaviour and decreased physical activity with age and pubertal onset[10,31]. These changes are explained by physical, social and emotional changes[32]. However, sedentary behaviour and physical activity, which could have influenced the outcomes, were not measured in the present study. The increased risk of obesity among girls in our study is in keeping with studies in other LMIC[29] and in South Africa in particular[6]. Several factors may explain the sex differences in obesity: (i) biologically, energy needs differ for boys and girls and also in relation to rate of growth[33]; and (ii) behaviourally, boys are generally more physically active than girls especially during adolescence[11,32,34]. Concerns about body image, particularly among adolescent girls, can lead to problematic eating behaviours such as irregular meal patterns which may result in increased weight gain[35]. Differential problematic eating behaviours by sex have been reported among youth in South Africa[36].

While many studies have documented the effect of mother's age on child undernutrition, little has been documented on the effect of mother's age on adolescent obesity. The present study indicates that adolescents with older mothers are significantly more likely to be centrally obese. Although this needs further study, we postulate that this may be associated with less knowledge of the adverse health effects of obesity in the older age group, particularly given their lower literacy levels in the study community[37], and a stronger adherence to the cultural value ascribed to larger women. This may lead to practices that promote obesity since studies indicate that parents serve as role models for their children; for example, children often prefer foods eaten by their parents. Additionally, older mothers may monitor their child's behaviour less, which may affect the child's diet and physical activity patterns[10].

The household-level predictors of obesity observed in the present study include household head's highest education level, food security and SES. Education may affect nutritional status through knowledge of a healthy diet and of the harmful effects of overnutrition. It may also affect income levels leading to sedentary lifestyles, availability of food and dietary changes. In our study, education less than secondary certificate was protective, while secondary and tertiary education – levels that could lead to higher SES – were not significantly associated with obesity. There was, however, a tendency towards a positive association. There seems, therefore, to be a mixed effect: while on the one hand education is protective, it also leads to higher BMI and central obesity. However, the household head's education level was observed to be significantly associated with SES (although there was no significant collinearity); this may indicate attenuation of each of these factors in the overall effect.

Available literature on the association between food (in)security and childhood/adolescent overweight/obesity is generally conflicting[38,39]. In high-income countries, food insecurity is often associated with child and adolescent overweight/obesity[38] because the poor may opt for cheaper, energy-dense processed foods[40]. However, there are also studies that indicate otherwise[39]. Similarly, in the limited literature from LMIC, some studies have found a positive association between food insecurity and overweight/obesity, and others the opposite[38]. The Agincourt study area, a former homeland, has low local food production; hence food security may relate strongly to the ability to afford purchased (processed) food.

The relationship between SES and obesity varies across different countries depending on economic development[41]. The pathways through which SES is associated with overnutrition include income, education and occupation, resulting in behaviours which influence the balance between energy intake, expenditure and metabolism[42]. The positive relationship found in the present study is in keeping with several other studies in LMIC[9,29,41], but contradicts findings in high-income countries[41]. However, even in high-income countries such as the USA the reverse association between SES and overnutrition is said to be weakening over time and is population specific, particularly in children[43,44]. Although South Africa is classified as a middle-income country, there is high intra-country inequality with regard to income distribution and high levels of poverty in some regions. The study area is low-income, located in one of the three provinces with the highest poverty rates in South Africa[14]. The relationship observed may be associated with the sedentary lifestyle and ability to afford processed foods of those in the highest SES category relative to those in the lowest SES category. Results not shown on the assets that constitute the socioeconomic score indicate that while almost all of the highest SES households owned a television (96 %), slightly below 50 % of the lowest SES did; while 35 % of the highest SES households owned a car, only 7 % of the lowest SES households did. SES and food security variables were significantly associated, although the association was not significantly collinear. This may indicate attenuation of the overall effect of each of these variables.

Extensive labour migration to larger towns outside the study area[15,16] facilitates the transfer and introduction of urban practices to rural settings with consequent change in diet, resulting in substitution of traditional foods with energy-dense processed foods as seen in some settings in South Africa[45]. While those in higher SES households may afford to purchase such foods, the poorest may not and would therefore rely on limited home-grown produce and wild foods. Consumption of animal products and energy-dense foods has been associated with overweight/obesity in countries undergoing nutrition transition[1].

The present study did not address the association between weight status and central obesity and their more proximate determinants; i.e. imbalance between energy intake and expenditure such as dietary patterns and physical activity. However, there is little

controversy concerning these factors. The study therefore focused on the more distal determinants which give rise to the imbalance and for which current evidence is more limited. A further limitation relates to the measurement of food security, which was designed primarily as a simple tool to measure trends in household food security in the Agincourt health and sociodemographic surveillance area over time rather than to detail multiple dimensions of food security.

