Ecology of Food and Nutrition
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gefn20

Physical Activity and Socioeconomic Status Explain Rural-Urban Differences in Obesity: a Cross-Sectional Study in Benin (West Africa)

Gervais Ntandou [a], HéLène Delisle [a], Victoire Agueh [b] & Benjamin Fayomi [c]

[a] WHO Collaborating Centre on Nutrition Changes and Development (TRANSNUT), Department of Nutrition, Université de Montréal, Canada

[b] Regional Institute of Public Health (IRSP), Université d'Abomey Calavi, Ouidah, Bénin

[c] Applied Biomedical Sciences Institute (ISBA), Cotonou, Benin

Published online: 28 Jul 2008.

Ecology of Food and Nutrition, 47: 313–337, 2008

ISSN: 0367-0244 print / 1543-5237 online
DOI: 10.1080/03670240802003835

Routledge
Taylor & Francis Group

PHYSICAL ACTIVITY AND SOCIOECONOMIC STATUS EXPLAIN RURAL-URBAN DIFFERENCES IN OBESITY: A CROSS-SECTIONAL STUDY IN BENIN (WEST AFRICA)

GERVAIS NTANDOU
HÉLÈNE DELISLE

WHO Collaborating Centre on Nutrition Changes and Development (TRANSNUT), Department of Nutrition, Université de Montréal, Canada

VICTOIRE AGUEH

Regional Institute of Public Health (IRSP), Université d'Abomey Calavi, Ouidah, Bénin

BENJAMIN FAYOMI

Applied Biomedical Sciences Institute (ISBA), Cotonou, Benin

To explore the relationships between obesity, socioeconomic status (SES), and physical activity (PA), we conducted a study with 341 subjects of a medium-size city of Benin and its semi-rural outskirts. PA was appraised with 24-hour recalls and SES, with a questionnaire. The overall prevalence of obesity (body mass index [BMI] ≥ 30), abdominal obesity (waist circumference) and elevated percent of body fat (%BF) were 10.6%, 23.8% and 20.2%, respectively. However, 14.6% were underweight (BMI < 18.5). Overweight (BMI ≥ 25) was significantly higher in urban than rural areas and in women

Address correspondence to Hélène Delisle, Ph.D., Director of TRANSNUT, WHO Collaborating Centre on Nutrition Changes and Development, Department of Nutrition, Faculty of Medicine, Université de Montréal, PO Box 6128 Downtown Station, Montreal, Canada H3C 3J7. E-mail: helene.delisle@umontreal.ca

than men. SES and PA were independently associated with obesity indicators, while urbanization variables were not.

KEYWORDS obesity, socioeconomic status, physical activity, medium-size city of Benin

INTRODUCTION

Overweight and obesity have considerably increased in developing countries during the last two decades (Caballero, 2001). Rapid changes in urbanization and socioeconomic circumstances, related to the nutrition transition, are contributing to major epidemiological changes with the emergence of chronic diseases like obesity, diabetes, hypertension, cardiovascular diseases (CVD), and others (Maire et al., 2002; Popkin, 2001). Increasing level of obesity is more frequent in middle income developing countries where the nutrition transition had reached an advanced stage than in low income countries (Popkin, 2002), as most Sub-Saharan African countries. While obesity increases, undernutrition persists and coexists with obesity in the same environment (Monteiro et al., 2002; Monteiro et al., 2004b; van der Sande et al., 2001), and even in the same households (Doak et al., 2000; Ntandou et al., 2005; Raphael et al., 2005).

Living in a city is associated with a higher risk of obesity than in rural areas, especially in women as shown in the Cameroon (Sobngwi et al., 2004; Sobngwi et al., 2002). Additionally, more overweight is seen in higher than lower socioeconomic groups (Fezeu et al., 2006; Singh et al., 1999). There is also evidence that physical inactivity or sedentary lifestyle increase the risk of overweight and obesity (Kruger et al., 2002), while high levels of physical activity reduce that risk (Gregory et al., 2007).

Benin, like most sub-Saharan African countries, has seen its urban population grow from 27% in 1979 to 39% in 2002 (INSAE, 2003). Changes in urbanization rate are accompanied by increasing overweight level. Among women aged 15–49 years, Demographic and Health Surveys (DHS) have reported between 1996 and 2001 an increase of 105% of overweight. Underweight declined by only 27% over the same period, so that it coexists with overweight (INSAE/DHS, 1996; INSAE/DHS, 2001). There is some data on obesity in Benin, unpublished and published (Acakpo et al., 2000; INSAE/DHS, 2001). However, no study examined its relationship with major determinants, including physical activity. In addition, most studies were performed in the two largest cities, which represent less than 15% of the total population of Benin. Our study aimed at assessing the prevalence of obesity and its relationships with socioeconomic status (SES) and physical activity in apparently healthy adults living in the medium-size city of Ouidah and its semi-rural outskirts. We hypothesised that overweight and obesity are more frequent in the urban than rural area and in the higher SES subjects compared to lower SES ones primarily because of a more sedentary lifestyle.

METHODS

Setting

The study took place in Ouidah, a medium-size city located 50 km away from Cotonou, the economic capital of Benin, West Africa. The estimated population is 64 433 and the municipality consists of 60 urban or rural neighborhoods (Commune de Ouidah, 2005; INSAE, 2003). An urban area is defined as an administrative center with a population of at least 10 000 and offering four or more public services among the following: a post office, a finance department of the government, a public water distribution system, electricity, a health center, and a secondary school (INSAE, 2003). Administrative activities, commerce, transport, and tourism are more common in the urban areas, whereas agriculture, animal farming, crop transformation, and sand exploitation are common in semi-rural neighborhoods (Commune de Ouidah, 2005). This study is part of a larger multi-site research project on the nutrition transition and its links with cardiovascular diseases risk factors in adults.

Sample

A sample of 340 adult subjects was randomly selected in 5 urban and 5 rural neighborhoods of Ouidah, also picked at random. We used the PASS (Power analysis and sample size) software package (2005) for calculating sample size, which was estimated at 328 subjects (164 in each group). This sample size is adequate to detect a difference of 7% in the prevalence of obesity among urban and rural women with 80% statistical power. This is based on a prevalence rate of 1% in rural and 8% in urban women, respectively, according to the DHS data (INSAE/DHS, 2001). The size of the sample was increased to 340[1] to provide some margin for drop-outs and missing subjects, as well as incomplete data sets. We assumed that the design effect within groups (rural and urban) was close to one and that our sample could be considered a random sample. The two-sided Fisher's Exact test is used for group comparisons and the level of significance is set at $p < 0.05$. Due to the absence of census data, we first made a list of all the extended families (or compounds) of the selected villages (including all hamlets) or Ouidah neighborhoods and randomly selected 34 in each case. Then we numbered all the households in each selected family/compound and drew one of them. The final step was to make a list of all eligible adults of the selected household and to pick a name among them, alternating one man and one woman. A total of 171 subjects were studied in the urban area (86 men and 85 women) and 170 in the semi-rural area (85 men and 85 women). Only Benin Native subjects aged 25–60 years, and living in Ouidah since at least 6 months were included in the sample. All had two Beninese parents and grand parents and were apparently healthy (not diagnosed for hypertension, diabetes, and cardiovascular diseases). Pregnant and lactating women, and physically or mentally disabled subjects, were excluded.

