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TRENDS IN NUTRITIONAL STATUS OF ADULT WOMEN IN SUB-SAHARAN AFRICA

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The main objectives of the MEASURE DHS project are:

- to provide decisionmakers in survey countries with information useful for informed policy choices;
- to expand the international population and health database;
- to advance survey methodology; and
- to develop in participating countries the skills and resources necessary to conduct high-quality demographic and health surveys.

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Trends in Nutritional Status of Adult Women in Sub-Saharan Africa

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Preface

One of the most significant contributions of the MEASURE DHS program is the creation of an internationally comparable body of data on the demographic and health characteristics of populations in developing countries. The *DHS Comparative Reports* series examines these data across countries in a comparative framework. The *DHS Analytical Studies* series focuses on specific topics. The principal objectives of both series are to provide information for policy formulation at the international level and to examine individual country results in an international context.

Whereas *Comparative Reports* are primarily descriptive, *Analytical Studies* have a more analytical approach. The *Comparative Reports series* covers a variable number of countries, depending on the availability of data sets. Where possible, data from previous DHS surveys are used to evaluate trends over time. Each report provides detailed tables and graphs organized by region. Survey-related issues such as questionnaire comparability, survey procedures, data quality, and methodological approaches are addressed as needed.

The topics covered in *Comparative Reports* are selected by MEASURE DHS staff in conjunction with the U.S. Agency for International Development. Some reports are updates of previously published reports.

It is anticipated that the availability of comparable information for a large number of developing countries will enhance the understanding of important issues in the fields of international population and health by analysts and policymakers.

Ann Way
Project Director

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Executive Summary

The study investigates long-term trends in nutritional status of adult African women, using data from 70 Demographic and Health Surveys (DHS) conducted in 33 sub-Saharan countries. The study reports recent data on women's height and Body Mass Index (BMI). Overall, the average height of adult women increased from 157.3 cm for cohorts born in 1940 to 158.7 cm for cohorts born in 1965, then decreased to 157.5 cm for cohorts born in 1990, almost back to its original level. Trends in adult female height were highly correlated with the rise and fall in income per capita at the time of adolescence for the same cohorts.

This pattern of a rise in height followed by a fall was found in both urban and rural areas, and for all categories of wealth, for the 33 countries overall. However, it was not universal among the countries. In affluent countries of Southern Africa, trends in height were only positive. In Sahelian countries, where the average height was much higher than elsewhere, there was no negative trend in urban areas, and only the rural areas underwent a minor decline. The largest declines were in Coastal West Africa, Central Africa, and most of Eastern Africa. Trends were therefore contrasted depending on the level of income, trends in income, and regional peculiarities (genetic endowment or diet). Only a few countries indicated a reversal to a positive trend in recent years for the youngest generations, a trend that remains to be confirmed by further studies.

Trends in BMI were assessed using an age pattern for women between age 15 and 49 years, calculated separately by large region and by area of residence. In countries of Southern Africa, the BMI was much higher than elsewhere, was increasing fast with age, and the age effect tended to increase with time, in both urban and rural areas. In Sahelian countries, the BMI was much lower but tended to catch up with time. In urban areas of the Sahelian countries the age pattern was marked, but was less pronounced in rural areas. In countries of Coastal West Africa, Central Africa, and Eastern Africa, cohort trends were not linear: the age standardized BMI tended to first increase, then to decrease with time, and the negative trends were larger in urban areas. The age effect was moderate in Coastal West Africa and in Central Africa, and very small in Eastern Africa. Weight gains with age were very small in most of the countries ranging from Ethiopia to Madagascar, which are the poorest countries in the continent.

The study also displays differences in height and BMI by socio-economic status defined by an absolute wealth index (AWI). The findings were confirmed by multivariate analysis.

Key words: Health transition; Adult height; Secular trend in height; Body Mass Index (BMI); Body shape; Women health; Economic development; Income per capita; Genetic factors; Sub-Saharan Africa.

Introduction

Background

The Demographic and Health surveys (DHS) offer a unique opportunity to study long-term trends in nutritional status in developing countries. DHS surveys have included child anthropometry since Round I (1984-1989), adult female anthropometry from the next round (1989-1993), and have more recently included biomarkers, such as anemia/iron deficiency, vitamin A deficiency, and iodine deficiency. These data have been analyzed in a number of DHS publications. Loaiza [1997] compared the nutritional status of mothers in the first two rounds of DHS surveys and found major differences in chronic energy deficiency and obesity by continent. Sommerfelt and Stewart [1994] compared the nutritional status of children in the DHS surveys conducted in Round I and Round II. They studied the prevalence of malnutrition, the age patterns, the distribution of nutritional status, and the differentials by various socio-economic, demographic and health variables. Mukuria et al. [2005] repeated a similar analysis of nutritional status of children for surveys of Round III and Round IV. They added a section on overweight and obesity among children. They also reported the relationship between child anthropometry and mother's Body Mass Index (BMI), but without a full-scale analysis of BMI for adult women. Other reports have focused on micronutrients and related health problems among adult women, such as anemia, iron supplementation, iodized salt and vitamin A [Mukuria and Kothari, 2007]. Bradley and Mishra [2008] studied the complex relationship of BMI with HIV infection among adult women in 12 African countries, based on cross-sectional analysis.

In developing countries, trends in height and weight have been largely favorable since 1950, as was the case in developed countries much earlier, since about 1850. These trends are assumed to be closely related with the health transition, in particular with the control of infectious diseases, as well as with improving nutrition associated with rising income per capita. However, Tobias [1985] showed declining height in a number of African countries. Ganguly [1979] showed that the average height of 40 out of 60 groups from India also declined. On average, the height of Indians seems to have declined by about 1cm between 1880 and 1960. In a series of papers, Moradi [2002, 2006, 2010] analyzed the height of African women, using DHS data. This author showed that African countries had different dynamics, and that cases of increasing or declining height were often associated with periods of economic growth or recession during the first years of life or at puberty. Akachi and Canning [2007, 2010] also found a declining trend in height of adult women in many African countries, and showed an unexpected correlation between decreasing child mortality and declining height in recent decades.

With respect to body composition, many developing countries, especially the most economically advanced, have experienced an increase in weight and in weight-for-height since 1960, leading to an obesity epidemic [Prentice, 2006; Villamor et al. 2006; Amuna and Zotor, 2008; Himes, 1979]. Little attention has been devoted so far in Africa to prevailing conditions before the rise of obesity, to cases of declining weight-for-height, and in our search we did not find any published study providing a synthesis of trends in BMI in Africa.

Beyond national trends, many analysts have noted marked differentials in height and in weight-for-height by socio-economic status [Boix and Rosenbluth, 2006; Deaton, 2003, 2007, 2008; Moradi and Baten, 2005; Singh-Manoux et al. 2010; Stecker, 1995]. Usually the higher socio-economic strata have greater height, and often obesity is more prevalent among the poorer strata, although not always.

Study objectives

The aim of this study is to investigate trends in height and BMI of sub-Saharan African women, at the national level, and for selected socio-demographic categories, in particular urban and rural areas, and selected categories of wealth. Africa went through various phases of development over the past century, with ups and downs, and in some cases with major economic downturns, and major periods of political instability or civil wars. The good times are expected to have a positive impact on anthropometric indicators, whereas the difficult times are expected to have a negative impact, in particular on the height of adult women. Obesity requires enough wealth to provide a surplus diet, so the poorest strata of African societies are expected to be free of this condition. This study focuses on periods with positive trends in height (improvements in nutritional status), periods with negative trends (deterioration) and periods with no change. Trends in BMI are more difficult to analyze: an increase in weight-for-height from very low values indicates an improvement, but an increase from average value to very high values indicates obesity, a deterioration in health status. This study is restricted to height and weight of adult women, since very few African DHS surveys included anthropometric data on men.

Data and Methods

Data

DHS surveys

All DHS surveys from sub-Saharan Africa available with anthropometric measurements for adult women were considered for this study. The list of these surveys is provided in Table A-1. This set accounts for 33 countries, 70 surveys, and 438,220 women with weight and height measurements. Outstanding cases of abnormally low weight or height were excluded: women age 15-49 with weight <30.0 Kg or ≥200 kg, with height <130 cm or ≥205 cm, of with a BMI <13.0 or ≥60 kg/m². These might be cases of outstanding anthropometry (dwarfs, giants), or simply data errors.

Sampling biases

Most surveys were based on representative samples of women age 15-49. Some focused on women who gave birth in the past three or five years. Earlier studies showed that this introduced only a negligible bias compared with proper samples of women age 15-49 years [Moradi, 2006]. Of the 70 surveys in our study, 32 were based on a complete sample of women, 32 were based on samples of about one woman in every two (birth in the past five years), and 6 were based on smaller samples (Cameroon 1998; Comoros 1996; Nigeria 1999; Senegal 2005; Uganda 2006; Zimbabwe 1994). On average, selected women tended to be from somewhat poorer households and had a somewhat lower level of education, most likely because they had higher fertility and therefore were more likely to be selected. All biases in the second and third groups were statistically significant, but were of small magnitude. In the second group, with an average sampling fraction of 51%, the average absolute wealth index was 2.3 compared with 2.4 in the total population, and the average level of women's education was 3.3 years compared with 3.8 years in the total population. (see below 'differential analysis' for the definition of the absolute wealth index). In the third group, with an average sampling fraction of 31%, the average wealth index was 3.1 compared with 3.5 in the total population, and the average level of education was 4.2 years compared with 5.7 years in the total population. Two surveys are questionable because of small sample size and large bias: Comoros 1996 and Nigeria 1999. They should be considered with caution.

Precision of estimates

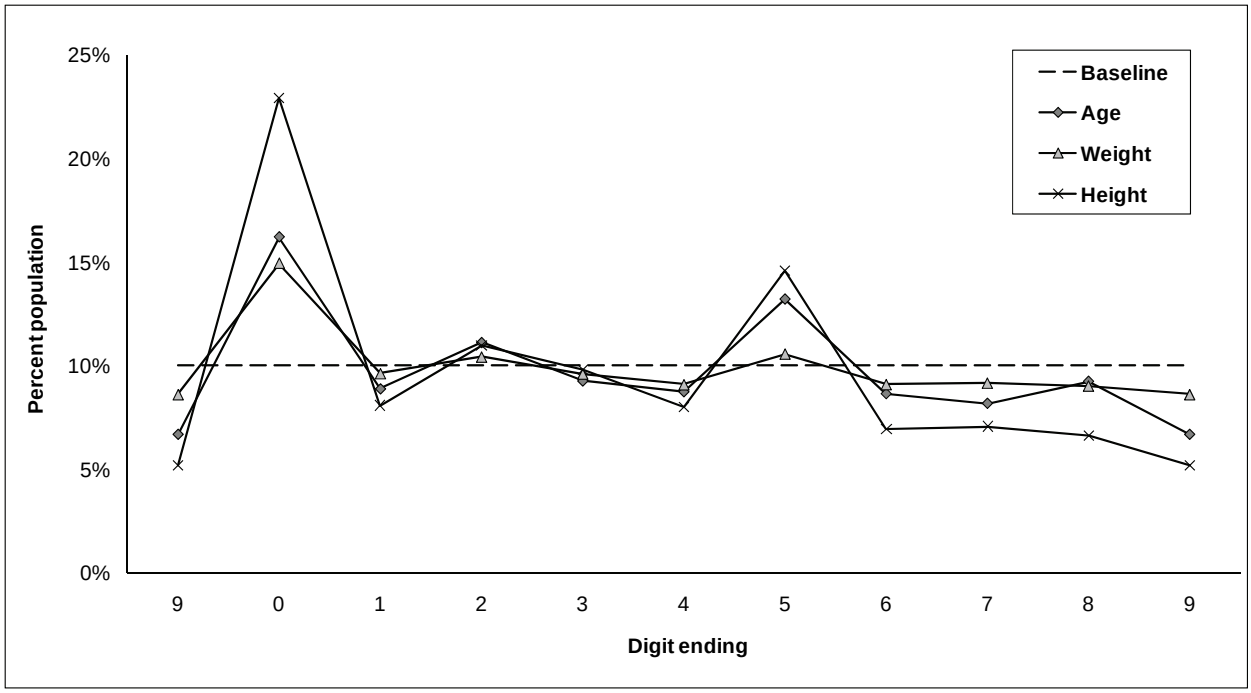
In DHS surveys, anthropometric measures are taken by two well trained persons. Height is measured to the nearest millimeter (mm) using measuring boards with a headpiece made in the USA for DHS. Weight is taken to the nearest 100 grams (0.1 kg) using Seca digital scales. Measurements procedures are standardized during the training of the field workers [Macro International, 2008].

Due to the very large data set for this study, the sampling errors are very low, and the precision is very high for average country estimates, if one ignores measurement errors. To give an idea, in a national sample of 4,000 women, an average height of 160.0 cm will be given with a precision of ±0.2 cm, an average weight of 60.0 kg will be given with a precision of ±0.3 kg, and an average BMI of 23.0 kg/m² will be given with a precision of ±0.1 kg/m². For trend analysis, a linear regression model was used, and proper estimates of standard errors are provided in Appendix A for computing confidence intervals. Except in the case of erratic data, in the case of very small samples, or in the case of trends computed on short periods, the precision of the estimates provided by trend analysis is also very high. The analysis of consistency between surveys conducted in the same country showed that measurement errors appeared small, and of about the same order of magnitude as the sampling errors (see below § 1.7 for details).

Digit preference

Another way at looking at precision of measurements is to consider digit preference for age, weight and height. The analysis of the 70 surveys revealed significant preferences for ages ending in 0 and 5, for weights ending in .0 and .5 kg and for heights ending in .0 and .5 cm (Figure 1). The Myers index for age was 10.5 and the Whipple index was 147, which are relatively high values. Large variations could be seen by survey. The Myers index for age varied from 3.6 to 24.6 and the Whipple index from 100 to 223. Low values were found in Southern Africa (South Africa, Zambia, Zimbabwe, Swaziland, Namibia) and in two countries with good vital registration (Congo-Brazzaville and Madagascar). High values were found in West Africa (Sierra Leone, Chad, Niger, Guinea, Benin, Mali), the worst case of all countries being Nigeria.

Figure 1 ***Digit preference for age, weight and height in DHS surveys of sub-Saharan Africa***



The Myers index for weight was 5.9 and the Whipple index was 127, which are moderate values indicating relatively good precision of the scales and the readings. Here again, variations between countries and surveys were very large. Three surveys had no precision, since most weights were rounded to integer values of kilograms: Nigeria 1999 (89%), Madagascar 2008 (71%), and South Africa 1998 (78%). For the others, the Myers index varied from 0.9 to 18.4, and the Whipple index from below 100 to 192. There was no obvious geographical pattern, and the quality could vary greatly in the same country from survey to survey. For instance, in Burkina Faso the Myers index was low in 1993 and 1999 (4.4 and 2.8 respectively), but high in 2003 (18.4). Similar variations were found in Madagascar. Some countries were consistently good, such as Malawi (Whipple index ≤105 in 3 surveys), or Uganda (Whipple index ≤100 in 3 surveys).

The Myers index for height was 18.4 and the Whipple index was 187, which are high values indicating poor precision of the equipment or of the readings. Here again, variations by survey were large. Two surveys had no precision, since most heights were rounded to integer values of centimeters: Nigeria 1999 (88%), and Congo-Brazzaville 2005 (67%). For the others, the Myers index varied from 3.7 to 39.6. Most surveys (60/68) had a Whipple index classified as ‘bad’ or ‘very bad’ (≥125 or ≥175), and only two surveys were in the category ‘good’ or ‘very good’ (<110 or <105): Uganda 1995 and Rwanda 2000.

How the lack of precision affects the averages computed for weight, height and BMI remains unclear. Digit preference suggests that many of the values rounded to 0 or 5 come from the nearby categories ending in 8, 9, 1, 2 or 3, 4, 6, 7. If so, the precision is again ±2 decimals, which is consistent with the inaccuracies found between surveys. Assuming that there was no systematic bias, this would not affect the means or the trends. If anything, these biases would tend to increase the variance between yearly estimates, and therefore would decrease the power of the statistical testing for trends. So, when trends are significant despite this limitation, they are in fact probably even more significant in the real world.

Reference sets

There are no international anthropometric standards for adults, as there are for under-five children [WHO, 1995; WHO, 2007]. For the sake of international comparisons, two reference sets were used: one American (USA), and one European (France). Height for adolescents (age 15-19) was compared with the CDC-2000 set from USA [Kuczmarski et al., 2002], and with the INSERM sets from France [Sempe et al. 1979]. Both sets were equivalent, leading to a median adult height= 163 cm, and similar growth between age 15 and age 20. The BMI was compared with the NHANES-III set from USA [McDowell et al., 2009] and with the IRSA set from France published by Rolland-Cachera et al. [1991]. Here the two reference sets were very different, the American set having much higher values, although they had a similar slope with respect to age (see below § 3.1).

The BMI was calculated as the ratio of weight by height-squared (W/H^2). We did not find any justification to use another formula, such as that suggested by Nestel and Rutstein [2002]. First, as noted by these authors and by others, "the convenience of using 2 as an exponent in the Quetelet index outweighs the advantage of other *de facto* indexes." Second, we checked the empirical relationship between weight and height in our samples. The average power in the African samples was 1.93, and it varied by age from 1.82 at age 20-29 to 2.04 at age 40-49, as well as by group of body shape, from 1.64 in the Southern group to 2.06 in the Sahelian group (see below § 1.1 for the definition of groups). So the choice of 2 for the power of the Quetelet index seemed obvious in this case.