Our study has identified key predictors of adolescent weight status and central obesity in rural South Africa. The findings show that female sex, pubertal development, being in a household that is food secure and of higher SES (measured using household assets) are the most important predictors of weight status and central obesity. These findings indicate a need for gender-sensitive intervention strategies that take into consideration pubertal development, relative wealth and related behaviours in curbing the rising problem of child and adolescent obesity. Further research into dietary patterns and physical activity among adolescents in the study area and related settings, and their associations with child- and household-level characteristics, is necessary for effective interventions.

Acknowledgments

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Table 1

Distribution of combined overweight and obesity[*] for adolescents aged 10–20 years (n 1848) and central obesity[†] for adolescents in Tanner stages 3–5 (n 1110) by various covariates, Agincourt sub-district, South Africa, 2007

Variable	n	%	Combined overweight and obese (%)	n	%	Central obesity (%)
CHILD CHARACTERISTICS						
Age (years)			$P=0.003$			$P=0.014$
10–14	944	51.1	7.5	285	25.7	6.3
15–20	904	48.9	11.6	825	74.3	11.4
Sex			$P<0.001$			$P<0.001$
Boy	903	49.6	3.5	425	38.3	2.4
Girl	945	50.5	15.2	625	61.7	14.9
Pubertal status			$P<0.001$			$P<0.001$
Pre-pubertal	283	15.4	4.2	–	–	–
Pubertal	1374	74.6	8.4	926	83.4	7.4
Post-pubertal	184	10.0	26.6	184	16.6	23.9
MATERNAL CHARACTERISTICS						
Age, current (years)			$P50.015$			$P=0.011$
15–34	302	8.0	8.3	614	61.7	8.2
35–49	1001	59.7	8.2	103	10.3	10.7
50+	373	22.3	13.1	279	28.0	14.7
Nationality			$P=0.023$			$P=0.087$
South African	1131	67.5	10.4	709	71.2	11.3
Mozambican	544	32.5	7.0	287	28.8	7.7
Education			$P=0.949$			$P=0.568$
No formal education	547	37.4	9.0	340	38.9	8.8
Some education below secondary certificate	659	45.1	8.5	393	44.9	9.7
Secondary and higher	255	17.5	9.0	142	16.2	12.0
Marital/union status			$P=0.862$			$P=0.655$
Currently in union	944	51.1	9.6	562	50.6	10.5
Not in union	904	48.9	9.4	548	49.4	9.7
Co-residence with child			$P=0.875$			$P=0.547$

Variable	n	%	Combined overweight and obese (%)	n	%	Central obesity (%)
Alive, co-residing	1536	83·1	9·5	921	83·0	10·5
Alive, not co-residing	163	8·8	10·7	96	8·7	8·3
Dead	149	8·1	8·7	93	8·4	7·5
HOUSEHOLD CHARACTERISTICS						
Age of HHH (years)			P=0·296			P=0·435
15–49	739	40·0	8·7	414	37·4	9·2
50+	1107	60·0	10·1	694	62·6	10·7
Sex of HHH			P=0·131			P=0·343
Male	1207	65·4	8·8	717	64·7	9·5
Female	639	34·6	11·0	391	35·3	11·3
Education of HHH			P=0·022			P=0·318
No formal education	806	49·1	10·3	496	50·5	10·3
Some primary, completed primary, some secondary	692	42·2	7·4	402	40·9	8·2
Secondary and higher	143	8·7	14·0	84	8·55	13·1
HHH's relationship to child			P=0·132			P=0·660
Parent	1272	68·8	8·8	1272	69·1	10·6
Grandparent	430	23·3	12·9	430	23·3	8·9
Other relative	140	7·6	10·0	140	7·6	8·3
Enough food (last month/year)			P=0·073			P=0·051
Yes	1443	81·2	10·4	872	81·5	11·3
No	335	18·8	7·2	198	18·5	6·6
SES (wealth index tertile)			P=0·002			P=0·074
Lowest	605	33·4	6·8	345	31·7	7·9
Medium	603	33·3	9·6	364	33·5	9·9
Highest	603	33·3	12·8	378	34·8	13·0
COMMUNITY FACTORS						
Area of residence			P=0·047			P=0·712
Predominantly South African	1746	94·5	9·9	1063	95·8	10·2
Predominantly Mozambican	102	5·5	3·9	47	4·2	8·5

HHH, household head.

*
International Obesity Taskforce criteria[23] for those <18 years and BMI 25 kg/m^2 for those 18 years.

†Waist-to-height ratio of >0·5[24].