Anthropometry and Body Composition

Anthropometric measures were all taken by the first author. Weight was measured on a portable mechanical scale with a maximum capacity of 150 kg (Seca Model 761 Mechanical Personal Scale, Germany) to the nearest 0.1 kg and height was measured to the nearest of 0.5 cm with a stadiometer (Seca 214 Portable Height Rod, Germany). BMI (kg/m^2) was computed (weight divided by height squared). The BMI cut-offs for overweight and general obesity were 25 and 30, respectively; underweight was defined as BMI < 18.5 (WHO, 2000). While subjects were standing and breathing normally, waist circumference (WC) was measured to the nearest of 0.1 cm with a flexible non-stretch steel tape at the midpoint between the lower rib margin and the iliac crest (Després et al., 2001). The average of two separate measures of WC was used in the analyses. Abdominal obesity was defined as a

[1]The final sample is 341 because one subject whom we thought was lost returned and insisted to complete the study.

waist circumference ≥ 102 cm for men and ≥ 88cm for women (WHO, 2000).

We used Bioelectrical Impedance Analysis (BIA) measure body composition (RJL System, Quantum II, USA). For BIA measurements, subjects had to be in the fasting state since at least 12 hours, had not engaged in vigorous work or physical activity during the last 24 hours and had to be sober since 48 hours before. The individual was lying on a non- conductive surface with a minimum of clothing before placing the electrodes on the hand and foot of the same body side (left or right). We computed the percentage body fat (%BF) using the prediction equation for fat-free mass (FFM) suggested by Sun et al., (2003). Excess body fat was defined as %BF > 25% in men, and %BF > 33% in women, as suggested for both black and white subjects (Jackson et al., 2002).

Demographic and Socioeconomic Parameters

Demographic and socioeconomic data were obtained with a structured questionnaire pre-tested in 10 non-participating subjects. We collected information on age, place of birth (0 = rural; 1 = urban), place of current residence (0 = rural, 1 = urban), and we computed the total duration of urban and rural residence in years. Information about education level (0 = none; 1 = elementary school; 2 = high school and above) and socio-professional category (1 = professional and technical employment; 2 = sales and services, 3 = agriculture, 4 = other manual employment and 5 = no employment or women and men stay at home) were also collected.

We used as proxy for income a household amenity score such as used in DHS in Benin (INSAE/DHS, 2001). This score included 12 items: ownership of plot of land, motorcycle, car, TV, mobile phone, line phone, and refrigerator; electricity, water in the house; type of fuel used for cooking; and wall and floor material. The first nine items were dichotomous and coded “1” if the amenity was present and “0” if absence. The last two items were also dichotomous and coded “1” for cement wall or floor, and “0” for other material. Fuel used for cooking was coded 1; 0.5 and 0 for petroleum or gas, charcoal, and firewood, respectively. The amenity (or SES) score was the summation of these items for a maximum of 12. The internal consistency of the score was acceptable with Cronbach a = 0.71. Based on score tertiles, we identified three SES levels: low (0 to 2), medium (3 to 4) and high (5–10). No subject reached a maximum SES score of 12.

Physical Activity

Physical activity was assessed with three non-consecutive 24-hour recalls (Gortmaker et al., 1999). Two interviewers asked participants about all the activities of the previous day, including time spent in bed, in various modes of transportation, for main (and secondary) occupations, for house chores, and for leisure activities. We first classified all activities in three groups: main occupation, transportation, and leisure. We then categorized activities of each group according to intensity level according to the metabolic equivalents (METs), based on the compendium of physical activities (Ainsworth et al., 2000): light (< 3.0 METs); moderate (3.0 ≤ METs ≤ 6.0 METs), and vigorous (> 6.0 METs). Time devoted to each type of activity was also expressed as mean number of hours per day for each level of energy expenditure. The total daily hours of intense, moderate and light activity were computed. For example, daily hours of light physical activity were obtained by summing hours of sedentary occupation, sedentary transportation, and sedentary leisure. For the main occupation, we considered vigorous work (e.g., masonry, professional athletic, professional drummer), moderate work (e.g., gardening, carpentry, fishing, hunting, teaching) and light or sedentary work (e.g., studying, house chores, computer work, waitress). For transportation, we retained bicycling as vigorous, walking as moderate and motor vehicle as light activity. Three levels of energy expenditure were also considered for leisure activity: vigorous (football, basket-ball, and intense physical exercises), moderate (dancing, gymnastics, and moderate physical exercises), and light or sedentary (Television viewing, playing cards, board games . . .).

Data Collection Procedure

Enrolment of subjects was done during home visits. The author, along with a local guide and a survey team of two, went from house to house to explain the study and obtain the informed consent of selected individuals. The data were collected over a period of 6 months (July–December 2006). The study was approved by the Ethics Committee of the Faculty of Medicine (Université de Montréal) and by the Ministry of Health in Benin. All subjects were informed about the purpose of the study and data collection procedures. Participation was on a volunteer basis. All participants signed the informed consent form in the presence of a witness. According to local customs, we also obtained husbands' consent to include married women. Participants were given and explained the results of anthropometric measures.

Statistical Analyses

Data were analysed using SPSS, version 15.0 (SPSS Inc, Chicago, IL). Urban-rural and men-women differences were assessed using as appropriate two-tailed chi-square tests, t-tests, and Oneway analyses of variance (Anova) with Tukey post hoc test. Multiple linear regression models of obesity indicators on urbanization indicators, socio-economic factors and physical activity, adjusted for age and sex, were constructed using stepwise method. Separate models were also performed for men and women. Employment was not included in the multivariate models because it could not be aggregated into two or three meaningful categories. Models are presented in order to show the variance of obesity when each independent variable was added in the models. Non significant variables were automatically rejected. The level of statistical significance was $p < 0.05$ for chi-square, t-test, and Anova, and $p < 0.10$ for multiple regressions.

RESULTS

A total of 364 subjects were invited to participate in the study; 356 accepted and 341 completed the study, giving a 93.7 % participation rate.