Methods

Country analysis

Countries were first analyzed one by one, displaying the relationship between height, BMI, and year of birth. Results of the country analysis are displayed in Appendix B. When several DHS surveys were available for the same country, they were merged together, cohort by cohort, after checking the data consistency on height and BMI between surveys. Note that since the study deals with cohorts, there is no need to adjust for population increase between surveys. So, each dataset includes weight and height data from the oldest cohort in the first survey to the youngest cohort in the latest survey. Weighted datasets were used in each case for calculating the mean height, weight, and BMI.

This procedure ignores the minor bias associated with selection for mortality in the same cohort between two surveys. Note that selection biases might also affect the estimation of cohort trends: if shorter women are more likely to die earlier, the mean height of a cohort will be higher for survivors at age 50 than for survivors at age 20, which may lead to a false impression of decreasing height over time. Likewise, if fatter women are more likely to die earlier, the mean BMI of a cohort will be lower for survivors at age 50 than for survivors at age 20, and one may get a false impression of increasing obesity. These biases cannot be estimated from DHS surveys since they would require prospective studies. We tried to estimate the magnitude of these biases from our own prospective studies conducted in 1983-1984 in Niakhar, a rural area in Senegal [Garenne et al. 2000]. Some 6,800 women were measured for weight

and height and were followed for mortality for an average of five years. Mortality was higher for women of short stature, and for women with higher BMI (unpublished results). Selection for mortality between age 20 and age 50 induced very minor biases: +0.13 cm for an average height of 160.8 cm, and -0.03 kg/m² for an average BMI of 21.3 kg/m², which are negligible quantities given the sampling and measurement errors in DHS surveys.

Trends

The trend analysis is based on a straightforward study of height and BMI by cohort, defined as the year of birth. DHS surveys provide anthropometric measures for women age 15-49 at time of survey, and provide directly the year of birth of respondents. For height, the analysis by cohort is straightforward with only a minor correction for adolescents, since height is approximately constant between age 20 and 49 (see below § 1.2). No attempt was made to correct for the very minor changes in height that occur after age 40. For BMI, a method was developed to make a similar analysis by using an age pattern stratified by large groups of body shape (see below § 3.1). Trends were then tested by ordinary least square (OLS) regression.

Coverage

Anthropometric measures among women age 15-49 were included in DHS surveys in the early 1990s, and the latest surveys available when this study was done were conducted in the mid-2000s. So, this study has the potential to investigate trends for about 50 years of birth cohorts, ranging from cohort 1940 to cohort 1990. Trends were therefore estimated over this time frame, for all the countries involved, with of course some gaps. In order to have full scale trends for the continent as a whole and for groups of countries, some of the trends were extrapolated before the oldest cohort available, or after the youngest cohorts. These have no value for each country individually, and should be considered as imputed values for missing years for the whole set. This procedure should provide reliable estimates for the continent as a whole and for large groups of countries.

Body Mass Index of adult women and body shape

BMI was calculated directly from the surveys as weight (in kg) divided by height-squared (in m²). Women who were known to be pregnant at time of the measurement, and women in the post-partum period (two months after delivery) were excluded from the computations. The BMIs have a variety of age patterns among adults age 15-49, and there is no accepted standard for the BMI [WHO, 1995]. So, no standard can be readily used for computing cohort estimates. The conversion of age-specific BMI data into cohort estimates is explained below (see § 3.1). In brief, four age profiles were identified in Africa, based on country of residence, and all calculations were made for urban and rural areas separately.

Merging countries

As mentioned, the analysis was first conducted country by country, and trends were estimated for all cohorts available (see Appendix B for details by country). An average for sub-Saharan Africa, or for subgroups, was computed by weighting each country by its population in year 2000. The 2000 population estimates were taken from the United Nations Population Division, 2006 revision [United Nations, 2007].

Differential analysis

Differential analysis focused on urban versus rural residence, and on wealth status. Urban residence was taken directly from the DHS surveys. In some cases, the proportion of urban women age 15-49 in DHS surveys might differ from the proportion urban in population censuses, although the gap

between the two is usually small. Of course, urban residence is fixed at time of survey, and does not include previous urban/rural migration.

A wealth index was computed for each survey, as a sum of dummy variables indicating the presence of modern goods or amenities in the household. This Absolute Wealth Index (AWI) has been described in detail elsewhere [Garenne and Hohmann, 2003; Hohmann and Garenne, 2010]. In brief, the wealth index score varies from 0 to 14, 0 indicating no modern goods, and large numbers (12+) indicating all modern comforts (running water, flushing toilet, electricity, radio, television, refrigerator, means of transportation, telephone, etc.). This Absolute Wealth Index has been shown to correlate well with mortality (under-five children and young adults), with fertility, with age at marriage, and with nutritional status [Hohmann and Garenne, 2009]. Here again, the wealth index is computed at time of survey and ignores previous changes in wealth for the households.

For the sake of presenting results in tables, a typology of wealth was computed from the Absolute Wealth Index, in five categories: poorest (0-1), poorer (2-3), medium (4-5), wealthier (6-7), wealthiest (8+). Another typology was also used, using five categories and mixing urban residence and wealth: rural poor (0-2), urban poor (0-2), rural medium (3-7), urban medium (3-7), and wealthy (AWI $\geq$8), whatever the area of residence. Some tables refer to 'poor', 'medium', and 'wealthy' based on the same thresholds, and mixing urban and rural areas together. The proportion poor, or in poverty, also refers to the proportion of households whose AWI is lower than 3. Note that all the differential analysis is based on current status at time of survey (urban residence, country, wealth), which is a limitation to this study.

Other sources of data

Beyond statistical analysis at micro-level (individual), we also conducted analysis at macro-level (country). In particular, we correlated aggregate values of anthropometry with national income. For income per capita at the country level, we used the database developed by Angus Maddison and colleagues, in its latest 2010 update [Maddison, 2010]. This set provides estimates of Gross Domestic Product per capita in Parity Purchasing Power (GDP-PPP), expressed in constant US dollars. It is complete for all countries in this study, and covers the period from 1950-2008 in its latest edition. It is a perfect match for cohorts 1940-1990, who became adolescent over the study period.

Results

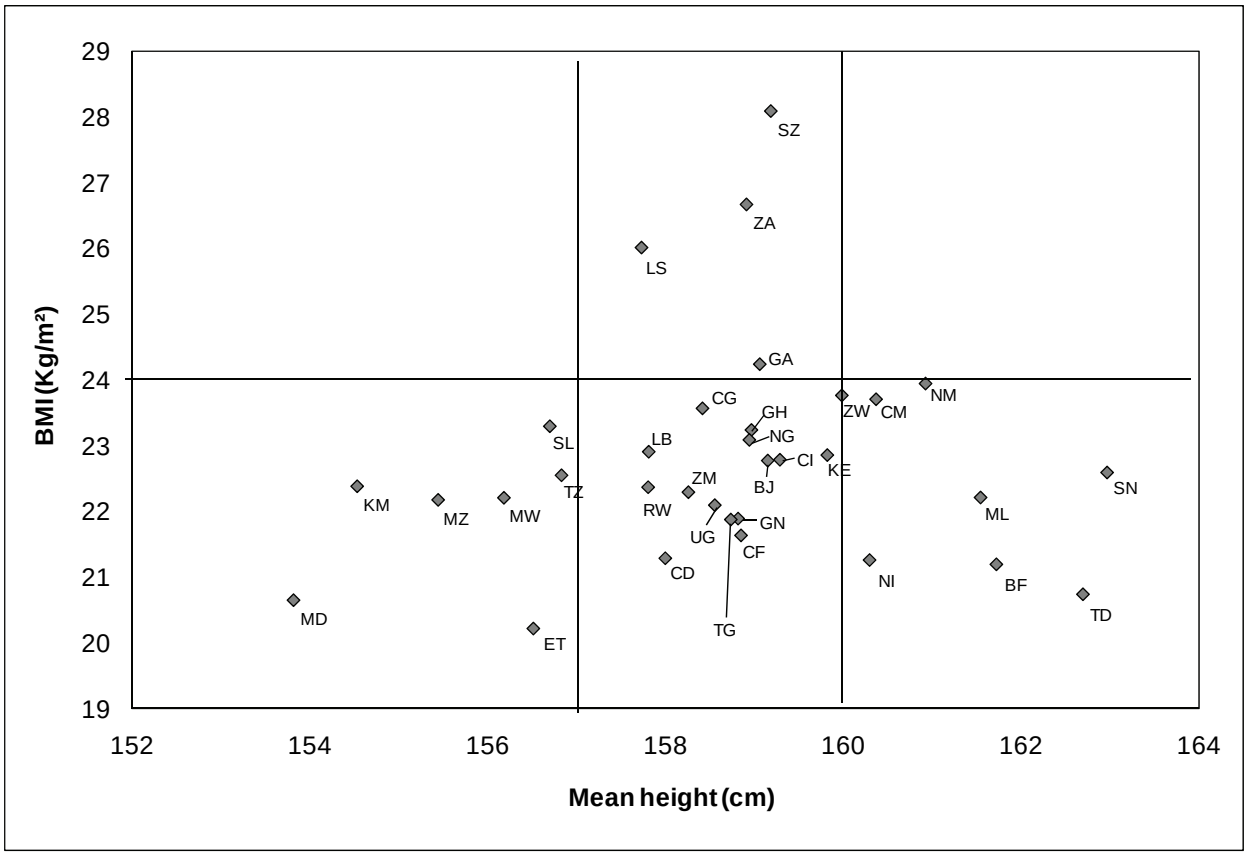
Part I: Overview on Anthropometric Indicators

This part is devoted to general considerations on anthropometric indicators in sub-Saharan Africa. The first section is devoted to heterogeneity, and the identification of groups of body shapes; the second section on average values and comparison with international standards; the third section to differential analysis.

1.1 Typology of body shapes

The distributions of height, weight and BMI vary widely throughout Africa, and there is a great variety of body shapes in Africa, striking in the data and also visible in photographs of people, or from direct observation when visiting African countries. For this analysis, four large groups of body shapes were identified, based on the cross-classification of BMI by height (Figure 2).

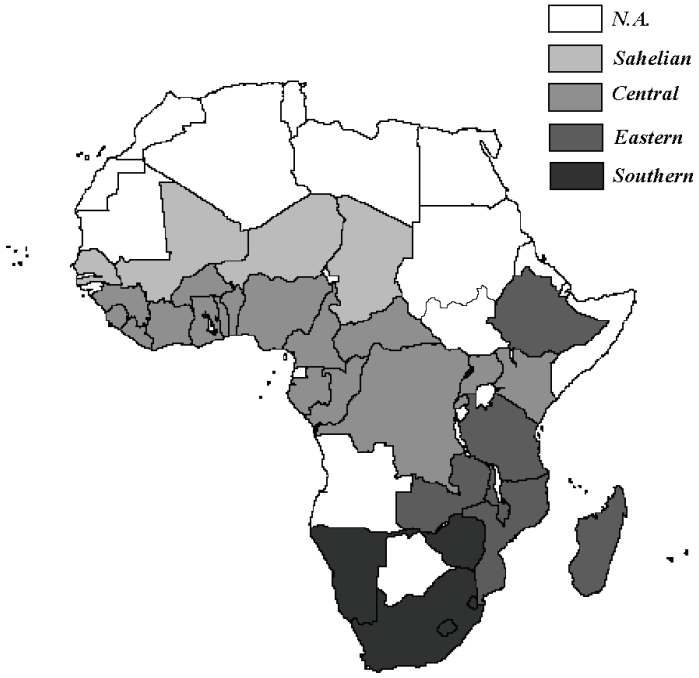
Figure 2 ***Correspondence between height and BMI in DHS surveys of sub-Saharan Africa***



Note: Country codes are those used by DHS surveys (see Table A-1).

Thresholds were arbitrarily selected based on geographical patterns: 157 cm and 160 cm for height, and 24 kg/m² for BMI. Countries were classified according to these thresholds. Countries on the borderline were grouped with the nearest group geographically. Four large groups of body shapes were identified empirically from DHS survey data, by plotting height against BMI (Figure 3).

Figure 3 ***Groups of body shape in DHS surveys of sub-Saharan Africa***



A first group of countries, with average height and average BMI, was found in countries from Central Africa, in countries from Coastal West Africa, and in Uganda and Kenya. The second group had higher height and lower BMI (tall and slim), and was found in Sahelian countries, from Senegal to Chad. The third group had lower height and lower BMI (short and slim), and was found in Eastern Africa from Ethiopia to Madagascar. The last group had average height and higher BMI, and was found in the five countries of Southern Africa.

Due to their geographical pattern, the first group was labeled 'Central,' the second 'Sahelian,' the third 'Eastern' and the fourth 'Southern.' Note that this classification is empirical and was necessary for our study. It is based on a combination of genetic, nutritional and socio-economic factors: the Sahelian pattern seems primarily due to genetic factors, or possibly to a different diet, since women are taller despite being poorer, whereas the Eastern pattern is associated primarily with very low income and major stunting, and the Southern pattern with higher income and prevalent obesity (Table 1).

Table 1 Large groups of body shapes in sub-Saharan countries

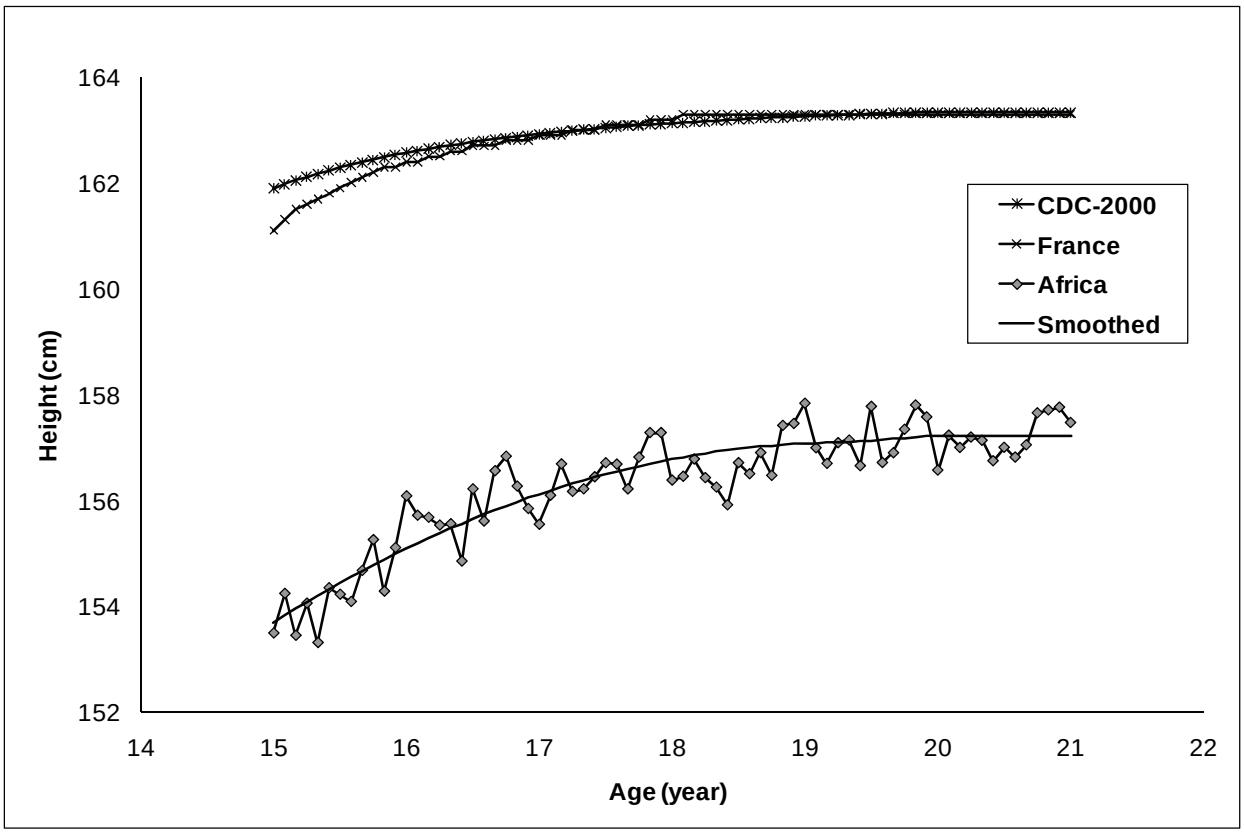
	Group 1 Average	Group 2 Tall and slim	Group 3 Short and slim	Group 4 High BMI
Location	Coastal West and Central Africa	Sahelian Africa	Eastern Africa	Southern Africa
Countries	Others	SN, ML, BF, NI, TD	MD, KM, MZ, MW, TZ, ET	ZA, LS, SZ, NM, ZW
Anthropometry				
Height range	157-159	≥160	<157	
BMI range	<24	<24	<24	≥24
Average height	158.6	161.6	155.7	159.8
Average BMI	22.7	21.7	21.6	24.8
Correlates				
GDP per capita	936	815	690	3,261
Wealth (AWI)	3.0	2.3	1.5	5.6
Poverty (%)	49%	69%	82%	24%

Note: Country codes are DHS codes (see Table A-1); GDP in constant USD (source: Maddison, 2010); Wealth: AWI computed from DHS data; Percent in poverty= AWI < 3 (see text for details)

1.2 Age pattern of height of adult women

The height of adult women is considered stable after age 20, so it can be readily used for cohort estimates of adult height. The height of women age 15-19 was also used after correcting for increase in height between age (x) in months and age 20. The main reason for doing so was to investigate whether some kind of reversal trend could be seen among the most recent cohorts. The age pattern used for the correction was derived from the average pattern of linear growth found in Africa. In fact, maturation and the adolescent growth spurt occur somewhat later in Africa than in Europe or in the United States, so we used the African pattern for making the correction (see Figure 4).