Table 2

Determinants of BMI-for-age Z-score and combined overweight and obesity[*] in adolescents aged 10–20 years (n 1848), Agincourt sub-district, rural South Africa, 2007

	BMI-for-age Z-score[†]			Overweight and obesity[‡]		
	Coefficient	95 % CI	P	OR	95 % CI	P
CHILD CHARACTERISTICS						
Age	−0·00	−0·03, 0·02	0·790	1·01	0·94, 1·07	0·822
Sex						
Boy (ref.)	0			1·00	–	
Girls	0·58	0·46, 0·69	<0·001	4·24	2·82, 6·38	<0·001
Pubertal status						
Pre-pubertal (ref.)	0			1·00	–	
Pubertal	0·31	0·14, 0·48	<0·001	1·40	0·71, 2·75	0·331
Post-pubertal	1·07	0·77, 1·36	<0·001	4·41	1·93, 10·10	<0·001
MATERNAL CHARACTERISTICS						
Age (years)						
35–49 (ref.)				1·00	–	
15–34				1·39	0·83, 2·32	0·211
50+				1·45	0·96, 2·20	0·075
Nationality						
South African (ref.)	0			1·00	–	
Mozambican	−0·10	−0·25, 0·05	0·176	0·85	0·55, 1·31	0·459
Education						
No education (ref.)	0					
Some education below secondary level	0·05	−0·11, 0·12	0·517			
Completed secondary/tertiary	0·04	−0·18, 0·26	0·702			
HOUSEHOLD CHARACTERISTICS						
Sex of HHH						
Male (ref.)						
Female						
Education of HHH						

	BMI-for-age Z-score[†]			Overweight and obesity[‡]		
	Coefficient	95 % CI	P	OR	95 % CI	P
No education (ref.)	0			1·00	–	
Some education below secondary level	−0·14	−0·28, −0·00	0·046	0·60	0·40, 0·89	0·012
Completed secondary/tertiary	0·14	−0·10, 0·38	0·243	1·11	0·61, 2·02	0·737
Food security						
Yes (ref.)	0			1·00	–	
No	0·15	−0·00, 0·29	0·052	1·35	0·84, 2·16	0·216
SES (wealth index tertile)						
Lowest (ref.)	0			1·00	–	
Medium	0·25	0·11, 0·39	0·001	1·40	0·90, 2·19	0·134
Highest	0·28	0·14, 0·43	<0·001	1·99	1·28, 3·09	0·002
COMMUNITY FACTORS						
Area of residence						
Predominantly South African (ref.)	0			1·00	–	
Predominantly Mozambican	−0·08	−0·34, 0·17	0·528	0·51	0·17, 1·51	0·227

HHH, household head; ref., reference category.

[*] International Obesity Taskforce criteria[(23)] for those <18 years and BMI 25 kg/m^2 for those 18 years.

[†] Linear regression.

[‡] Logistic regression.

Table 3

Determinants of waist-for-height ratio Z-score for adolescents aged 10–20 years (*n* 1848) and central obesity[*] for adolescents in Tanner stages 3–5 (*n* 1110), Agincourt sub-district, rural South Africa, 2007

	Waist-for-height ratio Z-score[†]			Central obesity[‡]		
	Coefficient	95% CI	P	OR	95% CI	P
CHILD CHARACTERISTICS						
Age	−0·16	−0·03, 0·00	0·062	1·10	1·00, 1·21	0·041
Sex						
Boy (ref.)	0			1·00	–	
Girl	−0·04	−0·13, 0·06	0·447	7·19	3·65, 14·15	<0·001
Pubertal status						
Pre-pubertal§	0					
Pubertal‖	0·06	−0·09, 0·20	0·448	1·00	–	
Post-pubertal	0·44	0·22, 0·66	<0·001	2·87	1·79, 4·61	<0·001
MATERNAL CHARACTERISTICS						
Age (years)						
35–49 (ref.)				1·00	–	
15–34				1·88	0·88, 3·98	0·101
50+				1·75	1·09, 2·82	0·020
Nationality						
South African (ref.)	0			1·00	–	
Mozambican	−0·06	−0·17, 0·05	0·275	0·87	0·50, 1·49	0·603
HOUSEHOLD CHARACTERISTICS						
Sex of HHH						
Male (ref.)						
Female						
Education of HHH						
No education (ref.)						
Some education below secondary level						
Completed secondary/tertiary						
Food security						

	Waist-for-height ratio Z-score[†]			Central obesity[‡]		
	Coefficient	95% CI	P	OR	95% CI	P
Yes (ref.)	0			1·00	–	
No	0·12	0·00, 0·24	0·046	1·69	0·90, 3·18	0·103
SES (wealth index tertile)						
Lowest (ref.)	0			1·00	–	
Medium	0·08	–0·03, 0·19	0·163	1·27	0·73, 2·22	0·399
Highest	0·13	0·01, 0·25	0·031	1·90	1·10, 3·30	0·021
COMMUNITY FACTORS						
Area of residence						
Predominantly South African (ref.)						
Predominantly Mozambican						

HHH, household head; ref., reference category.

[*] Waist-to-height ratio of >0·5[(24)].

[†] Linear regression.

[‡] Logistic regression.

[§] Pre-pubertal used as reference in the model for central obesity and waist-for-height Z-score for adolescents aged 10–20 years.

[//] Pubertal used as reference in the model for central obesity for adolescents in Tanner stages 3–5.