Socioeconomic Characteristics

Mean age of participants was 37.7 ± 10.2 years and did not differ by sex or current residence (urban or rural) (Table 1). Overall, 60.7% of subjects were born in the city and 39.3% in a rural area. Roughly one out of four subjects currently living in rural neighborhoods was born in the city (25.9% in men and 28.2% in women). The average number of total years of urban and rural residence was 22.9 ± 18.3 and 14.7 ± 17.4, respectively. Close to one third of participants had no education (30.5%), 37.5% had reached primary school, and 32%, secondary school level or higher. Current urban dwellers were more educated than rural subjects, both men ($p = 0.007$) and women ($p = 0.002$). In both locales, men were more educated than women ($p < 0.001$). Regarding employment (Table 1), 54.3% were in sales or services; 21.1% were engaged in agriculture and 12% were manual workers (without professional qualification). Only 8.5% of subjects were in professional or technical occupations (skilled or

Table 1. Characteristics of subjects

	All (n=341)	Urban		p	Rural		p	Urban vs Rural	
		Men (n=86)	Women (n=85)		Men (n=85)	Women (n=85)		Men (n=171)	Women (n=170)
Age (y)	37.7 ± 10.2[a]	37.1 ± 10.7	38.9 ± 9.8	0.27	36.8 ± 9.8	37.9 ± 10.5	0.47	0.35	0.53
Place of birth, % (n)									
Urban	60.7	98.8 (85)	89.4 (76)	0.009	25.9 (22)	28.2 (24)	0.86	< 0.001	< 0.001
Rural	39.3	1.2 (1)	10.6 (9)		74.1 (63)	71.8 (61)			
Total duration of urban residence (y)	22.9 ± 18.3	35.6 ± 11.8	37.1 ± 11.6	0.42	8.1 ± 12.1	10.6 ± 14.3	0.26	< 0.001	< 0.001
Total duration of rural residence (y)	14.7 ± 17.4	1.49 ± 5.3	1.69 ± 4.8	0.79	28.7 ± 15.3	27.3 ± 15.4	0.55	< 0.001	< 0.001
Education level, % (n)									
No education	30.5 (104)	7.0 (6)	36.5 (31)	< 0.001	16.5 (14)	62.4 (53)	< 0.001	0.007	0.002
Elementary school	37.5 (128)	36.0 (31)	37.6 (32)		49.4 (42)	27.1 (23)			
High school and above	32.0 (109)	57.0 (49)	25.9 (22)		34.1 (29)	10.6 (9)			
Employment, % (n)									
Professional and technical	8.5 (29)	19.8 (17)	0	< 0.001	10.6 (9)	3.5 (3)	< 0.001	< 0.001	0.002
Sales and services	54.3 (185)	33.7 (29)	92.9 (79)		11.8 (10)	78.8 (67)			
Agriculture	21.1 (72)	4.7 (4)	0		65.9 (56)	14.1 (12)			
Other manual	12 (41)	36 (31)	1.2 (1)		10.6 (9)	0			
None (stay at home)	4.1 (14)	5.8 (5)	5.9 (5)		1.2 (1)	3.5 (3)			
SES score [b]	3.4 ± 2.1	4.8 ± 1.9	4.3 ± 1.8	0.12	2.2 ± 1.7	2.0 ± 1.7	0.39	< 0.001	< 0.001
BMI (kg/m^2)	23.2 ± 5.1[a]	22.3 ± 3.0	26.4 ± 6.3	< 0.001	20.9 ± 3.4	23.1 ± 5.3	0.002	0.007	< 0.001
Waist circumference (cm)	83.5 ± 11.7	82.6 ± 9.2	88.2 ± 14.3	0.003	79.3 ± 7.6	84.0 ± 12.9	0.004	0.013	0.049
Percent of body fat	15.1 ± 9.8	17.4 ± 6.2	29.5 ± 9.4	< 0.001	16.4 ± 6.8	24.7 ± 8.9	< 0.001	0.28	0.001

[a]Variables are presented as Means ± SD; [b]Socioeconomic status based on household amenities.

semi-skilled), and 4.1% were unemployed. A majority of rural men (65.9%) were in the agricultural sector, while urban men were involved equally in manual jobs (36%) and sales (33.7%). A high percentage of women were in sales and services in both locales (92.9% and 78.8% for urban and rural areas, respectively). Socioeconomic status score (SES) based on amenities was significantly higher in urban compared to rural men and women ($p < 0.001$), but not in men compared to women in the same locale.

Weight Status and Body Composition

Body mass index (BMI), waist circumference (WC), and percent of body fat (%BF), used as obesity indicators (Table 1), were all significantly higher in urban than rural women ($p < 0.001$, $p < 0.05$, $p < 0.01$ respectively for BMI, WC and %BF). The same tendency was observed in men, but the difference was only significant for BMI and WC ($p < 0.01$ and $p < 0.05$ respectively). The overall prevalence rate of general obesity was 10.6%, abdominal obesity 23.8%, and elevated %BF 20.2%. We found highly significant correlations among these three obesity indicators in both men and women, but the correlations were stronger in women than men.

Interestingly, we observed a similar rate of underweight (14.7%) and overweight (16.4%). Underweight was more frequent in rural than urban area in both sexes (22.4% vs 7%, $p < 0.01$ in men and 22.1 % vs 7.1%, $p < 0.01$ in women). Conversely, overweight (and obesity) was significantly higher in urban compared to rural areas (Figure 1).

Physical Activity

Data on physical activity broken down by type of activity and intensity level are presented in Table 2. We observed that little time was devoted to vigorous activity compared to moderate and sedentary activities, whether for work or leisure. Rural subjects devoted more time to moderate activities for work compared to urban dwellers (2.6 vs 1.2 hours, in men, $p < 0.001$; 3.5 vs 2.65 hours in women, $p < 0.05$). Conversely, urban subjects had more sedentary activities than rural counterparts, especially for motorized transportation (1.4 vs 0.7 hours in men, $p = 0.008$; 0.6 vs 0.3 hours in women, $p = 0.028$) and leisure activities (1.2 vs 0.3, in men, $p < 0.001$; 0.3 vs 0.1 hours in

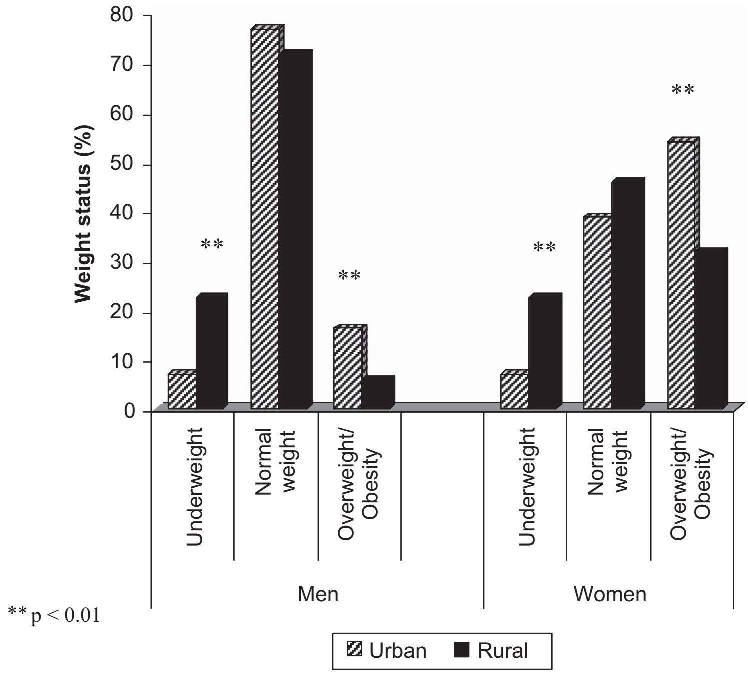

Figure 1. Weight status among men and women.

women, p = 0.07). The total daily moderate physical activity was higher in rural than urban subjects (4.2 vs 2.5 hours in men, p < 0.001; 4.3 vs 3.4 hours in women, p < 0.05), while the total daily sedentary activity was higher in urban subjects, especially in men (4.3 vs 2.4, p < 0.01), which confirms a more active lifestyle in rural compare to urban areas (Table 2).