Figure 4 ***Comparison of growth in height among African adolescent women with international reference sets***



Note: USA: CDC-2000 standard; France: Sempe standard; Africa: author's calculations from DHS surveys.

The African pattern was derived from the same DHS surveys, by plotting height at age (x) against age in month, from 180 months (age 15) to 240 months (age 20). Data were smoothed using a second degree polynomial. A coefficient K(x) was calculated as height(240) / Height(x). This coefficient was applied to the observed value of height at survey for all women age 15-19. It was not considered necessary to stratify by body shape, since these coefficients were almost identical for each of the four population groups considered, decreasing from about 1.020 at age 15 (range 1.016 to 1.024) to 1.0 at age 19.5.

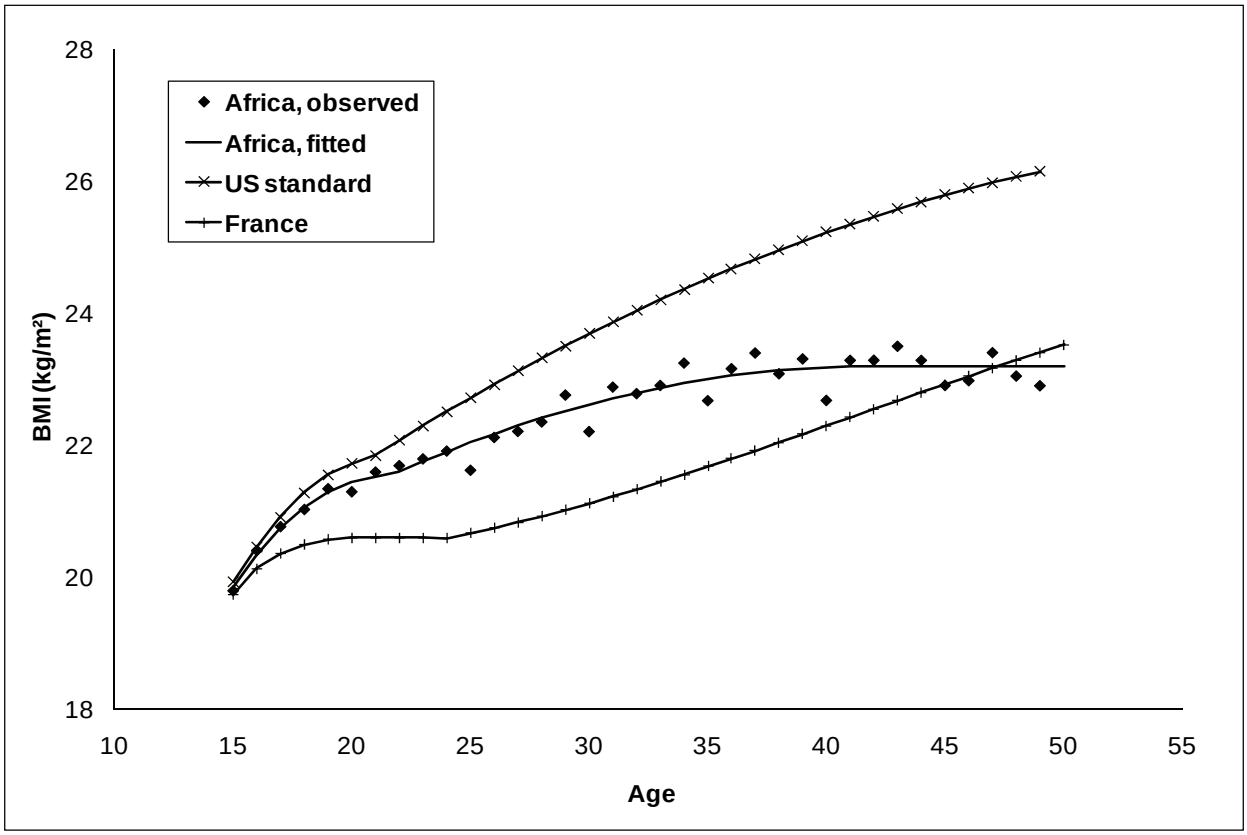
1.3 Age pattern of BMI by group of body shape

In order to convert age specific BMI data into cohort data, one needs an age pattern. This was done by plotting the BMI from age 15 to age 49. In affluent populations, the BMI tends to increase from age 25 or 30 until age 50 or 60, in a log-linear pattern. The pattern of BMI change between age 15 and

age 25 is complex, usually with a fast increase followed by some kind of plateau. In affluent populations with prevalent obesity, as in the USA, the average BMI can reach high values (26 kg/m² at age 50). In affluent populations with low obesity, as in France, it is lower at age 50, but still with a steady increase since age 25. The average BMI observed in African DHS surveys lies somewhere in between (Figure 5). Average BMI in Africa was similar to that in France or in the USA at age 15, then increased faster than in France but not as fast as in the USA between age 15 and age 20, then increased at a slower pace up to age 35, and then stabilized. This pattern suggests a mixture of age and cohort effects, since the nutritional status of younger cohorts could be much better than that of older cohorts (see below § 3.2 for a full analysis of age and cohort effects).

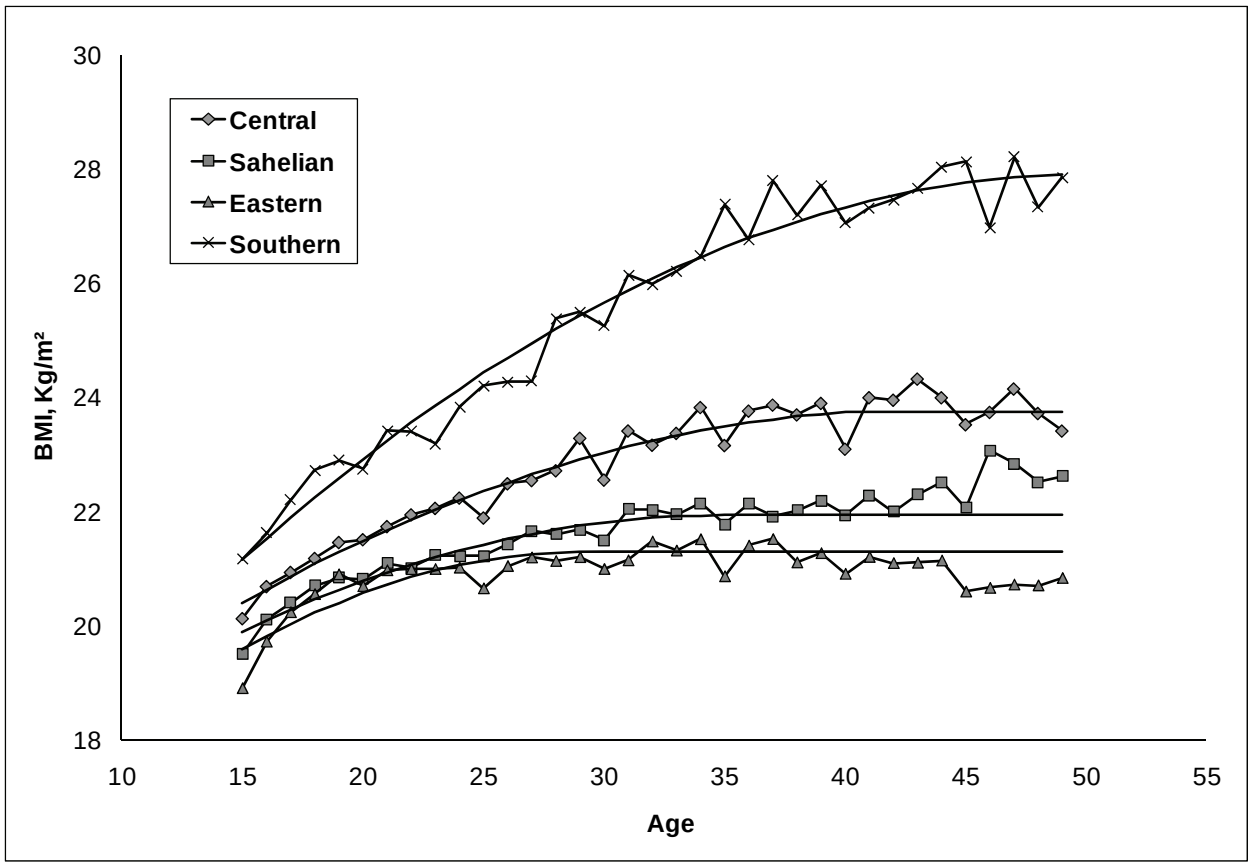
For this study, the BMI at age 30 was taken as the reference for standardizing BMI by age. For the final analysis, the age pattern of the BMI was taken after controlling for cohort effects, as well as for wealth and urban residence (see below § 3.1 for details). This allowed one to compute a 'standardized BMI,' corresponding to the BMI that the same cohort was expected to have at age 30. This was the only way to produce cohort estimates from period data, and to investigate trends, as was done for height.

Figure 5 ***Comparison of age-specific BMI of African women with international reference sets***



This procedure assumes that the age pattern of BMI remains the same for all cohorts, and that it is the same for all countries in the same group (Figure 6). There are no data so far with which to investigate whether this hypothesis is realistic in situations of changing malnutrition or increasing obesity, and most likely it is not. This analysis should therefore be considered with caution, and be later checked in specific situations. One could only hope that it provides a realistic view for aggregate data. Whenever possible—that is, when several surveys were available in the same country—the study provides the comparison with the variations between surveys. It will be seen below (see § 1.7) that the average weight gain between surveys in the same countries matches the average weight gain expected from the age pattern.

Figure 6 ***Age patterns of BMI in the four groups of body shape (raw data)***



1.4 Average anthropometric indicators of adult women (raw data)

The average height of adult women age 20-49 was 158.6 cm, average weight was 56.5 kg, and average BMI was 22.4 kg/m². All these parameters had large variations by age, area of residence, wealth, and group of body shape (Table 2).

Table 2 Average values of anthropometric indicators, by category, women age 20-49

		Number of women	Weight (kg)	Height (cm)	BMI (kg/m²)
	Total	298,706	56.5	158.6	22.4
Group	Central	143,472	57.1	158.6	22.7
	Sahelian	55,692	56.6	161.6	21.6
	Eastern	68,946	52.1	155.7	21.5
	Southern	30,596	63.3	159.8	24.8
Area	Urban	101,810	61.2	159.5	24.0
	Rural	196,896	54.4	158.2	21.7
Wealth	Poorest	110,107	52.8	157.7	21.2
	Poorer	87,448	55.4	158.7	22.0
	Medium	44,022	59.0	159.1	23.3
	Wealthier	29,034	61.9	159.5	24.3
	Wealthiest	28,095	65.9	160.5	25.6
Category	Rural-Poor	140,903	53.1	157.9	21.3
	Urban-Poor	21,401	56.2	158.4	22.4
	Rural-Medium	51,381	57.3	159.0	22.7
	Urban-Medium	56,926	60.7	159.4	23.9
	Wealthy	28,095	65.9	160.5	25.6

Note: About 10% of women were excluded from computations because they were pregnant or in the postpartum period at time of survey.

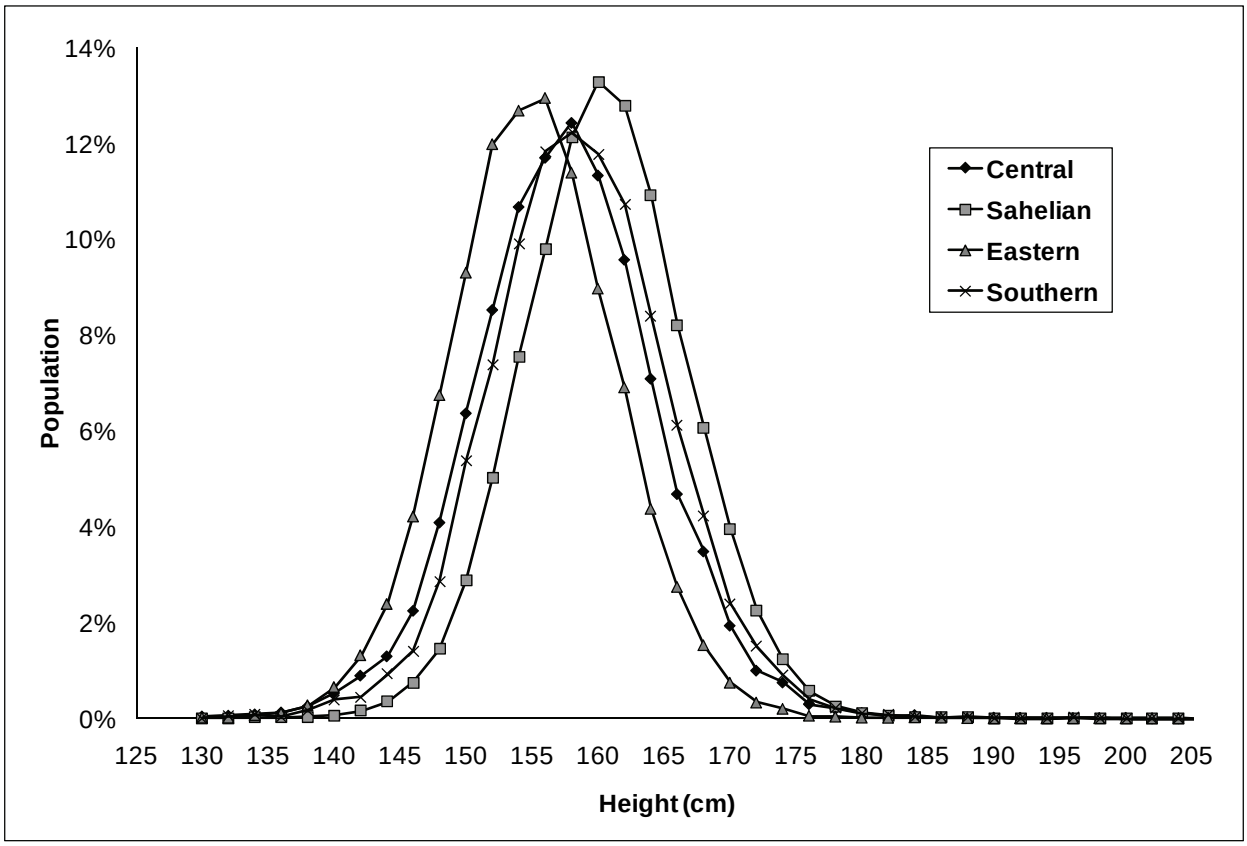
1.5 Distribution of heights in African populations

The distributions of heights of adult women were close to log-normal distributions, with a mild skewness (>0), and a mild coefficient of concentration (kurtosis >3) (Table 3). Of course, they differed by category of body shape, but in each category they could be fitted by log-normal curves (Figure 7).

Table 3 Characteristics of the distribution of heights, by body shape, women 20-49, raw data

Group	Number of women	Mean	Standard Deviation	Skewness	Kurtosis
Central	172,335	158.6	6.66	0.114	3.953
Sahelian	68,469	161.6	6.17	0.090	3.417
Eastern	79,439	155.7	6.17	0.160	3.584
Southern	33,852	159.8	6.49	0.051	3.525

Figure 7 ***Distribution of women's height, by group of body shape (raw data)***



1.6 Distribution of BMI in African populations

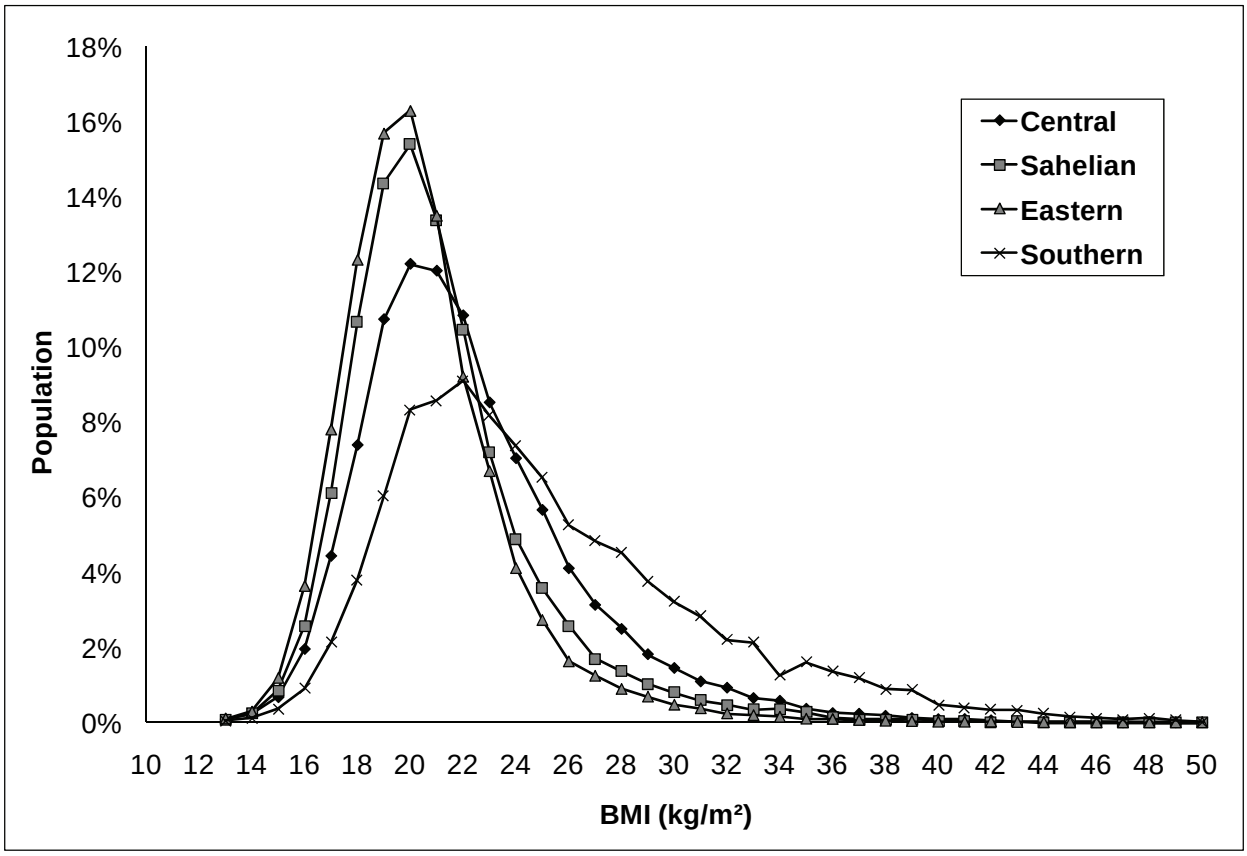
The distribution of BMI in African populations was skewed towards the right (high values), as in all populations. The distribution of BMI varied considerably by type of body shape (Table 4, Figure 8). The Central group had the most regular distribution, with a mean of 22.8 and a standard deviation of 4.36. The distributions of BMI in the Sahelian group and in the Eastern group were quite similar, despite the major difference in height, with somewhat higher mean, higher dispersion, and more skewness in the Sahelian group. The Southern group was very different, with much higher values, much wider dispersion, and less skewness, producing a flatter distribution.

Table 4 Characteristics of the distribution of BMI, by body shape, women 20-49, raw data

Group	Number of women	Mean	Standard Deviation	Skewness	Kurtosis
Central	143,245	22.8	4.36	1.64	8.61
Sahelian	56,342	21.7	3.67	1.81	9.80
Eastern	68,578	21.0	3.19	1.63	9.04
Southern	30,801	25.6	5.87	1.09	4.26

Note: Pregnant and post-partum women excluded.

Figure 8 ***Distribution of BMI among women age 20-49, by group of body shape (raw data)***



1.7 Changes from survey to survey in the same country

Among the 33 countries considered, 22 had several surveys that could be used for studying changes over time and data consistency. Among these, 10 countries had two surveys, 9 countries had three surveys, and 3 countries had four surveys, so that 37 intervals between successive surveys could be

studied. Any time there were successive surveys, the mean height, weight, and BMI were computed for the same cohorts seen at both surveys.

Height

Height was expected to remain constant for the same cohorts. Using all possible pairs of successive surveys with the same cohorts, there was a small average systematic bias of +0.32 cm in height from the index survey to the next survey, which is probably a fair indication of measurement errors. Among the 37 intervals considered, 18 of these differences were not statistically significant, and could be simply attributed to random fluctuations due to sample size. In 17 cases the difference was significantly positive, and in two cases the difference was significantly negative. These last two cases were both from Kenya: cohorts born from 1953 to 1978 measured 160.1 cm in 1998 and 159.8 cm in 2003; cohorts born from 1958 to 1983 measured 159.9 cm in 1998 and 159.6 cm in 2003. Such biases could come from variations in the sampling scheme, from mortality selection and possibly from HIV/AIDS, as well as from minor variations in measurement tools or systematic reading errors. Even if these differences are statistically significant, they remain very small in absolute value, and fall with the ±0.3 cm range of possible measurement errors.

Weight and BMI

Contrary to height, weight and BMI were expected to increase from survey to survey in the same country for the same cohorts, simply because women tend to gain weight between age 20 and age 50. The interval between surveys was on the average 6.0 years, with a range from 4.0 to 14.4 years, so the mean change over time was standardized for a five-year period. On average, women of the same cohorts gained 2.2 kg per five years between surveys, which corresponds to an increase of BMI of 0.77 kg/m². These values are consistent with expected values from age patterns of BMI (Table 5). Of the 37 cases considered, the average change in weight and BMI was significant in 33 cases, not significant in 3 cases, and significantly negative in only one case: in Madagascar, weight of women born between 1959 and 1984 declined from 49.6 kg to 49.1 kg between the 2003 and the 2008 surveys. This may be a real negative change, which requires further investigation.

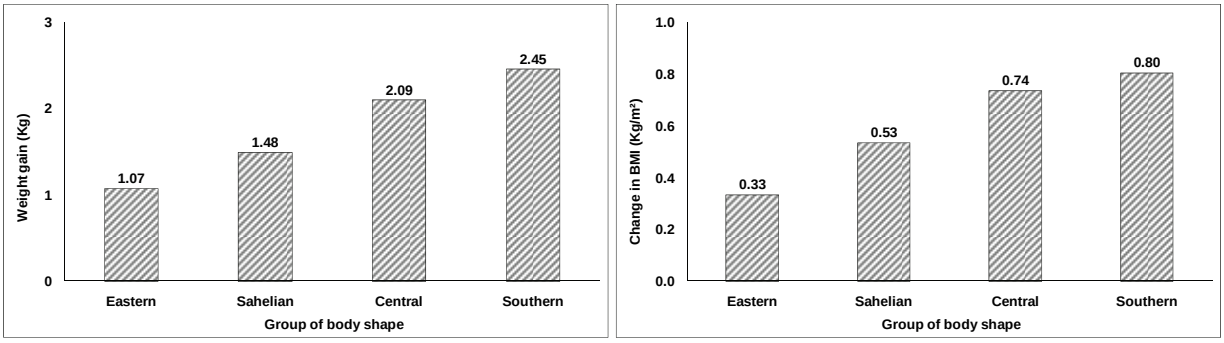
Table 5 Average gains in weight and BMI, over five-year period, (women age 20-49, not pregnant, not in post-partum period)

	Number of cases	Average change over 5 years		From age pattern of BMI
		Weight (kg)	BMI (kg/m²)	(kg/m²)
Total sample				
Number of survey intervals	37	2.20	0.77	0.41
Number with significant increase	33	2.50	0.87	
Number with no change	3	-0.14	-0.02	
Number with decline	1	-0.57	-0.34	
Group of body shape				
Central	19	2.09	0.74	0.42
Sahelian	8	1.48	0.53	0.50
Eastern	7	1.07	0.33	0.17
Southern	3	2.45	0.80	0.65

Note: The changes obtained from the age pattern were calculated after controlling for wealth.

Differences in weight change by group of body size were very marked, and matched the age pattern of BMI noted above. In the Eastern group, weight gains averaged 1.07 kg (BMI: +0.33 kg/m²), in the Sahelian group 1.48 kg (BMI: +0.53 kg/m²), in the Central group 2.09 kg (BMI: +0.74 kg/m²), and in the Southern group 2.45 kg (BMI 0.80 kg/m²) (Table 5, Figure 9). These values and their hierarchy also matched the values in weight gain and the hierarchy by body shape obtained from age patterns of BMI.

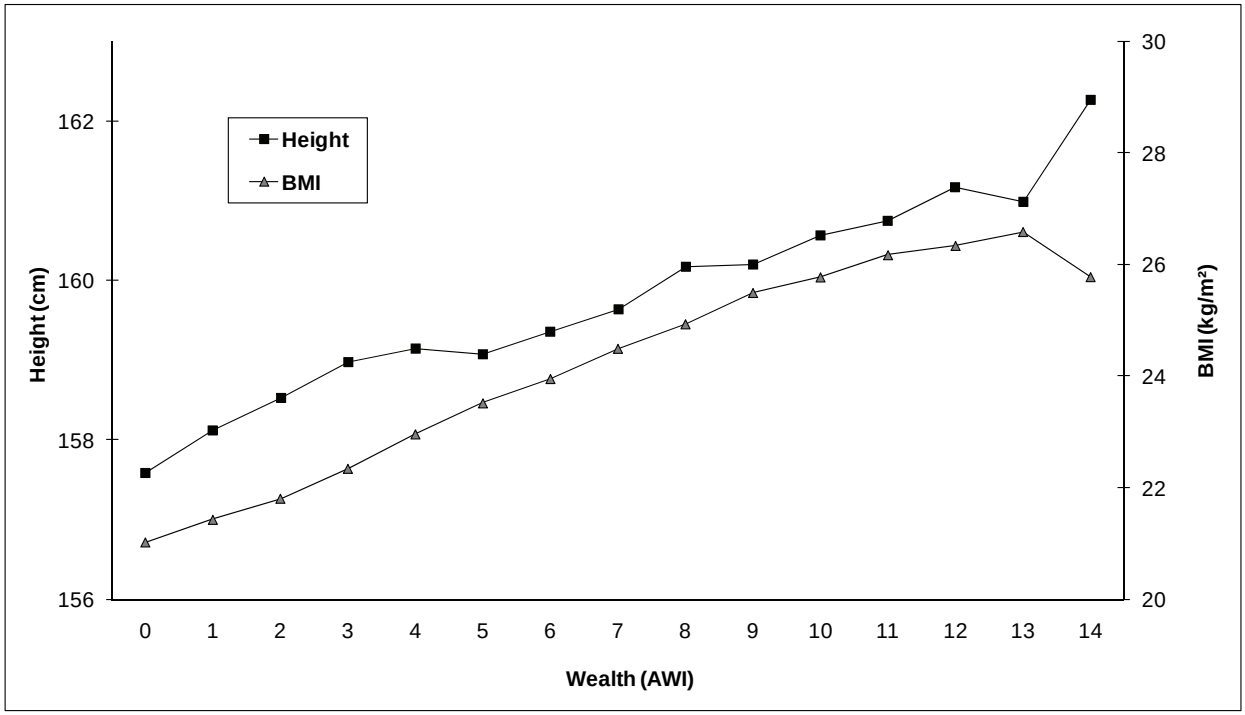
Figure 9 ***Average change in weight and BMI over a five-year period, women age 20-44 at first survey, by group of body size***



1.8 Relationship of anthropometric indicators with wealth

The relationship of weight, height and BMI with wealth was almost linear, despite the heterogeneity in body shape in sub-Saharan Africa. When the Absolute Wealth Index (AWI) increased from 0 (poorest) to 12+ (wealthiest), weight increased from 53.2 to 68.1 kg, height from 158.0 to 161.0 cm, and BMI from 21.3 to 26.3 kg/m² (Figure 10).

Figure 10 ***Average height and BMI by wealth, women age 20-49 (raw data)***



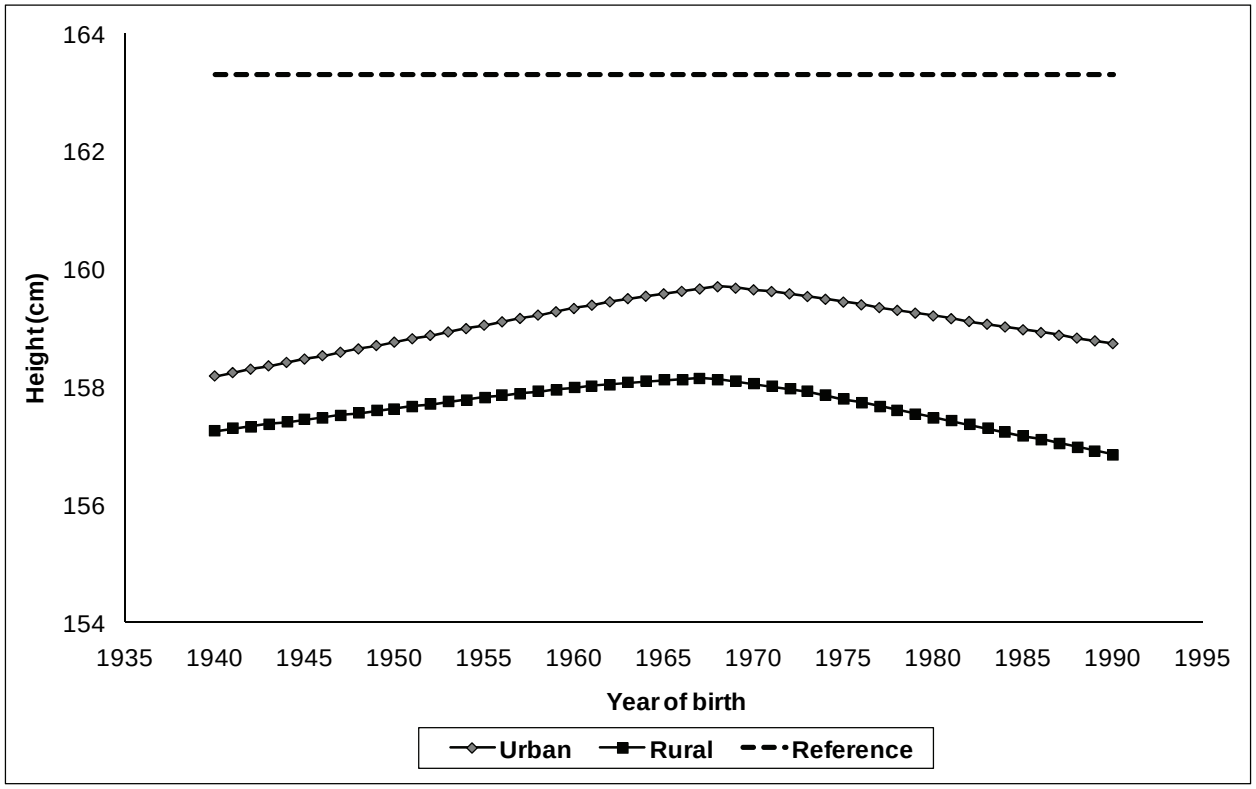
In conclusion, the study found that height, weight and BMI were very heterogeneous in sub-Saharan Africa. Average height was below Western standards, with large differences by country. Average BMI was somewhere between American and European reference sets, also with large variations between countries. The relationship of height with socio-economic status was as expected from the experience of developed countries. In contrast, high values of BMI were concentrated among the highest socio-economic groups, and the lowest values among the poorest groups, a pattern different from that of developed countries.

Part II: Trends and Differentials in Height

2.1 Trends in height of adult women

For sub-Saharan Africa as a whole, there was a marked pattern of increase then decrease in the height of adult women. Height averaged 157.3 cm for cohort 1940, 158.7 for cohort 1967, and was almost back to its original level (157.5 cm) for the 1990 cohort. Trends were basically the same for urban and rural areas, although the increase was somewhat faster in urban areas, and the decline faster in rural areas. In urban areas height was only slightly greater for cohort 1990 than for cohort 1940, and in rural areas it was even lower (Figure 11). The positive trend (0.6 cm per decade) was consistent with trends found earlier in Europe or the United States [Chamla, 1983; Chamla and Gloor, 1986; Cole, 2003]. The declining trend, however, was very marked, its duration was longer than in most downward trends identified elsewhere in the 20th century, and its magnitude was larger than the long downward trend in the USA in the first part of the 19th century [Carson, 2010].

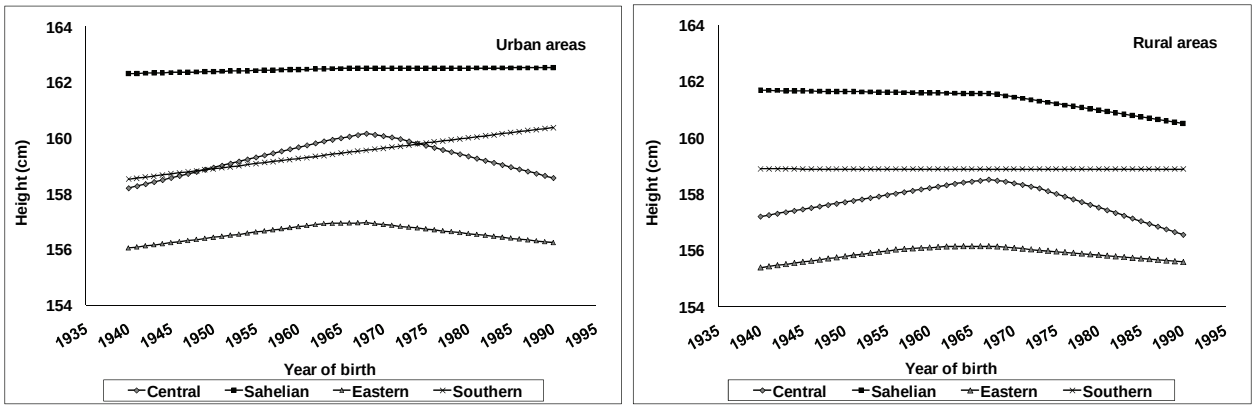
Figure 11 ***Trends in height of adult women, sub-Saharan Africa***



2.2 Trends in height: differential analysis

Trends varied for the four large groups of body shape. Women in Southern Africa experienced a steady increase in height on the average, more pronounced in urban areas. Urban women in the Sahelian band, who were much taller originally, had no change over time, whereas rural women in the same group experienced a decline in average height. Women in the two other groups experienced a rise followed by a decline, and changes were more pronounced in the Central group than in the Eastern group (Figure 12).