Vigorous activity was uncommon, but significantly higher in men than women in both locations, due primarily to main occupation. Women devoted roughly twice as much time than men to their main occupation, and they had more hours of moderate activity than men for their occupation in both locations. Conversely, women had substantially less leisure time than men, irrespective of the site. Surprisingly, women had more hours of total daily moderate activity than men in urban areas (3.4 vs 2.5 hours, p = 0.001), but not in the rural areas. Men spent more time than women in transportation, whether active or inactive, in both

Table 2. Daily physical activity in urban and rural subjects

	All (n=341)	Urban		p	Rural		p	Urban vs Rural	
		Men (n=86)	Women (n=85)		Men (n=85)	Women (n=85)		Men (n=171)	Women (n=170)
Main occupation (hr/d)									
Vigorous[a]	0.07 ± 0.3	0.19 ± 0.6	0	0.003	0.08 ± 0.3	0.01 ± 0.1	0.037	0.11	0.32
Moderate[b]	2.48 ± 2.0	1.18 ± 1.4	2.65 ± 1.7	< 0.001	2.64 ± 2.0	3.46 ± 2.2	0.011	< 0.001	0.07
Sedentary[c]	3.08 ± 3.1	1.75 ± 2.8	4.83 ± 3.0	< 0.001	1.36 ± 2.4	4.39 ± 2.8	< 0.001	0.31	0.32
Transportation (hr/d)									
Bicycle[a]	0.05 ± 0.4	0.08 ± 0.69	0	0.26	0.13 ± 0.5	0.003 ± 0.02	0.015	0.58	0.32
Walking[b]	1.10 ± 1.2	1.29 ± 1.3	0.75 ± 1.0	0.003	1.52 ± 1.5	0.85 ± 0.9	< 0.001	0.26	0.52
Motor vehicle[c]	0.74 ± 1.3	1.34 ± 1.8	0.61 ± 1.1	0.002	0.69 ± 1.3	0.31 ± 0.7	0.013	0.008	0.028
Leisure activities (hr/d)									
Vigorous	0.02 ± 0.2	0.07 ± 0.3	0	0.039	0.01 ± 0.9	0	0.32	0.091	–
Moderate	0.03 ± 0.2	0.007 ± 0.04	0.04 ± 0.3	0.3	0.05 ± 0.3	0.01 ± 0.9	0.15	0.11	0.34
Sedentary	0.48 ± 1.1	1.18 ± 1.6	0.28 ± 0.6	< 0.001	0.31 ± 1.0	0.11 ± 0.6	0.10	< 0.001	0.07
Total daily physical activity (hr/d)									
Vigorous	0.15 ± 0.6	0.34 ± 1,0	0	0.001	0.22 ± 0.6	0	0.001	0.33	0.23
Moderate	3.61 ± 2.4	2.47 ± 1.8	3,44 ± 2.0	0.001	4.2 ± 2.6	4.3 ± 2.3	0.8	< 0.001	0.013
Sedentary	4.29 ± 3.4	4.27 ± 3.6	5.72 ± 3.2	0.014	2.37 ± 3.1	4.81 ± 2.9	< 0.001	< 0.001	0.055

[a]Intensity level > 6 METs; [b]Intensity level: 3 ≤ METs ≤ 6; [c]Intensity level < 3 METs.

locations. Total daily hours of sedentary activity were significantly higher in women than men in both locations.

We found a strong positive association of the SES score with total sedentary activity ($r = 0.46$, $p < 0.001$, $n = 171$) and a negative association with total moderate activity ($r = -0.33$; $p < 0.001$, $n = 171$) in men. Among women, the SES score was significantly correlated only with total sedentary activity ($r = 0.22$; $p = 0.004$, $n = 170$).

Association of Socioeconomic Variables and Physical Activity with Obesity Indicators

The SES score showed a strong positive association with all three obesity indicators in men and women. In both men and women, age was positively associated with BMI ($r = 0.18$, $p = 0.018$ and $r = 0.19$, $p = 0.015$, respectively) and even more strongly so with WC ($r = 0.43$, $p < 0.001$ and $r = 0.34$, $p < 0.001$, respectively). Living and having lived long in urban areas, as well as being born in the city, were also positively associated with BMI and WC in both men and women, and with %BF only in women. Conversely, total duration of rural residence was negatively associated with BMI ($r = -0.17$, $p = 0.025$) and WC ($r = -0.16$, $p = 0.039$) only in women. Education level was only associated with WC in women ($r = 0.16$; $p < 0.05$).

Daily hours of sedentary activity were positively correlated with all three obesity indicators in men ($r = 0.245$, $p = 0.01$; $r = 0.25$, $p = 0.01$ and $r = 0.245$, $p = 0.01$, respectively for BMI, WC and %BF), and with BMI ($r = 0.215$, $p = 0.005$) and WC ($r = 0.22$, $p = 0.003$) in women. The correlation of obesity indicators and daily hours of moderate activity was negative but only significant in men. No significant association was observed between daily vigorous activity and obesity indicators.

Using multiple linear regression models and adjusting for age, the SES score was positively and significantly associated with BMI, WC and %BF in men and women (Table 3). Daily hours of sedentary activity were positively associated with BMI and WC in women and with %BF in men. Daily moderate activity was negatively associated with BMI and WC only in men. In these multivariate models, the urbanization related variables and education level were not significant determinants of obesity status.

Table 3. Multiple linear regression models of obesity criteria on socioeconomic factors and total physical activity

Independent variables	Dependent variables								
	BMI[1]			WC[1]			%BF[1]		
	R^2	β	p	R^2	β	p	R^2	β	p
Men (N=171)									
Age (y)	0.033	0.148	0.038	0.187	0.399	< 0.001	0.022	0.131	0.076
SES score	0.152	0.294	< 0.001	0.306	0.300	< 0.001	0.113	0.235	0.005
Daily moderate activity (h)	0.175	–0.160	0.034	0.324	–0.140	0.039			
Daily sedentary activity (h)							0.129	0.145	0.079
Women (n=170)									
Age (y)	0.035	0.188	0.009	0.114	0.334	< 0.001	0.034	0.197	0.007
SES score	0.152	0.313	< 0.001	0.184	0.233	0.001	0.142	0.329	< 0.001
Daily sedentary activity (h)	0.167	0.129	0.079	0.203	0.141	0.049			

[1]Non significant variables in models: Place of residence (0 = rural; 1 = urban), place of birth (0 = rural; 1 = urban), percent of life in urban area and education level.

DISCUSSION

Overall Prevalence of Obesity

This study showed an overall prevalence of 10.6% for general obesity (BMI ≥ 30), 23.8% for abdominal obesity based on WC and 15.5% for elevated %BF according to the equation of BIA (Sun et al., 2003). The overall rate of 27% overweight and obesity (BMI ≥ 25) illustrates the epidemiological changes taking place in Benin, even in a medium-size city like Ouidah. The prevalence of obesity (BMI ≥ 30) that we observed in women (24.7% and 12.9% in urban and semi-rural areas, respectively) is considerably higher than reported in the last DHS for women aged 15–49 years (10.7% and 2.8% in urban and rural locations, respectively) (INSAE/DHS, 2001) and confirms that obesity is on the rise in this population, especially in urban areas.