Figure 12 ***Trends in height of adult women, by body shape and residence (urban and rural)***



Increasing and decreasing trends, although they varied by country, affected all socio-economic groups (Figure 13; Table 6). The two lowest wealth categories (poorest and poorer) had a net loss in height, after some minor increase; the two medium categories (medium and wealthier) behaved the same way: they had some increase over the whole period, resulting from a major increase followed by a decline. The highest socio-economic group (wealthiest) followed the same path, at a higher level.

Figure 13 ***Reconstructed trends in height of adult women, by wealth***

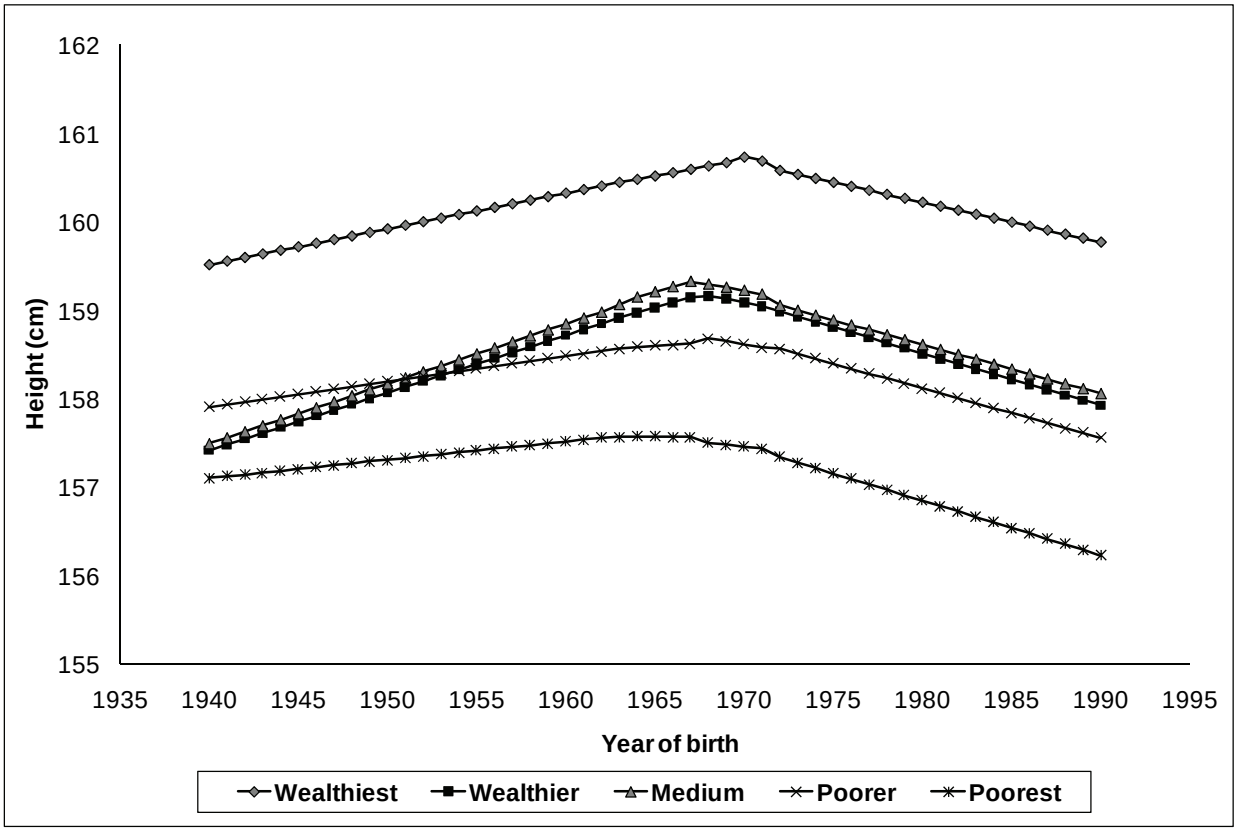


Table 6 Reconstructed trends in adult height (cm) by socio-economic categories

	Socio-economic category (wealth)	Baseline 1940	Peak value 1965-1970	Endpoint 1990	Net change 1940-1990
1	Poorest	157.1	157.6	156.2	-0.9
2	Poorer	157.9	158.7	157.6	-0.3
3	Medium	157.4	159.3	158.1	+0.7
4	Wealthier	157.4	159.2	158.0	+0.6
5	Wealthiest	159.4	160.7	159.9	+0.5

Cohort trends were tested using a regression line of height on cohort, for women age 20-49 and using raw data by wealth category. All trends were significant (all positive before 1967 and all negative after 1967), and all changes in trends were highly significant (all with $P < 10^{-10}$). The average year of change in trends was 1968, without any difference between the wealth categories.

2.3 Multivariate analysis on height of adult women

Linear multivariate regressions were run on the original sample of DHS data, that is without weighting by country. The results confirmed the major changes in the slope of the relationship between height and year of birth, positive before 1965 and negative after 1965 (Table 7). They also confirmed the net effect of each variable: greater height in urban areas, increasing height with increasing household wealth, greater height of Sahelians (+3.0 cm), lower height in Eastern Africa (-2.3 cm), and somewhat greater height of Southern Africans (+0.4 cm). Because the sample size was so large, all coefficients were highly significant ($P < 10^{-10}$). When comparing cohorts 1940-1965 with cohorts 1965-1990, the magnitude of the effects changed somewhat over time, although the magnitude of changes remained small: the effect of urban residence became slightly higher (+0.2 cm), the net effect of wealth increased also (+0.3 cm for 8 points increase in wealth), the natural advantage of Sahelians became somewhat more important (+0.2 cm), as well as the advantage of Southern Africans (+0.6 cm), and the coefficient for Eastern Africa did not change significantly. In summary, even after controlling for socio-economic status, urban residence, and major groups of body shape, heights of women increased by some 2.0 cm from 1940 to 1965 (157.4 to 159.4 cm), then decreased at about the same speed from 1965 to 1990 (159.4 to 157.5 cm). This phenomenon seems largely independent from urban residence, racial group and socio-economic status.

Table 7 Results of multivariate regression on adult female height (raw data)

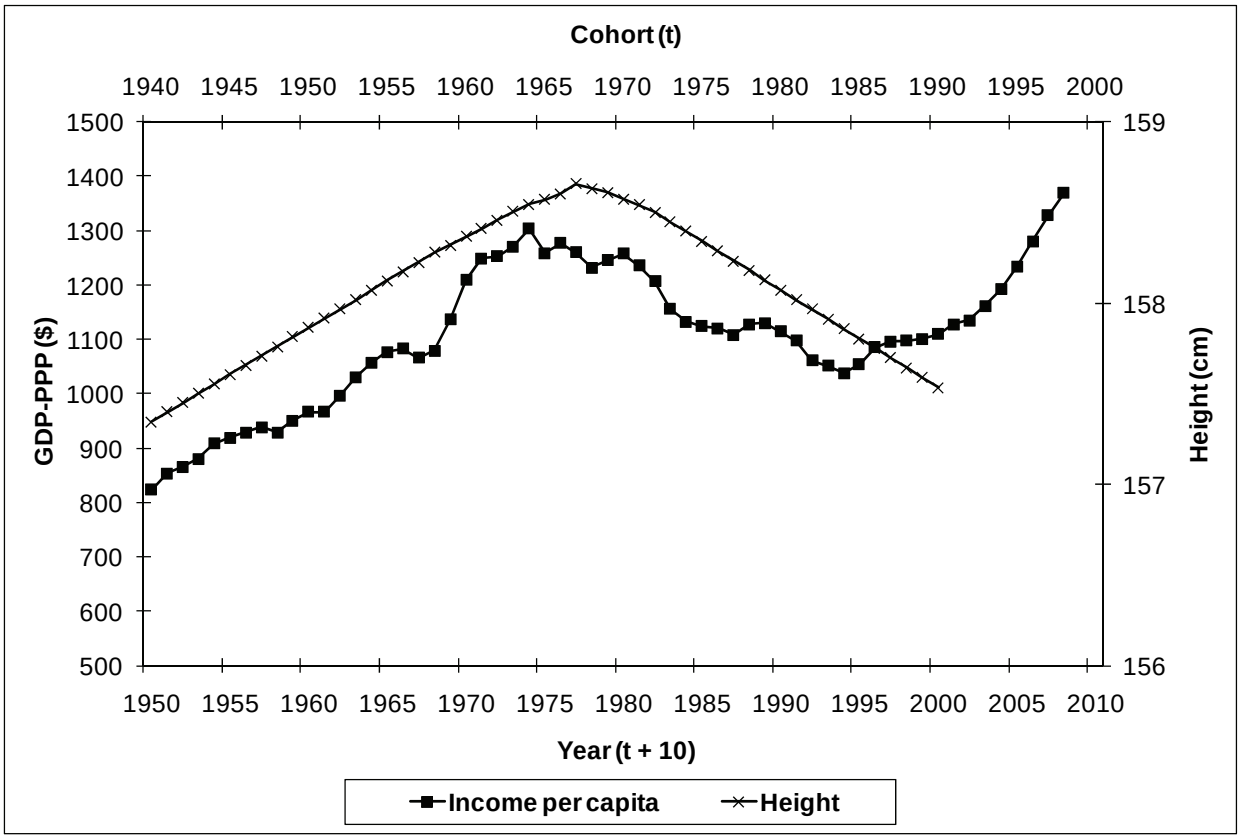
	Cohorts 1940-1965		Cohorts 1965-1990		Change P-value
	Coefficient	Standard Error	Coefficient	Standard Error	
Cohort (year of birth)	+0.07708	0.00361	-0.07332	0.00153	*
Urban residence	+0.15768	0.05210	+0.33317	0.02755	*
Wealth (AWI)	+0.18995	0.00918	+0.23014	0.00474	*
Sahelian	+3.01959	0.05207	+3.25479	0.03073	*
Eastern	-2.34818	0.05217	-2.29317	0.02842	NS
Southern	+0.42581	0.06823	+1.03090	0.03914	*
Central (Ref)					
Constant	7.16576	7.07497	302.42343	3.01901	

* P <0.05; NS = not significant

2.4 Height and income per capita

The rise and fall of average height of adult women for cohorts 1940-1990 was strikingly similar to the rise and fall of income per capita between 1950 and 2000 (Figure 14). For the 33 countries in this study, the average income per capita in parity purchasing power (GDP-PPP) increased from $823 in 1950 to $1,303 in 1974, then fell to $1,038 in 1994, stabilized until 2000, and then increased rapidly thereafter. The critical years of reversal in trends in income corresponded to the years when cohort 1965 became adolescent. Cohorts of women born in year (t) were matched with period year (t+10). The correlation between average height of the cohort (t) and average income in year (t+10) was high (ρ= 0.97). One could therefore argue that trends in height were primarily determined by the adolescent growth spurt: over periods with economic growth, the nutrition of adolescent girls improved and adult height of women increased; over periods with economic downturn, the nutrition of adolescent girls deteriorated, and their ultimate height was lower.

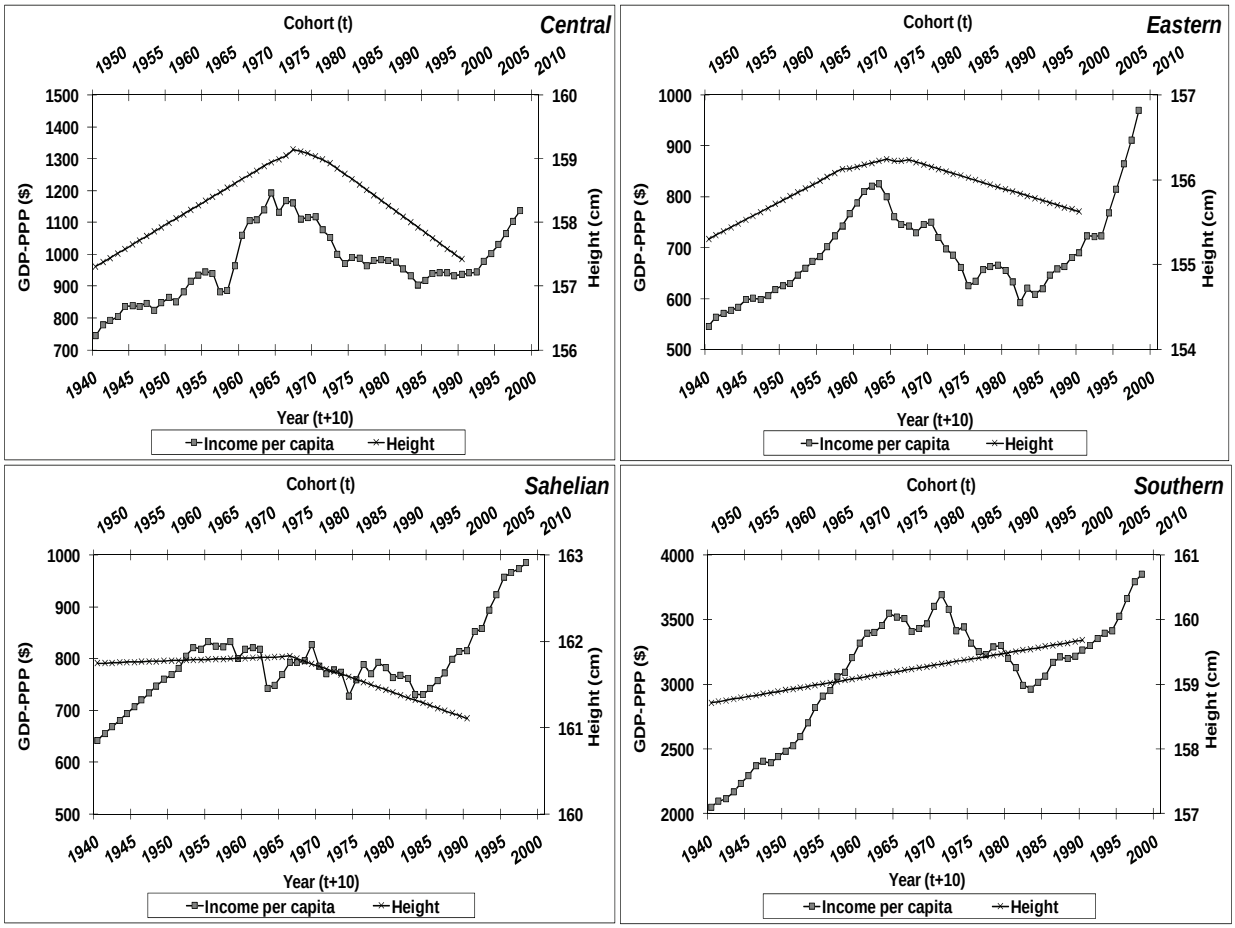
Figure 14 ***Correlation between trends in income per capita and trends in women's height, 33 African countries***



2.5 Height and income, by body shape

The relationship between income per capita and average height varied by groups of body shape (Figure 15). The pattern in the Central group and in the Eastern group was similar to the average pattern (correlation=0.93 and 0.90 respectively). In the Sahelian group, the economic downturn was less pronounced, as was the decline in height, and overall there was no correlation between both variables (r=0.07). In the Southern group, income was much higher, economic fluctuations were much smaller in relative terms, and they did not have any negative effect on height.

Figure 15 ***Correlation between trends in income per capita and trends in women's height, by groups of body shape***



2.6 Height and income at country level

At the country level, the relationship between changes in height and income growth was complex and could not be studied by simple correlations. For instance, in Swaziland the correlation between height and GDP was strongly positive (r=+0.91), whereas in Lesotho it was strongly negative (r=-0.98). Both countries had steady economic growth, but one had a slightly positive trend in height while the other had a slightly negative trend in height, which confuses the comparison despite the similarities between the two economic situations.

Based on the GDP-PPP data gathered by Maddison [2010], periods of positive and negative economic growth were identified. Among the 33 countries under study, 78 periods were considered. During the periods with declines in GDP-PPP, the average rate of change of height was -0.42 cm per decade, whereas it was +0.02 cm per decade during periods with positive economic growth. During large economic downturns, defined as periods when the rate of economic growth was below -2% per year, there was no case of increasing height. These observations underline at the country level the relationship between income growth (or decline) and changes in adult height found at aggregate levels.

2.7 Recent trends (cohorts 1982-1992)

Income per capita has been rising since 1994 for this set of 33 African countries. The last sample of anthropometric data was gathered in 2004-2008 at best, and often before, so that one could not properly investigate trends in height associated with recent economic growth. However, one could check on individual data trends for the cohorts born after 1982. Six countries showed significant positive trends in height: Cameroon, Guinea, Mozambique, Namibia, Swaziland and Zimbabwe (Table 8). In Cameroon, trends were positive for both urban and rural areas, and for the 'poorest' category as well as 'wealthier' category. The same was true in Mozambique and Namibia. In Guinea and Swaziland, trends in urban areas were not significant. In Zimbabwe, trends were not significant in rural areas. Trends were not significant for other wealth categories. Even though these data are very limited, and are mostly based on adjusted adolescent heights, they tend to suggest that the downward trend in height of adult women may be coming to an end, at least in some countries. With the exception of Zimbabwe, all these countries had increasing GDP-PPP after 1992.

Table 8 Positive slopes of height versus cohort since 1982

			Area of residence		Wealth	
Country	Last cohort	Total	Urban	Rural	Poorest	Wealthier
Cameroon	1989	0.204	0.192	0.188	0.251	0.204
Guinea	1990	0.122		0.188	0.243	0.122
Mozambique	1988	0.173	0.169	0.172	0.174	0.173
Namibia	1992	0.096	0.137	0.088	0.153	0.096
Swaziland	1992	0.098		0.111	0.423	0.098
Zimbabwe	1991	0.081	0.119		0.145	0.081

Note: All slopes displayed were significantly higher than 0, with $p < 0.05$.

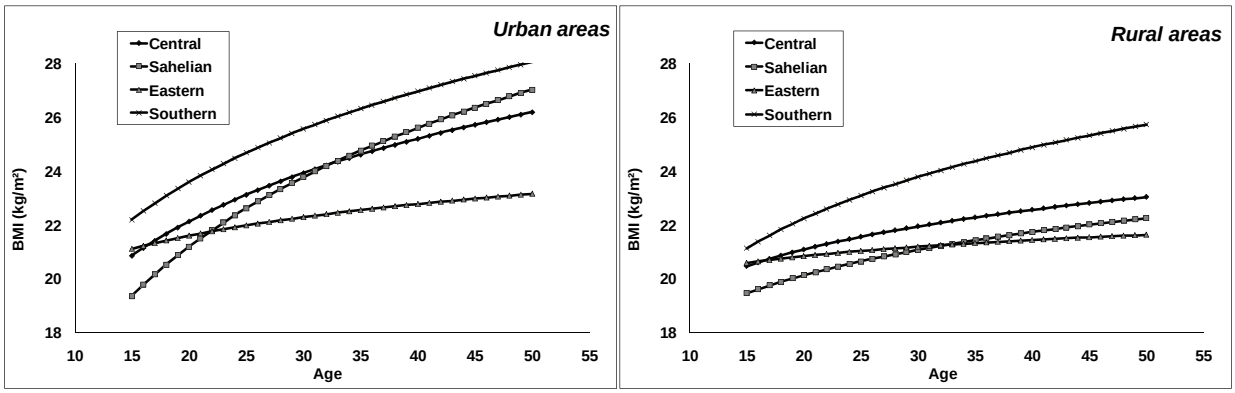
Part III: Trends in Weight and Body Mass Index

3.1 Underlying age patterns of BMI (net effect)

The underlying age patterns of BMI were estimated using multivariate analysis after controlling for trends, for each category of body shape, and separating urban and rural areas. The model was a simple linear regression, the age pattern was a logarithm function, and controls were cohort trends and wealth (Figure 16, Table 9).

$$BMI = A + B \times Log(Age) + C \times (Cohort) + D \times (Wealth)$$

Figure 16 ***Underlying age pattern of BMI, by group of body size (net effect after controlling for cohort and wealth)***



In urban areas, the BMI increased rapidly with age in three out of the four groups, and slowly in the Eastern group. In urban areas of the Southern group, the BMI increased from 23.6 kg/m² at age 20 to 28.1 kg/m² at age 50; corresponding values were 22.1 to 26.2 kg/m² in the Central group, 21.2 to 27.0 kg/m² in the Sahelian group and 21.6 to 23.2 kg/m² in the Eastern group. The increase in BMI with age was much less pronounced in rural areas, except in the Southern group where it was also very marked. In rural areas of the Southern group, the BMI increased from 22.2 at age 20 to 25.7 kg/m² at age 50; corresponding values were 21.1 to 23.0 kg/m² in the Central group, 20.1 to 22.3 kg/m² in the Sahelian group and 20.8 to 21.6 kg/m² in the Eastern group.

Table 9 Underlying age pattern of BMI (net effects in multivariate analysis after controlling for cohort trend and wealth)

Estimates at age	Central	Sahelian	Eastern	Southern	Total
Urban areas					
20	22.1	21.2	21.6	23.6	22.1
30	23.9	23.8	22.3	25.6	23.8
40	25.2	25.6	22.8	27.0	25.1
50	26.2	27.0	23.2	28.1	26.0
Rural areas					
20	21.1	20.1	20.8	22.2	20.9
30	21.9	21.1	21.2	23.8	21.8
40	22.6	21.7	21.4	24.9	22.4
50	23.0	22.3	21.6	25.7	22.9

These underlying age patterns, by group of body shape and area of residence, were used to compute the standardized BMI, in order to study cohort trends. The standardized BMI can be interpreted as the BMI of the cohort at age 30, given the pattern of increase by age in the same category of body shape and urban residence. For instance, if weight gain between age 30 and 40 corresponds to an increase in BMI of +1 kg/m², then a BMI of 23 at age 40 is equivalent to a BMI of 22 at age 30.

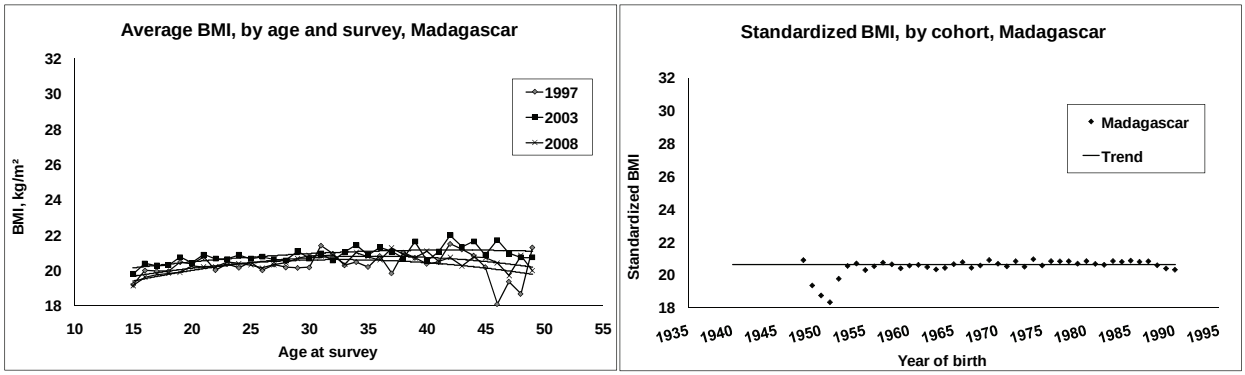
3.2 Interpretation of BMI trend figures

The interpretation of the figures displaying trends in standardized BMI is delicate, since they may combine several effects: a cohort effect (weight-for-height may be increasing with cohort, and in some cases may be decreasing), and interactions with age, which are a period effect (weight may be increasing, or decreasing, after a given period, and this may affect certain cohorts more than others). Here are some typical cases that occurred in this sample.

A. Madagascar: no age effect, no cohort effect

In Madagascar, the three surveys indicate about the same level of BMI, without any change by age, therefore without any age effect or cohort effect over a long period (Figure 17). The standardized BMI therefore has no slope with respect to cohort. Note that BMI values for Madagascar are among the lowest in the whole sample of African countries and much lower than European standards, indicating a very marked deficit in weight.

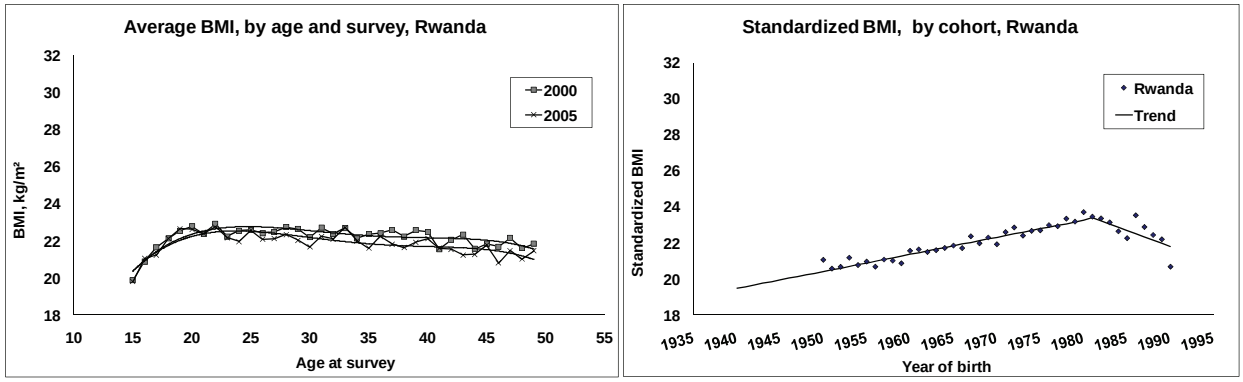
Figure 17 ***Age and cohort effects in Madagascar***



B. Rwanda: no age effect, increasing cohort effect

In Rwanda, BMI changed little between 2000 and 2005, but was decreasing with age in both surveys, which indicates a marked cohort effect. This cohort effect appears clearly in the standardized BMI trends (Figure 18). In Rwanda, the picture is further complicated with the late maturation of adolescents, and the strong period effect due to the civil war, which appears as a new negative cohort effect for the very recent cohorts in the standardized BMI figure.

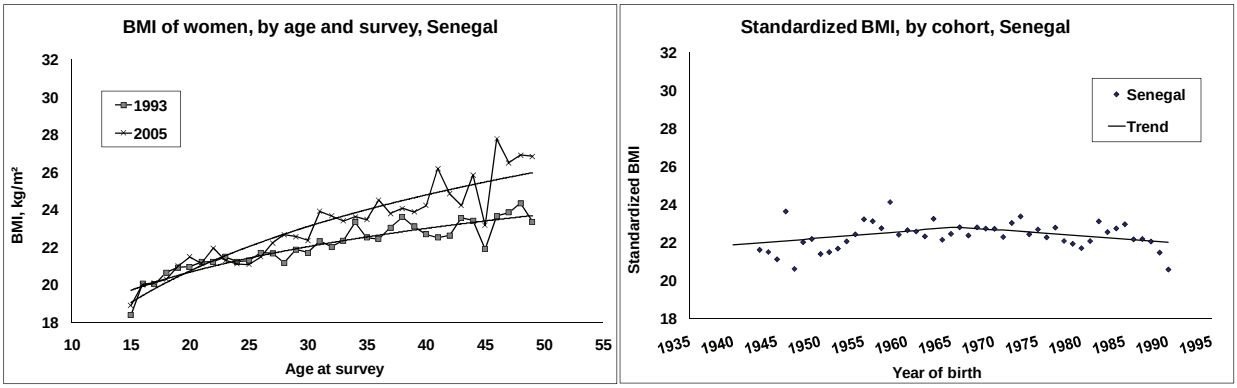
Figure 18 ***Age and cohort effects in Rwanda***



C. Senegal: changing age effect, no cohort effect

In Senegal, the age effect was already marked in 1993, but was much more pronounced in 2005, while the BMI below age 25 changed very little. This is typical of age and period interactions, the weight of older adult women increasing more rapidly with age in the recent period. As a result, the slope of the standardized BMI was negative (Figure 19). The fitting of the curve is not perfect on the figure since the standardized BMI is not equal to the BMI at age (x). The figure is simply illustrative of the trend after the conversion to standardized BMI.

Figure 19 ***Age and cohort effects in Senegal***

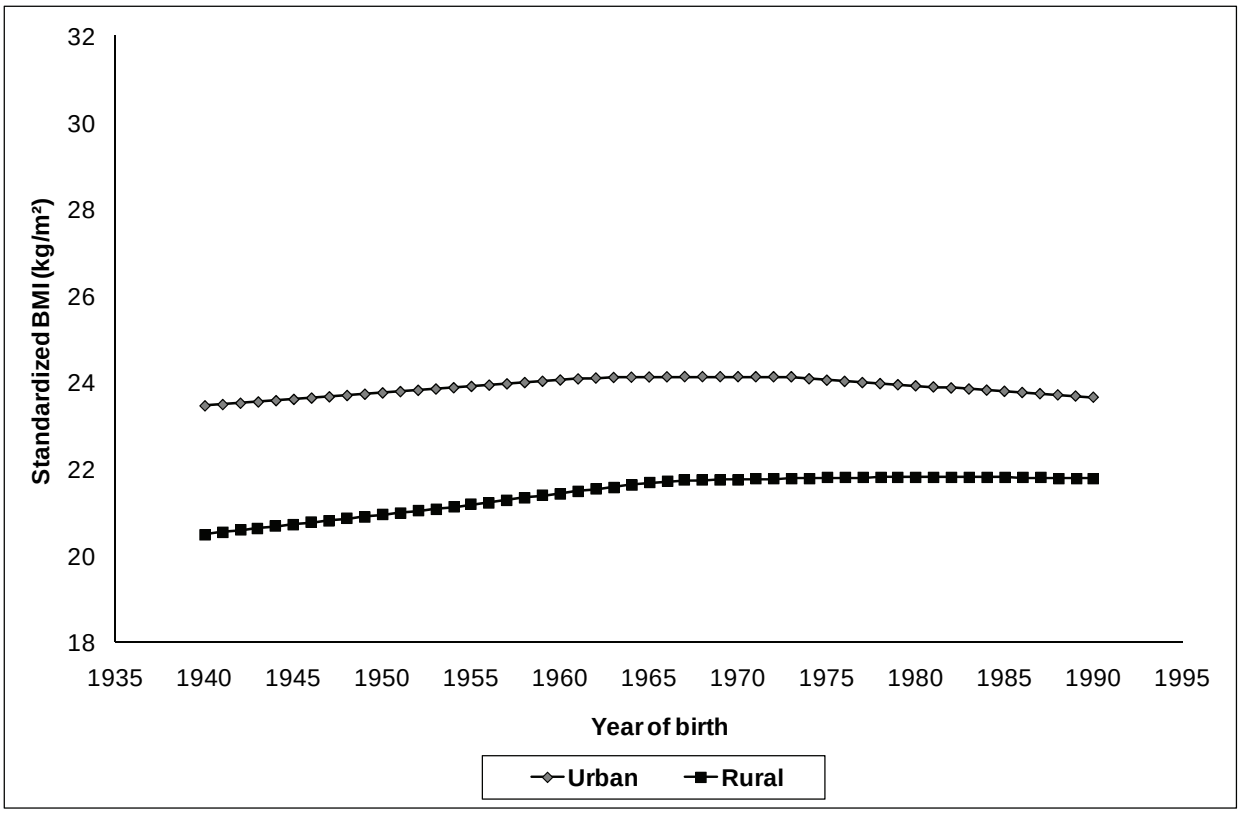


3.3 Trends in standardized BMI

For sub-Saharan Africa as a whole, reconstructed trends in standardized BMI showed some minor changes: first a small increase from 21.0 kg/m² for cohort 1940 to 22.6 kg/m² for cohort 1967, then a steady state (22.3 kg/m² for cohort 1990). This can be interpreted as a mild catch-up of weight for younger cohorts (about +4 kg for a height of 1.60 m), assuming constant age patterns used for the conversion. The reconstructed data showed a change in trends over time for the surveyed countries as a whole, the peak being for cohorts 1965-1969, as was the case for the changing trends for height.

As noted in many country studies, trends for urban and rural areas diverged. In urban areas trends were flat, around 23.6 kg/m², indicating steady increase of weight with age, whereas rural trends were upwards from low values (20.5 kg/m² for cohort 1940), indicating catch-up of weight for recent cohorts. As a result, the gap between urban and rural areas was narrowing for the most recent cohorts (Figure 20). The narrowing gap seems to be due primarily to the catch-up of most recent cohorts in rural areas, who reached values of BMI closer to international standards at young ages, as was the case already for urban areas. However, in urban areas cohorts continued to gain weight later with age, and much faster than in rural areas, as noted above.

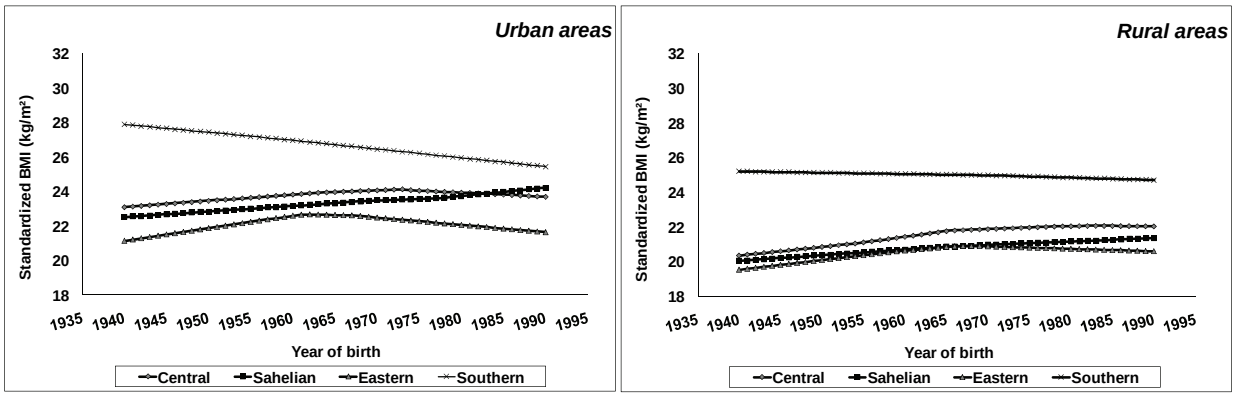
Figure 20 ***Reconstructed trends in standardized BMI of adult women***



3.4 Trends in standardized BMI by population group

Trends in standardized BMI also diverged for the four groups defined by body shape. In urban areas of the Southern group, trends were downward, indicating increasing obesity. In the Sahelian group, trends were upwards from low values, indicating catch-up weight. In the two other groups, trends were not steady: catch-up weight was visible for the earlier cohorts, but regressed for the younger cohorts. In both cases, long-term weight gains were minimal, as if earlier improvements were later cancelled, as was the case for height (Figure 21).