Obesity is defined as an excess of body fat which affects health and well-being. BMI is used as an anthropometric indicator of obesity because it is highly correlated with body fat. The standard BMI cut-offs of ≥ 25 ≥ 30 for overweight and obesity, respectively (WHO, 2000) were developed primarily on the basis of studies in Caucasian populations, and they may not be optimal for African or African-descent populations, as suggested by Sargeant et al., (2002) in their studies in Jamaica. In their meta-analysis including several ethnic groups, Deurenberg et al., (1998) showed that, for the same sex, age and level of body fat, African Americans had a 1.3 kg/m^2 and Polynesians a 4.5 kg/m^2 lower BMI compared to Caucasians. In contrast, in Chinese, Ethiopians, Indonesians and Thais, BMI are 1.9, 4.6, 3.2 and 2.9 kg/m^2 lower compared to Caucasians, respectively. In the light of our study and others (Jackson et al., 2002; Wagner and Heyward, 2000), it is possible that international BMI cut-offs overestimate the prevalence of obesity in African populations because of their lower percentage of body fat than Caucasians. In our study, a BMI of 30 was associated with 27.5% body fat in men and 36% in women, which tends to be lower than in Caucasians, at least in women.

Due to its strong correlation with visceral adipose tissue, WC is used as a complementary measure of BMI to assess abdominal obesity (NIH, 1998; WHO, 2000), which appears associated with increased chronic disease risk (Janssen et al., 2004). Based on the WHO (2000) standard WC cut-offs of 88 cm in women and 102 cm in men, we observed significantly more abdominal obesity in women than men (44.1% vs 3.5% for women and men, respectively, $p < 0.01$). Whether these cut-offs are appropriate in sub-Saharan African populations is an unanswered question. Cut-points of 94 cm in men and 88 cm in women are used in the metabolic syndrome definition of the International Diabetes Federation (IDF, 2005), but ethno-specific values are also recommended. The need for specific WC cut-points for African and African descent populations is supported in previous findings of our group in black Haitians of Montreal, with a Beninese ancestry. They had less visceral adipose tissue than matched white subjects for the same WC (Desilets et al., 2006). Other factors such as high parity may contribute to obesity in women (Goulart et al., 2007; Szklarska and Jankowska, 2003). However, in our study, no significant correlations were found between parity and BMI ($r = -0.035$. $p = 0.65$) or WC ($r = 0.03$, $p = 0.68$). Further research on obesity cut-points in Africans and African descent groups other than African Americans is needed.

Urban-Rural Obesity

Mean BMI and WC were significantly higher in urban than rural areas in men and women, confirming that urbanization is associated with an increased risk of overweight and obesity. The positive correlation between total duration of city life, city vs rural birth and current city residence with BMI and WC in both men and women supports this point. Several studies reported a similar association between urban or rural residence and overweight and obesity (Sobngwi et al., 2004; Sobngwi et al., 2002; van der Sande et al., 2001). Using BMI as obesity indicator, Sobngwi et al., (2002; 2004) found in women and men living in the capital city of Cameroon (Central Africa) a positive and independent association of current city residence, as well as lifetime exposure to the urban environment, with obesity. In our study, the association of current urban residence or total duration of urban residence with obesity was not independent of SES, which was higher in urban than rural subjects. This shows a modulating effect of SES on the relation of obesity with the urban or rural environment. Therefore, SES explains a good part of the urban-rural difference in obesity.

Urbanization criteria are a difficult issue. What is urban, what is rural? This is an arbitrary classification depending on intended use. In our study, we used Benin administrative criteria which take into account the urbanization changes in the last ten years to distinguish urban and rural locations (INSAE, 2003). Some authors suggest to take account of recent history of migration (Sobngwi et al., 2004) and changes in urbanization status, particularly when rural locations become part of the city in the process of city extension (Kinra, 2004). We used three variables to characterize urbanization and explored their links with other individual parameters: birth place (rural or urban), area of current residence (rural or urban) and total duration of urban or rural residence (or percent of lifetime in urban or rural area, respectively). Because many people living in the semi-rural outskirts of Ouidah were born in the city (25.9% in men and 28.2% in women) and vice versa (1.2% in men and 10.6% in women), we documented the full history of migration of each subject (including living abroad) to determine the total duration of urban or rural residence. This is important since in Benin and in other African countries such as Tanzania (Carlin et al., 2001), migration is bidirectional: from rural to city and from city to peri-urban and rural areas, especially when the density of population increases rapidly in cities.

Socioeconomic Status, Obesity and the Double Burden of Malnutrition

The strong positive association seen between SES, anthropometric parameters (BMI and WC) and body composition (%BF) among men and women in this study shows the importance of this variable as determinant of weight status particularly in women, who had more obesity in both urban and rural locations. However, the direction of the association between obesity and SES in developing countries varies from positive in poorer countries and population groups to negative in better-off societies (Fezeu et al., 2006; Mendez et al., 2004; Monteiro et al., 2004a; Monteiro et al., 2001; Monteiro et al., 2004b). A review of studies published between 1989 and 2003 on the relationship of SES with obesity (Monteiro et al., 2004c) concluded that obesity in the developing world can no longer be considered solely as a disease of affluence and that the burden of obesity progressively shifts towards the poor, particularly among women, as the country's gross national product (GNP) increases. In our study, mean BMI, WC and %BF was significantly higher in the upper tertile of the SES score compared to middle and lower tertiles in both sexes, and the association remained significant after controlling for age and physical activity. The still higher rate of overweight and obesity among the better-off is typical of low income countries.

Measuring SES in developing countries is difficult and imperfect. Assessing SES or poverty in the same population but with different tools can produce different groupings, as shown for instance in a large study of Vietnamese households (Khe et al., 2003). Family income is usually difficult to assess in African countries, as the population suspects or fears the use of this data for tax purposes, and because it is not socially acceptable to give this information considered private. Most families in Benin have various sources of income, and the income varies from month to month. Furthermore, rural and urban income cannot be easily compared. Urban income is mainly in cash whereas rural income is partly in kind such as crops and livestock. A household amenity score reflects individual and familial capacity to possess durable goods and get several services related to financial capacity; its assessment is easy and the same questionnaire can be using for all subjects. Household amenity scores are used to appraise SES in most Demographic and Health Surveys (DHS) and in several others studies in sub-Saharan African countries (Fezeu et al., 2006; Hatloy et al., 2000; Ntandou et al., 2005). In our study, the Cronbach alpha of the household amenity score was 0.71, which shows reasonable internal consistency. However, one issue is, can the same score be used to assess wealth of urban and semi-rural subjects?