Figure 21 ***Reconstructed trends in standardized BMI of adult women, by population group***



In rural areas, trends were in the same direction, but with different slopes. In the Southern group, the increase in obesity was smaller, and catch-up weight was lower in the Sahelian group. Changing trends were also visible in the Central group and in the Eastern group, but the reversals were less pronounced. All these differences were highly significant.

3.5 Multivariate analysis of BMI (raw data)

A multivariate analysis of BMI was conducted similar to the analysis of height, on raw data. Here, results are presented for the 1940-1990 cohorts together, except for the two groups with trend reversal (Central and Eastern). Standardization by age was done by fitting a Log-linear relationship with age. Results show a strong interaction with body shape and urban residence, as noted before, so that results are presented for each group separately.

Trends in BMI (net effect)

Compared with the major trends in height identified above, trends in BMI were small after controlling for other factors (age, urban residence, and wealth) (Table 10). BMI tended to increase somewhat in the Sahelian group, and to decrease in the Eastern and Southern groups, with virtually no change in the Central group and for the countries as a whole. All trends were highly significant, and differences compared with the average pattern were all significant ($P < 10^{-8}$) except for the Central pattern. These findings confirm the analysis conducted using the standardized BMI.

Table 10 Underlying cohort trends in standardized BMI (net effects in multivariate analysis after controlling for age, urban residence, and wealth).

	Central	Sahelian	Eastern	Southern	Total
P value (trends)	7.0E-13	<E-99	1.6E-04	5.2E-06	1.4E-07
Estimated standardized BMI					
1940	22.2	20.5	21.9	25.3	21.9
1965	22.3	21.3	21.8	24.3	22.1
1990	22.2	22.1	20.8	23.3	22.3

The effects of the other factors (age, cohort, wealth, urban residence) were as expected (Table 11). As seen above, the age effect was strong in the Southern pattern, and weak in the Eastern pattern. The effect of wealth was consistent in all four groups, and with a major gradient. The effect of urban residence was small in the Southern pattern, because rural areas also have a strong propensity to obesity in this group, and very small in the Eastern pattern where both urban and rural areas have very low BMIs. All coefficients were highly significant.

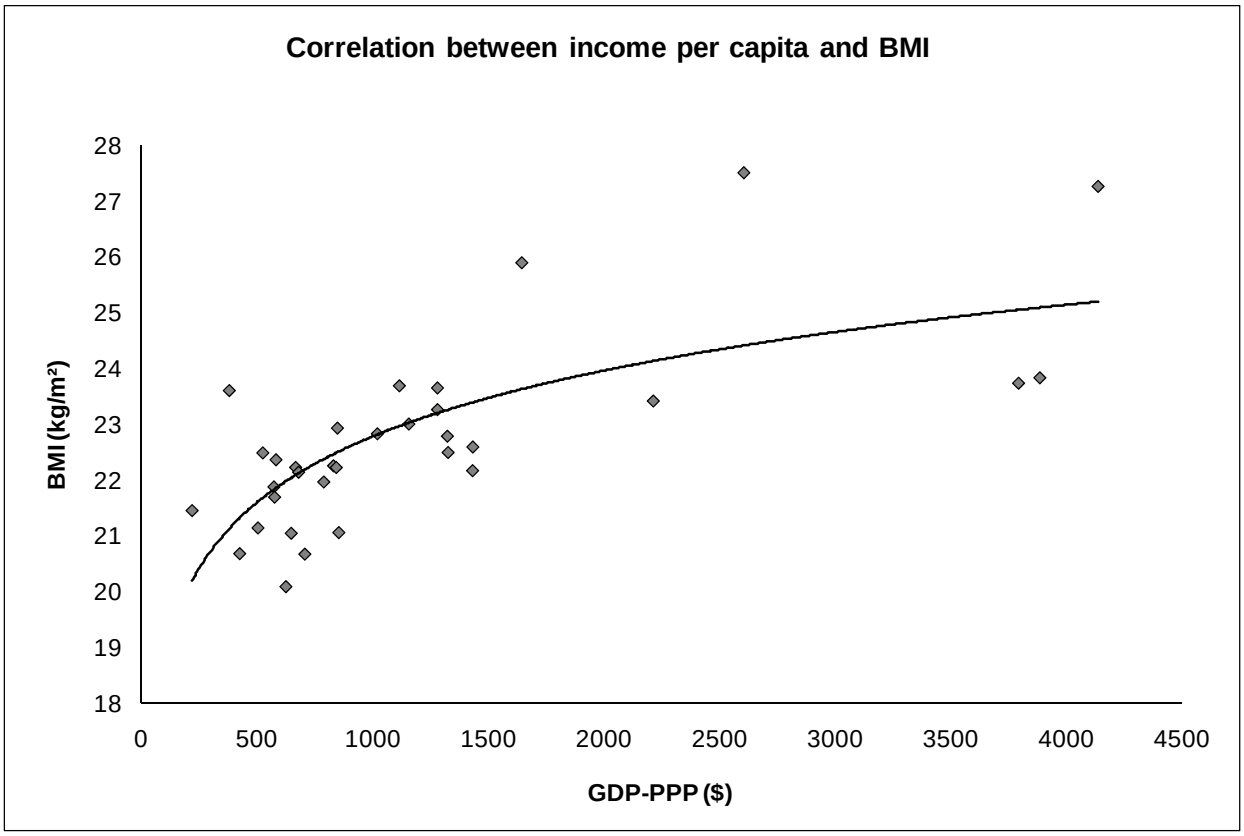
Table 11 Net effects in multivariate analysis of age, cohort, urban residence, and wealth on BMI

	Central	Sahelian	Eastern	Southern	Total
Constant	-11.1790	-56.7237	46.2567	87.8677	-3.0400
Log(age)	3.0198	3.4972	1.1663	4.1409	2.8886
Cohort	0.0113	0.0332	-0.0150	-0.0401	0.0073
Wealth	0.2990	0.2869	0.3661	0.3142	0.3640
Urban	0.8196	1.3914	0.0629	0.1655	0.6208

3.6 Correlation with economic development

The correlation between average BMI and the Logarithm of income per capita was significant, although rather weak. All wealthier countries (GDP-PPP >1500 USD) had a BMI above average (≥23.5), whereas all countries with a low BMI (<22 kg/m²) were among the poorest (GDP-PPP <1000 USD) (Figure 22).

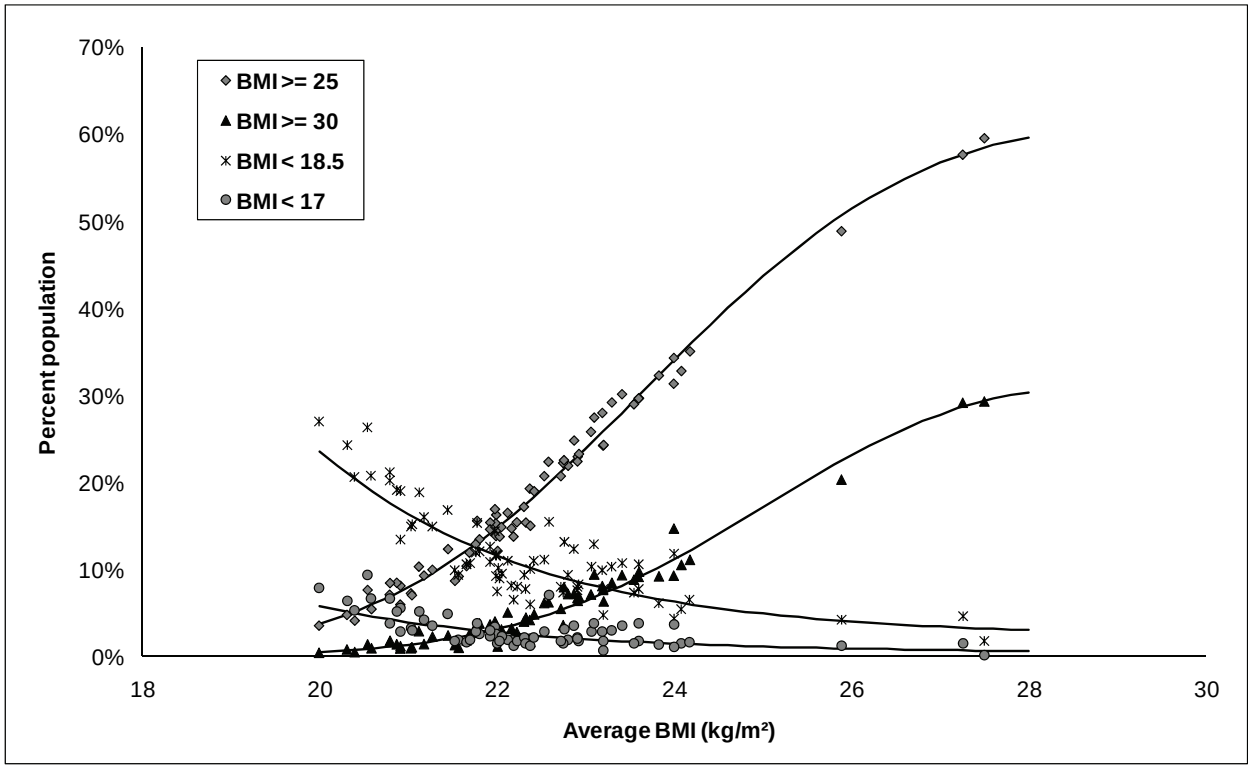
Figure 22 ***Relationship between average BMI and income per capita at country level***



3.7 Average BMI and prevalence of thinness and obesity

Investigating the prevalence of thinness and obesity was beyond the scope of this study, and prevalence is well documented in most final reports of DHS surveys. Furthermore, the average BMI was a more sensitive indicator for studying trends than any measure of prevalence. At survey level, the relationship between average BMI and the prevalence of thinness (BMI <17 kg/m²), under-weight (BMI <18.5 kg/m²), over-weight (BMI ≥25 kg/m²), and obesity (BMI ≥30 kg/m²) can be used for the conversion (Figure 23). Roughly speaking, an average BMI of 28 kg/m² corresponds to 30% obese and 60% overweight, and to virtually no very thin women. An average BMI of 20 kg/m² corresponds to 6% very thin women and 24% underweight, and virtually no obesity.

Figure 23 ***Relationship between average BMI and prevalence of thinness, underweight, overweight and obesity, 70 DHS surveys in sub-Saharan Africa, women age 20-49***



Much remains to be studied on trends in prevalence of thinness and obesity by age, cohort and period, for the same countries and same categories. We chose to present the mean BMI for the sake of simplicity and for providing a synthetic view, since with changing nutritional status the whole distribution shifts, with consequences for both ends (underweight and overweight).

Discussion

Trends in nutritional status of African women appeared as irregular and contrasted. Compared with the regular trend towards lower under-five mortality observed since 1950 [United Nations, 2007; Ahmad et al., 2000; Garenne and Gakusi; 2005], one could have expected regular improvements in nutritional status, and regular improvements in adult height. This was not the case for cohorts born between 1940 and 1990, and in particular, trends in height reversed for those born after 1965, as has been already noted by other authors [Moradi, 2006; Akachi and Canning, 2010]. The main reason seems to be the overwhelming economic downturn around 1975, which affected most African countries, lasted about 25 years, and seems to have had a major effect on the adolescent growth spurt for cohorts born after 1965.

Compared with trends in height in other developing countries, as well as in developed countries, an increase of about 2.0 cm over 25 years (1940-1965) was a significant achievement for sub-Saharan Africa. However, the decline in height that followed is a major downturn, with possibly long-term health consequences. Hopefully, this downturn is coming to an end with recent increases in income per capita.

Variations in women's heights by country, by urban or rural residence, and by wealth were large. In some situations (as in urban Senegal or urban Chad), the average height of adult women was almost identical to that of American or French women. In contrast, in the poorest situations (as in rural Madagascar or rural Comoro Islands) women were almost 10 cm below the international standards. Urban women were always doing better than rural women, and wealthier women than poorer women, as could have been anticipated. Gradients by wealth were particularly important (±5 cm), and were rather larger than elsewhere.

Overall, the average BMI of young African women was rather favorable, and consistent with international standards. This average hides very large disparities. In the poor countries and in the poor strata of most countries, the BMI was rather low, indicating a deficit in weight and nutrition. However, trends were indicating some catch-up for the poorer groups, and a moderate increase of weight with age, which is considered healthy. On the contrary, for wealthier countries, for urban areas and for the wealthiest strata the increase of weight with age was very marked and was increasing with time, indicating the fast emergence of obesity. Some countries and some socio-economic groups had a higher average BMI and more obesity than the USA, a country considered to have abnormally high prevalence of excess weight.

The study has a number of limitations. We considered only four large groups of body size and body shape, and classified each country into one of the four groups. This is obviously a serious limitation of the study. Of course, numerous other patterns are likely to exist in Africa, even within the same country. Some countries, such as Cameroon, Nigeria, Kenya or Uganda, are a mix of very different body shapes. More analysis could be conducted at the country and regional levels. The origin of these differences remains also to be analyzed. In our analysis they persisted after controlling for wealth, whereas for under-five children little differences persisted for higher socio-economic groups [Hohmann and Garenne, 2010]. Genetic factors probably play a role, since they are known to affect the ratio of leg length to trunk length and to originate primarily during the adolescence growth spurt. However, the quality of diet might also play a role, in particular the quantity of milk and micronutrients ingested. The role of diet could also be further analyzed.

Another limitation of this study is the use of current status of the household at time of survey, in particular for urban residence and household wealth. This however is likely to only minimize the differences in height and BMI in the real world.

We did not discuss the relationship of anthropometry with HIV/AIDS, which is complex. As noted by Bradley and Mishra [2002], the relationship of average BMI with prevalence of HIV is contrary to what could be anticipated (higher BMI among HIV positive women). This was true within countries as well as among countries. However, we checked the change in standardized BMI for cohorts 1955 to 1975 (age 30 in 1985 to 2005) in comparison with HIV prevalence in 2005. In countries with low (<5%) or moderate (5-14%) HIV prevalence in 2005, the increase in BMI was moderate (+0.50 and +0.89 kg/m² respectively), whereas in countries with high HIV prevalence (≥15%) there was a decline in standardized BMI (-0.34 kg/m²), as expected. These relationships could be studied in more detail.

This study was primarily general and exploratory, and aimed at providing a broad overview of trends in height and BMI. Much remains to be studied on trends and patterns of nutritional status in Africa and their relationships with economic and public health variables. Further research could be conducted on genetic factors and nutritional factors at ethnic group level. More research could be conducted on interactions with economic trends at local level, in particular with economic crises in urban areas, and with food shortages in rural areas. Many countries with very low height and with apparent underweight (as in Ethiopia and Madagascar) are also prone to recurrent famines [Devereux, 2007; Garenne, 2007]. The role of urban residence could also be further explored, since urban areas are associated with major differences not only in levels but also in trends in nutritional status of adult African women. In this respect, the emergence of extreme poverty in the slums of large cities deserves further attention with respect to the nutritional status of adult women.