In the absence of disease or famine, underweight in adults can be linked to chronic undernutrition, which is without doubt the result of extreme poverty. In this context, it is understandable that underweight is more prevalent in households of lower SES. Indeed, 70% of underweight subjects were in the low SES tertile against only 6% in the upper SES tertile. In contrast, 41.3% of overweight subjects were in the upper SES level against 25% in the lower SES tertile. The overweight observed in the poorer segment can be partly ascribed to the lack of food diversity (Ntandou et al., 2005) resulting in energy-dense but nutrient-poor diets (Drewnowski and Specter, 2004).

The current prevalence of 14.6% underweight ($BMI < 18.5$) and 27% overweight ($BMI \geq 25$) as observed in our study reflects the double burden of malnutritions in this population. This nutrition paradox was previously described as a phenomenon related to accelerated nutrition transition in developing countries (Galal, 2002; Monteiro et al., 2002; Monteiro et al., 2004b; van der Sande et al., 2001). In Benin, the coexistence of underweight and overweight was assessed at the national level (Garrett and Ruel, 2003) and at the household level in poor neighborhoods of Cotonou, the commercial capital of Benin (Ntandou et al., 2005). We had observed a significant association of the "double burden" (underweight child/overweight mother) with socioeconomic circumstances and lack of food diversity in the household, but not with urbanization or lifetime in city. In the present study, underweight was significantly more prevalent in rural subjects ($p < 0.01$) and overweight in urban dwellers ($p < 0.01$).

Physical Activity, Socioeconomic Status and Obesity

This study confirmed a more sedentary lifestyle in urban than rural subjects, which was correlated with overall and abdominal obesity, in both men and women. This is supportive of our hypothesis of more overweight and obesity among urban than semi-rural subjects. Similar results were obtained in Cameroon (Sobngwi et al., 2004; Sobngwi et al., 2002). In theses studies, urban subjects from capital or major cities were compared with rural inhabitants and showed that the urban-rural difference in the rate of obesity was linked to physical inactivity. According to our knowledge, our study is the first to report on physical activity in subjects of a medium-size city and of the surrounding semi-rural areas. We showed that semi-rural subjects were more active than the urban counterparts because of their work in agriculture, which contributes to higher daily hours of moderate physical activity. For instance, 65.9% semi-rural men were involved in agriculture, compared with 4.7% of urban dwellers (14.1% vs none in rural and urban women, respectively). In contrast, sedentary transportation (motor vehicle) and sedentary leisure activities (watching TV, playing cards . . .) were more frequent in urban compared to rural areas. The fact that a high percentage of women are involved in the sales and service sector, which is quite a sedentary activity, in both locations (92.9% in urban and 78.8% in rural areas) probably contributes to the sedentary lifestyle of women compared to men.

The study was conducted over a period of 6 months between July and December 2006, at a time of year when agriculture and related activities are more pressing. This may partly explain that despite the high number of daily hours engaged in sedentary activities, 95% of subjects (96.5% and 93.3% in rural and urban areas, respectively) reached the recommendations of WHO and other bodies for physical activity to prevent chronic diseases, that is: moderate activity ≥ 30 min/day or heavy activity ≥ 20 min/day (Haskell et al., 2007; WHO/FAO Expert Consultation, 2003). Most physical activity time was accounted for by moderate occupation and walking. Leisure-time hours were few and mainly sedentary. This is a real challenge for prevention in the years ahead, because manual occupation was the main source of physical activity. As people shift to non-manual employment and motor-transportation with urbanization, lifestyles are likely to be very sedentary, contributing to rising obesity and others chronic diseases, unless environmental and educational action is conducive to active transportation and leisure.

Methods used for the assessment of physical activity in sub-Saharan African populations are primarily structured or semi-structured questionnaires to assess activity at work, at home, during leisure time, and for transportation (Forrest et al., 2001; Mbalilaki et al., 2007; Sobngwi et al., 2001). The 24-hour unstructured recall method as used in our study is not common. In some studies, total daily energy expenditure is computed and expressed in kcal/kg/d (Mbalilaki et al., 2007) or in METs scores, much their same as we did (Forrest et al., 2001; Kriska et al., 2003). Some studies take seasonal variations of physical activity into account (Adams, 1995; Bénéfice and Cames, 1999; Sobngwi et al., 2001), which our method did not allow to, but as stated above, the season of the study was probably the most active at least in the semi-rural community, for agriculture. In our study, three 24-hour recalls were conducted over a one-month period, as for the food recalls. However, all these recall methods rely on the memory of the subjects and on their ability to estimate the duration of activities and the variation during the reference period. Some validation would be advisable. Sobgnwi (2001) was able to validate a physical activity questionnaire covering a 12-month period against 24-hour heart rate monitoring and accelerometer recording. He obtained significant correlation of total energy expenditure from the questionnaire with heart rate monitoring and accelerometer measures. One limitation of our original method of three non-consecutive 24-hour recalls of physical activity is that it was not validated specifically. Another limitation is the inability of the method to capture seasonal patterns of physical activity, which is particularly important in rural and semi-rural population groups.

We observed a positive association between total daily hours of sedentary activity and SES score in both sexes. The South Africa Black Women Study found a positive association between BMI and household income and a greater risk of increased BMI and WC with lower physical activity (Kruger et al., 2002). In our study, a high SES allowed the use of motorized transportation (motorcycle, car) and the practice of sedentary leisure activities, which contributed to the sedentary lifestyle, especially in urban area. We also observed an independent association of daily hours of sedentary activity with BMI and WC after adjusting for age, SES and urbanization indicators (Table 3). The multivariate analyses confirmed the independent contribution of sedentary lifestyle to obesity, especially in women, irrespective of the SES level. Our study confirms previous reports showing that physical inactivity is a major determinant of obesity in sub-Saharan African (Kruger et al., 2002).

Daily hours of moderate activity were a significant variable in the multiple regression models of obesity indicators, but only among men. This suggests that moderate physical activity, which is associated with work primarily, has a role in protecting men against overweight and obesity. This point is supported, for instance, by the significant difference observed in BMI between men engaged in sales (BMI = 23 ± 3.3) as opposed to those in agriculture (BMI = 20.7 ± 3.8, $p < 0.05$) Socioeconomic status and physical activity were both more strongly linked to BMI and WC than %BF, in men and women. This difference could be explained by the method for estimating %BF. We used the equation of prediction based on BIA measurement (Sun et al., 2003), an equation known to overestimate body fat in the underweight and to underestimate it in overweight or obese subjects (Sun et al., 2005). Furthermore, this prediction equation has not been specifically validated for Africans. Therefore, there is no clear benefit to using %BF in addition to BMI and WC until more validation work is conducted.

CONCLUSION

This study showed a higher prevalence of obesity in urban than semi-rural areas and among women compared to men. Obesity coexists with underweight in both locales, but this double burden is more prevalent in semi-rural areas, where the rate of underweight and that of overweight are similar in women. This highlights the need for programs to simultaneously prevent obesity and fight against undernutrition, even in rural areas where obesity is for the moment lower than in cities. Promotion of walking and more active leisure like bicycling, running or team sports could help to improve the level of physical activity and therefore, reducing sedentary lifestyle, which is linked to obesity. Unfortunately, physical activity is not as yet part of main-stream culture or health concerns in sub-Saharan Africa and time is needed for such changes to take place.

Urban-rural differences in obesity were mainly explained by the level of SES and by physical activity. The fact that SES and physical activity are independent predictors of obesity in men and women after adjusting for age confirms the higher risk of obesity with high SES and the importance of physical activity in the modulation of this risk. Analysis of food habits and food consumption are necessary to complement these observations (separate paper in preparation).

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of all members of TRANSNUT/ISBA /IRSP research teams and the subjects for their participation. The authors also thank the Canadian Institute for Health Research (CIHR) for supporting this study.

REFERENCES

Acakpo, A., B. Fayomi, F. Djrolo, J. Kolanowski, V. Agueh, M. Makoutode, and J. Sahaha (2000). Prévalence et étude des facteurs déterminants de l'obésité à Cotonou. *Louvain Med*, 119, S276–81S.

Adams, A. M. (1995). Seasonal variations in energy balance among agriculturalists in central Mali: compromise or adaptation? *European Journal of Clinical Nutrition*, 49(11), 809–23.

Ainsworth, B. E., W. L. Haskell, M. C. Whitt, M. L. Irwin, A. M. Swartz, S. J. Strath, W. L. O'Brien, D. R. J. Bassett, K. H. Schmitz, P. O. Emplaincourt, D. R. Jacobs, and A. S. Leon (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise*, 32(9 suppl), S498–504.

Bénéfice, E., and C. Cames (1999). Physical activity patterns of rural Senegalese adolescent girls during the dry and rainy seasons measured by movement registration and direct observation methods. *European Journal of Clinical Nutrition*, 53(8), 636–43.

Caballero, B. (2001). Obesity in developing countries: biological and ecological factors. Introduction symposium. *Journal of Nutrition*, 131(3), 866S–870S.

Carlin, L., T. Aspray, and R. Edwards (2001). Civilization and its discontents: non-communicable disease, metabolic syndrome and rural-urban migration in Tanzania. *Urban and Anthropology,* 30(1), 51–70.

Commune de Ouidah (2005). Plan de développement communal de Ouidah 2005–2009. Ouidah: 146p.

Desilets, M. C., D. Garrel, C. Couillard, A. Tremblay, J. P. Despres, C. Bouchard, and H. Delisle (2006). Ethnic Differences in Body Composition and Other Markers of Cardiovascular Disease Risk: Study in Matched Haitian and White Subjects from Quebec. *Obesity*, 14(6), 1019–1027.

Despres, J. P., I. Lemieux, and D. Prud'homme (2001). Treatment of obesity: need to focus on high risk abdominally obese patients. *BMJ*, 322(7288), 716–720.

Doak, C. M., L. S. Adair, C. Monteiro, and B. M. Popkin (2000). Overweight and Underweight Coexist within Households in Brazil, China and Russia. *Journal of Nutrition*, 130(12), 2965–2971.

Doll S, P. F., P. Bovet, M. Burnier, and V. Wietlisbach. (2002). Body mass index, abdominal adiposity and blood pressure: consistency of their association across developing and developed countries. *International Journal of Obesity*, 26(1), 48–57.

Drewnowski, A., and S. E. Specter (2004). Poverty and obesity: the role of energy density and energy costs. *American Journal of Clinical Nutrition*, 79(1), 6–16.

Fezeu, L., E. Minkoulou, B. Balkau, A. P. Kengne, P. Awah, N. Unwin, G. K. M. M. Alberti, and J. C. Mbanya (2006). Association between socioeconomic status and adiposity in urban Cameroon. *International Journal of Epidemiology*, 35(1), 105–111.

Forrest, K. Y., C. H. Bunker, A. M. Kriska, F. A. Ukoli, S. L. Huston, and N. Markovic (2001). Physical activity and cardiovascular risk factors in a developing population. *Medicine & Science in Sports & Exercise*, 33(9), 1598–604.

Galal, O. M. (2002). The nutrition transition in Egypt: obesity, undernutrition and the food consumption context. *Public Health Nutrition,* 5(1A), 141–48.

Garrett, J. L., and M. Ruel (2003). Stunted child-overweight mother pairs: An emerging policy concern? International Food Policy Research Institute. Food Consumption and Nutrition Division. Discussion paper no. 148.

Gortmaker, S. L., L. W. Y. Cheung, K. E. Peterson, G. Chomitz, J. H. Cradle, H. Dart, M. K. Fox, R. B. Bullock, A. M. Sobol, G. Colditz, A. E. Field, and N. Laird (1999). Impact of a School-Based Interdisciplinary Intervention on Diet and Physical Activity Among Urban Primary School Children: Eat Well and Keep Moving. *Archives of Pediatrics and Adolescent Medicine*, 153(9), 975–983.

Goulart, A. C., F. M. Silva, I. de Castro, P. A. Lotufo, M. A. Cardoso, and I. M. Bensenor (2007). Race and parity as risk factors for obesity among low-income women in Brazil. *Nutrition Research*, 27(1), 27–32.

Gregory, C. O., J. Dai, M. Ramirez-Zea, and A. D. Stein (2007). Occupation Is More Important than Rural or Urban Residence in Explaining the Prevalence of Metabolic and Cardiovascular Disease Risk in Guatemalan Adults. *Journal of Nutrition*, 137(5), 1314–1319.

Haskell, W. L., I. M. Lee, R. R. Pate, K. E. Powell, S. N. Blair, B. A. Franklin, C. A. Macera, G. W. Heath, P. D. Thompson, and A. Bauman (2007). Physical Activity and Public Health: Updated Recommendation for Adults From the American College of Sports Medicine and the American Heart Association. *Circulation,* 116(9), 1081–1093.

Hatloy, A., J. Hallund, M. M. Diarra, and A. Oshaug (2000). Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). *Public Health Nutrition*, 3(1), 57–65.

IDF (2005). The IDF consensus worldwide definition of themetabolic syndrome. Consensus from the International Diabetes Federation could help stop the cardiovascular disease time bomb. Berlin, International Diabetes Federation: 7p.

INSAE (2003). Troisième recensement général de la population et de l'Habitat (2002). Cotonou, Institut national de la statistique et de l'analyse économique.

INSAE/DHS (1996). Enquête démographique et de santé du Bénin 1996, rapport final. Cotonou, Institut National de Statistique et d'Analyse Économique/Ministère du plan, de la restructuration économique et de l'emploi/Demographic Health survey.

INSAE/DHS (2001). Enquête démographique et de santé du Bénin 2001, rapport final. Cotonou, Institut National de Statistique et d'Analyse Économique, 387 p.

Jackson, A., P. Stanforth, J. Gagnon, T. Rankinen, A. S. Leon, D. Rao, J. Skinner, C. Bouchard, and J. Wilmore (2002). The effect of sex, age and race on estimating percentage body fat from body mass index: The Heritage Family Study. *International Journal of Obesity*, 26(6), 789–96.

Janssen, I., P. T. Katzmarzyk, and R. Ross (2004). Waist circumference and not body mass index explains obesity-related health risk. *American Journal of Clinical Nutrition*, 79(3), 379–384.

Khe, N. D., B. Eriksson, D. N. Phuong, B. Hojer, and V. K. Diwan (2003). Faces of poverty: sensitivity and specificity of economic classifications in rural Vietnam. *Scandinavian Journal of Public Health Supplement*, 62, 70–5.

Kinra, S. (2004). Commentary: Beyond urban-rural comparisons: towards a life course approach to understanding health effects of urbanization. *International Journal of Epidemiology*, 33(4), 777–778.

Kriska, A. M., A. Saremi, R. L. Hanson, P. H. Bennett, S. Kobes, D. E. Williams, and W. C. Knowler (2003). Physical Activity, Obesity, and the Incidence of Type 2 Diabetes in a High-Risk Population. *American Journal of Epidemiology*, 158(7), 669–675.

Kruger, H. S., C. S. Venter, H. H. Vorster, and B. M. Margetts (2002). Physical inactivity is the major determinant of obesity in black women in the North West province, South Africa: the THUSA study. *Nutrition*, 18(5), 422–427.

Maire, B., S. Lioret, A. Gartner and F. Delpeuch (2002). Transition nutritionnelle et maladies chroniques non transmissibles liées à l'alimentation dans les pays en développement. *Cahiers santé*, 12, 45–55.

Mbalilaki, J. A., M. L. Hellenius, Z. Masesa, A. T. Hostmark, J. Sundquist, and S. B. Stromme (2007). Physical activity and blood lipids in rural and urban Tanzanians. *Nutrition, Metabolism and Cardiovascular Diseases*, 17(5), 344–348.

Mendez, M. A., R. S. Cooper, A. Luke, R. Wilks, F. Bennett, and T. Forrester (2004). Higher income is more strongly associated with obesity than with obesity-related metabolic disorders in Jamaican adults. *International Journal of Obesity,* 28(4), 543–550.

Monteiro, C. A., W. L. Conde, B. Lu, and B. M. Popkin (2004a). Obesity and inequities in health in the developing world. *International Journal of Obesity*, 28(9), 1181–6.

Monteiro, C. A., W. L. Conde, and B. M. Popkin (2001). Independent Effects of Income and Education on the Risk of Obesity in the Brazilian Adult Population. *Journal of Nutrition*, 131(3), 881S–886.

Monteiro, C. A., W. L. Conde, and B. M. Popkin (2002). Is obesity replacing or adding to undernutrition? Evidence from difference social classes in Brazil. *Public Health Nutrition*, 5, 105–12.

Monteiro, C. A., W. L. Conde, and B. M. Popkin (2004b). The Burden of Disease From Undernutrition and Overnutrition in Countries Undergoing Rapid Nutrition Transition: A View From Brazil. *American Journal of Public Health*, 94(3), 433–434.

Monteiro, C. A., E. C. Moura, W. L. Conde, and B. M. Popkin (2004c). Socioeconomic status and obesity in adult populations of developing countries: a review. *Bull World Health Organisation*, 82(12), 940–6.

NIH (1998). Clinical Guidelines on the identification, Evaluation and Treatment of Overweight and Obesity in Adult. The evidence Report, Publication N° 98–4083, National Institutes of Health Heart Lung and Blood Institute.

Ntandou, G., B. Fayomi, and H. Delisle (2005). Child malnutrition and maternal overweight in same households in poor urban areas of Benin. *Cahiers Santé*, 15(4), 263–70.

Popkin, B. (2002). The shift in stages of the nutrition transition in the developing world differs from past experiences! *Public Health Nutrition*, 5 (1A), 205–14.

Popkin, B. M. (2001). The Nutrition Transition and Obesity in the Developing World. *Journal of Nutrition*, 131, 871S–873.

NCSS. (2005). Power analysis and sample size software package. Kaysville, USA., from http://www.ncss.com/pass.html.

Raphael, D., C. Villegrain, and H. Delisle (2005). Households with Undernourished children and Overweight mothers: Is this a concern for Haiti? *Ecology of Food and Nutrition*, 44, 147–65.

Singh, R. B., R. Beegom, A. S. Mehta, M. A. Niaz, A. K. De, R. K. Mitra, M. Haque, S. P. Verma, G. K. Dube, H. M. Siddiqui, G. S. Wander, E. D. Janus, A. Postiglione, and M. S. Haque (1999). Social class, coronary risk factors and undernutrition, a double burden of diseases, in women during transition, in five Indian cities. *International Journal of Cardiology,* 69(2), 139–47.

Sobngwi, E., J.-C. Mbanya, N. C. Unwin, R. Porcher, A.-P. Kengne, L. Fezeu, E. M. Minkoulou, C. Tournoux, J.-F. Gautier, T. J. Aspray, and K. Alberti (2004). Exposure over the life course to an urban environment and its relation with obesity, diabetes, and hypertension in rural and urban Cameroon. *International Journal of Epidemiology*, 33(4), 769–776.

Sobngwi, E., J. C. Mbanya, N. C. Unwin, A. P. Kengne, L. Fezeu, E. M. Minkoulou, T. J. Aspray, and K. G. Alberti (2002). Physical activity and its relationship with obesity, hypertension and diabetes in urban and rural Cameroon. *International Journal of Obesity*, 26(7), 1009–16.

Sobngwi, E., J. C. N. Mbanya, N. C. Unwin, T. J. Aspray, and K. Alberti (2001). Development and validation of a questionnaire for the assessment of physical activity in epidemiological studies in Sub-Saharan Africa. *International Journal of Epidemiology*, 30(6), 1361–1368.

Sun, G., C. R. French, G. R. Martin, B. Younghusband, R. C. Green, Y.-g. Xie, M. Mathews, J. R. Barron, D. G. Fitzpatrick, W. Gulliver, and H. Zhang (2005). Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. *American Journal of Clinical Nutrition*, 81(1), 74–78.

Sun, S. S., W. C. Chumlea, S. B. Heymsfield, H. C. Lukaski, D. Schoeller, K. Friedl, R. J. Kuczmarski, K. M. Flegal, C. L. Johnson, and V. S. Hubbard (2003). Development of bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys. *American Journal of Clinical Nutrition*, 77(2), 331–340.

Szklarska, A., and E. A. Jankowska (2003). Independent effects of social position and parity on body mass index among Polish adult women. *Journal of Biosocial Science,* 35(4), 575–83.

van der Sande, M. A. B., S. M. Ceesay, P. J. M. Milligan, O. A. Nyan, W. A. S. Banya, A. Prentice, K. P. W. J. McAdam, and G. E. L. Walraven (2001). Obesity and Undernutrition and Cardiovascular Risk Factors in Rural and Urban Gambian Communities. *American Journal of Public Health*, 91(10), 1641–1644.

Wagner, D. R., and V. H. Heyward (2000). Measures of body composition in blacks and whites: a comparative review. *American Journal of Clinical Nutrition*, 71(6), 1392–1402.

WHO (2000). Obesity: Preventing and managing the global epidemic. WHO Expert Consultation. Technical Report Series N° 894. Geneva, World Health Organization

WHO/FAO Expert Consultation (2003). Recommendations for preventing excess weight gain and obesity. In: Diet, Nutrition and the prevention of chronic diseases. WHO Technical Report Series NO 916. Geneva, World Health Organization: pp. 61–70.