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Appendix A: Annex Tables

Table A-1 List of surveys included in the study of trends in women's nutritional status

Code	Country	DHS-II	DHS-III	DHS-IV	DHS-V
BJ	Benin		1996	2001	2006
BF	Burkina Faso	1993	1999	2003	
CM	Cameroon		1998	2004	
CF	Central African Rep.		1994		
TD	Chad		1997		2004
KM	Comoros		1996		
CD	Congo-Kinshasa (RDC)				2007
CG	Congo-Brazzaville (RPC)				2005
CI	Côte d'Ivoire		1994	1999	
ET	Ethiopia			2000	2005
GA	Gabon			2000	
GH	Ghana	1993	1999	2003	2008
GN	Guinea		1999		2005
KE	Kenya	1993	1998	2003	2008
LS	Lesotho			2004	
LB	Liberia				2007
MD	Madagascar		1997	2003	2008
MW	Malawi	1992		2000	2004
ML	Mali		1995	2001	2006
MZ	Mozambique		1997		2003
NM	Namibia	1992			2007
NI	Niger	1992	1998		2006
NG	Nigeria		1999	2003	2008
RW	Rwanda			2000	2005
SN	Senegal	1993			2005
SL	Sierra Leone				2008
ZA	South Africa		1998		
SZ	Swaziland				2007
TZ	Tanzania		1996		2004
TG	Togo		1998		
UG	Uganda		1995	2001	2006
ZM	Zambia	1992	1997	2001	2007
ZW	Zimbabwe		1994	1999	2005

Table A-2 Trends in height, total

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1970	0.04877	63.528	0.01431	28.104
Benin	2	1970	1993	-0.09259	341.825	0.00768	15.206
Burkina Faso	1	1943	1965	0.04196	79.388	0.01629	31.913
Burkina Faso	2	1965	1993	-0.03456	229.850	0.00724	14.308
Cameroon	1	1948	1989	-0.01164	183.235	0.00814	16.077
Central African Rep	1	1944	1965	0.13572	-107.218	0.04894	95.958
Central African Rep	2	1965	1993	-0.07705	310.524	0.04563	89.963
Chad	1	1947	1965	0.01682	130.098	0.03985	78.145
Chad	2	1965	1993	-0.08542	331.099	0.01330	26.276
Comoro Islands	1	1946	1981	-0.02878	211.230	0.02731	53.726
Congo Kinshasa	1	1940	1975	0.06101	38.069	0.03276	64.467
Congo-Kinshasa	2	1975	1993	-0.13868	431.830	0.02653	52.643
Congo-Brazzaville	1	1955	1965	0.11187	-61.174	0.08971	176.007
Congo-Brazzaville	2	1965	1993	-0.05424	265.446	0.01477	29.233
Côte d'Ivoire	1	1944	1984	0.02019	119.478	0.00889	17.506
Ethiopia	1	1950	1990	-0.00217	160.744	0.00413	8.147
Gabon	1	1951	1985	0.00413	150.807	0.01720	33.935
Ghana	1	1944	1993	-0.00675	172.255	0.00504	9.955
Guinea	1	1949	1990	-0.00115	161.126	0.00774	15.277
Kenya	1	1943	1968	0.08977	-16.659	0.01471	28.870
Kenya	2	1968	1993	-0.05189	262.311	0.00691	13.681
Lesotho	1	1955	1989	-0.02706	210.798	0.01094	21.610
Liberia	1	1957	1992	-0.04897	254.007	0.00762	15.066
Madagascar	1	1948	1965	0.05881	39.051	0.02914	57.143
Madagascar	2	1965	1993	-0.07378	299.209	0.00589	11.659
Malawi	1	1942	1965	0.03741	83.009	0.01528	29.937
Malawi	2	1965	1993	-0.04311	241.161	0.00657	12.982
Mali	1	1946	1991	-0.03674	233.783	0.00350	6.912
Mozambique	1	1947	1960	0.15571	-148.789	0.05610	109.810
Mozambique	2	1960	1993	-0.03327	221.100	0.00691	13.640
Namibia	1	1942	1992	-0.01419	188.855	0.00533	10.521
Niger	1	1942	1991	-0.03413	227.415	0.00544	10.719
Nigeria	1	1949	1965	0.11746	-71.600	0.03408	66.849
Nigeria	2	1965	1993	-0.11053	377.001	0.00474	9.385
Rwanda	1	1950	1970	0.01881	121.273	0.01591	31.225
Rwanda	2	1970	1993	-0.22081	593.487	0.01193	23.616
Senegal	1	1943	1990	0.03488	94.126	0.00638	12.573
Sierra Leone	1	1958	1993	-0.06933	293.416	0.01954	38.668
South Africa	1	1942	1983	0.03310	93.919	0.00764	15.003
Swaziland	1	1956	1992	0.00074	157.536	0.00881	17.426
Tanzania	1	1947	1967	0.07765	4.264	0.02276	44.636
Tanzania	2	1967	1993	-0.04165	238.968	0.00928	18.352
Togo	1	1948	1983	-0.03587	229.309	0.01492	29.366
Uganda	1	1945	1965	0.05067	59.595	0.02646	51.867
Uganda	2	1965	1993	-0.07235	301.142	0.00953	18.822
Zambia	1	1942	1965	0.08608	-10.124	0.01678	32.878
Zambia	2	1965	1993	-0.07921	314.420	0.00650	12.843
Zimbabwe	1	1945	1991	-0.01553	190.523	0.00489	9.659

Table A-3 Trends in height, urban areas

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1970	0.06033	41.380	0.02330	45.768
Benin	2	1970	1993	-0.09507	347.369	0.01169	23.152
Burkina Faso	1	1943	1988	0.00882	144.914	0.00996	19.656
Cameroon	1	1948	1989	-0.01969	199.400	0.01112	21.969
Central African Rep	1	1944	1965	0.18827	-209.224	0.07879	154.652
Central African Rep	2	1965	1993	-0.06985	297.556	0.06415	126.545
Chad	1	1947	1965	-0.04808	257.679	0.05870	115.117
Chad	2	1965	1993	-0.04895	259.435	0.02338	46.153
Comoro Islands	1	1946	1981	-0.02587	206.144	0.05525	108.882
Congo-Kinshasa	1	1940	1975	0.06704	27.787	0.04961	97.684
Congo-Kinshasa	2	1975	1993	-0.08438	326.320	0.03566	70.766
Congo-Brazzaville	1	1955	1990	-0.03400	226.298	0.01478	29.233
Côte d'Ivoire	1	1944	1984	0.03528	90.340	0.01391	27.400
Ethiopia	1	1950	1990	-0.00430	165.643	0.00971	19.164
Gabon	1	1951	1985	0.00814	143.449	0.01985	39.167
Ghana	1	1944	1993	-0.01326	185.642	0.00755	14.900
Guinea	1	1949	1990	0.00019	159.284	0.01469	29.016
Kenya	1	1943	1968	0.04817	65.382	0.04456	87.503
Kenya	2	1968	1993	-0.08260	323.164	0.01401	27.734
Lesotho	1	1955	1989	-0.04841	253.172	0.02297	45.389
Liberia	1	1957	1992	-0.06883	293.973	0.01243	24.586
Madagascar	1	1948	1965	0.10432	-49.759	0.06342	124.411
Madagascar	2	1965	1993	-0.06617	284.932	0.01353	26.775
Malawi	1	1942	1965	0.14047	-117.724	0.04693	92.021
Malawi	2	1965	1993	-0.06510	285.711	0.01624	32.122
Mali	1	1946	1991	-0.02533	212.096	0.00644	12.727
Mozambique	1	1947	1988	-0.01118	178.927	0.00905	17.874
Namibia	1	1942	1992	-0.00134	163.734	0.00847	16.725
Niger	1	1942	1991	-0.01374	188.545	0.01291	25.453
Nigeria	1	1949	1965	0.12438	-84.118	0.05553	108.932
Nigeria	2	1965	1993	-0.11013	377.376	0.00793	15.711
Rwanda	1	1950	1970	-0.01166	182.717	0.04163	81.767
Rwanda	2	1970	1993	-0.23476	622.245	0.02255	44.652
Senegal	1	1943	1990	0.04648	71.587	0.00936	18.457
Sierra Leone	1	1958	1993	-0.12595	406.796	0.03280	64.965
South Africa	1	1942	1983	0.06322	34.954	0.00706	13.839
Swaziland	1	1956	1992	0.02677	106.299	0.01944	38.465
Tanzania	1	1947	1967	0.06199	35.544	0.02651	51.994
Tanzania	2	1967	1993	-0.05131	258.520	0.01046	20.699
Togo	1	1948	1983	-0.11544	386.862	0.03212	63.267
Uganda	1	1945	1965	0.16313	-160.187	0.08311	163.152
Uganda	2	1965	1993	-0.10611	368.204	0.02396	47.381
Zambia	1	1942	1965	0.12187	-79.470	0.02690	52.725
Zambia	2	1965	1993	-0.06119	279.874	0.00945	18.687
Zimbabwe	1	1945	1991	-0.02028	200.511	0.00853	16.840

Table A-4 Trends in height, rural areas

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1970	0.03650	87.259	0.01809	35.511
Benin	2	1970	1993	-0.10009	356.224	0.01015	20.087
Burkina Faso	1	1943	1965	0.03729	88.431	0.01745	34.194
Burkina Faso	2	1965	1993	-0.05319	266.473	0.00806	15.932
Cameroon	1	1948	1989	-0.01311	185.863	0.01038	20.498
Central African Rep	1	1944	1965	0.10159	-40.880	0.06181	121.226
Central African Rep	2	1965	1993	-0.09211	339.302	0.06257	123.385
Chad	1	1947	1965	0.01545	132.756	0.04166	81.695
Chad	2	1965	1993	-0.10167	363.116	0.01440	28.435
Comoro Islands	1	1946	1981	-0.02897	211.406	0.03137	61.745
Congo-Kinshasa	1	1940	1975	0.00407	148.906	0.04298	84.565
Congo-Kinshasa	2	1975	1993	-0.19760	546.778	0.03619	71.807
Congo-Brazzaville	1	1955	1990	-0.03007	216.291	0.01516	29.974
Côte d'Ivoire	1	1944	1984	0.01169	135.832	0.01124	22.118
Ethiopia	1	1950	1990	-0.00356	163.356	0.00452	8.909
Gabon	1	1951	1985	-0.01892	194.656	0.03300	65.139
Ghana	1	1944	1993	-0.01466	187.535	0.00663	13.070
Guinea	1	1949	1990	-0.00944	177.174	0.00914	18.019
Kenya	1	1943	1968	0.09087	-18.890	0.01569	30.778
Kenya	2	1968	1993	-0.04324	245.178	0.00795	15.733
Lesotho	1	1955	1989	-0.01570	188.184	0.01175	23.226
Liberia	1	1957	1992	-0.05000	255.536	0.00972	19.196
Madagascar	1	1948	1965	0.04961	56.978	0.03281	64.349
Madagascar	2	1965	1993	-0.07502	301.459	0.00652	12.910
Malawi	1	1942	1965	0.01969	117.561	0.01613	31.596
Malawi	2	1965	1993	-0.04237	239.484	0.00716	14.149
Mali	1	1946	1991	-0.05077	261.079	0.00418	8.250
Mozambique	1	1947	1960	0.17411	-184.728	0.06026	117.963
Mozambique	2	1960	1993	-0.02944	213.436	0.00779	15.376
Namibia	1	1942	1992	-0.02377	207.552	0.00687	13.569
Niger	1	1942	1991	-0.04014	238.985	0.00596	11.751
Nigeria	1	1949	1965	0.10767	-52.892	0.04262	83.604
Nigeria	2	1965	1993	-0.11036	376.006	0.00584	11.559
Rwanda	1	1950	1970	-0.00104	159.863	0.01664	32.641
Rwanda	2	1970	1993	-0.21078	573.290	0.01287	25.476
Senegal	1	1943	1990	0.02718	109.043	0.00806	15.892
Sierra Leone	1	1958	1993	-0.05373	261.864	0.02430	48.084
South Africa	1	1928	1983	0.03902	81.721	0.00863	16.914
Swaziland	1	1956	1992	-0.00598	170.760	0.00986	19.501
Tanzania	1	1947	1967	0.07746	4.749	0.02390	46.865
Tanzania	2	1967	1993	-0.04088	237.588	0.01010	19.972
Togo	1	1948	1965	0.03081	98.051	0.04928	96.642
Togo	2	1965	1993	-0.08691	329.807	0.03265	64.400
Uganda	1	1945	1965	0.03635	87.587	0.02794	54.771
Uganda	2	1965	1993	-0.06776	292.020	0.01039	20.538
Zambia	1	1942	1965	0.05517	49.890	0.02131	41.754
Zambia	2	1965	1993	-0.09632	347.463	0.00873	17.263
Zimbabwe	1	1945	1991	-0.01910	197.251	0.00595	11.751

Table A-5 Trends in standardized BMI, total

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1963	0.07551	-125.515	0.02716	53.213
Benin	2	1963	1993	0.00100	20.845	0.00451	8.921
Burkina Faso	1	1943	1988	0.06813	-113.023	0.00240	4.723
Cameroon	1	1948	1989	0.00049	22.751	0.00554	10.933
Central African Rep	1	1945	1979	0.08935	-154.322	0.00893	17.576
Chad	1	1947	1989	0.03568	-49.522	0.00439	8.658
Comoro Islands	1	1946	1981	0.00370	15.100	0.01975	38.860
Congo-Kinshasa	1	1957	1992	0.05814	-93.395	0.00539	10.659
Congo-Brazzaville	1	1955	1962	0.18541	-339.820	0.09506	186.385
Congo-Brazzaville	2	1962	1993	-0.03199	86.589	0.00690	13.662
Côte d'Ivoire	1	1944	1984	0.04542	-66.665	0.00573	11.283
Ethiopia	1	1950	1964	0.07416	-125.663	0.00933	18.268
Ethiopia	2	1964	1993	0.00160	17.066	0.00291	5.762
Gabon	1	1951	1985	-0.01144	46.629	0.01178	23.248
Ghana	1	1944	1965	0.13607	-243.946	0.02084	40.859
Ghana	2	1965	1993	0.00346	16.446	0.00524	10.357
Guinea	1	1949	1990	0.04654	-69.849	0.00433	8.543
Kenya	1	1943	1966	0.08955	-152.974	0.01273	24.955
Kenya	2	1966	1993	-0.01098	44.593	0.00394	7.785
Lesotho	1	1955	1989	-0.05023	124.681	0.00872	17.232
Liberia	1	1957	1992	0.00180	19.218	0.00503	9.947
Madagascar	1	1948	1994	-0.00034	21.282	0.00212	4.184
Malawi	1	1942	1990	-0.01056	42.851	0.00199	3.935
Mali	1	1946	1991	0.05109	-78.445	0.00220	4.347
Mozambique	1	1947	1960	0.10166	-176.757	0.03974	77.803
Mozambique	2	1960	1993	-0.03045	82.184	0.00389	7.678
Namibia	1	1942	1963	0.16298	-295.831	0.02732	53.518
Namibia	2	1963	1993	-0.06487	151.736	0.00562	11.126
Niger	1	1942	1991	0.03802	-53.646	0.00329	6.487
Nigeria	1	1949	1965	0.08445	-142.846	0.02353	46.156
Nigeria	2	1965	1993	-0.03382	89.799	0.00290	5.739
Rwanda	1	1950	1983	0.09447	-163.808	0.00286	5.639
Rwanda	2	1983	1993	-0.17827	376.526	0.02425	48.145
Senegal	1	1943	1965	0.03627	-48.509	0.01856	36.350
Senegal	2	1965	1993	-0.03244	86.566	0.00728	14.398
Sierra Leone	1	1958	1993	0.03330	-42.269	0.00995	19.682
South Africa	1	1902	1960	0.03495	-40.740	0.01216	23.665
South Africa	2	1960	1993	-0.15147	325.040	0.01285	25.333
Swaziland	1	1956	1992	-0.11569	255.687	0.00756	14.958
Tanzania	1	1947	1967	0.03879	-53.547	0.01504	29.500
Tanzania	2	1967	1993	-0.07942	179.250	0.00535	10.577
Togo	1	1948	1965	0.08269	-140.598	0.02757	54.065
Togo	2	1965	1993	0.00007	21.778	0.01586	31.272
Uganda	1	1945	1991	0.05673	-89.693	0.00330	6.510
Zambia	1	1942	1992	0.03138	-39.538	0.00242	4.768
Zimbabwe	1	1945	1991	0.00689	10.147	0.00323	6.378

Table A-6 Trends in standardized BMI, urban areas

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1965	0.13508	-240.964	0.03983	78.097
Benin	2	1965	1993	-0.02060	64.735	0.00818	16.184
Burkina Faso	1	1943	1988	0.10928	-191.498	0.00712	14.057
Cameroon	1	1948	1989	-0.04462	112.929	0.00825	16.306
Central African Rep	1	1945	1979	0.10616	-186.752	0.01576	31.022
Chad	1	1947	1975	0.00449	12.390	0.01201	23.625
Chad	2	1975	1993	0.25141	-475.701	0.03569	70.654
Comoro Islands	1	1946	1981	0.01638	-8.561	0.04850	95.611
Congo-Kinshasa	1	1940	1975	-0.00804	37.932	0.03114	61.311
Congo-Kinshasa	2	1975	1993	0.06428	-104.902	0.01906	37.836
Congo-Brazzaville	1	1955	1990	-0.04565	114.305	0.00802	15.858
Côte d'Ivoire	1	1944	1984	0.03250	-40.118	0.01027	20.218
Ethiopia	1	1950	1964	0.09954	-173.897	0.03900	76.439
Ethiopia	2	1964	1993	-0.00085	23.048	0.00841	16.629
Gabon	1	1951	1985	-0.02727	78.330	0.01406	27.742
Ghana	1	1944	1965	0.16937	-307.682	0.04085	80.113
Ghana	2	1965	1993	-0.01526	54.701	0.00819	16.196
Guinea	1	1949	1990	0.00409	15.395	0.00952	18.804
Kenya	1	1943	1994	-0.02105	66.323	0.00656	12.960
Lesotho	1	1955	1989	-0.07932	182.635	0.01757	34.710
Liberia	1	1957	1992	-0.03652	96.179	0.00889	17.584
Madagascar	1	1948	1994	-0.01428	49.668	0.00541	10.681
Malawi	1	1942	1990	-0.04773	117.614	0.00626	12.356
Mali	1	1946	1991	0.06291	-100.005	0.00465	9.189
Mozambique	1	1947	1960	0.20026	-367.808	0.10726	210.117
Mozambique	2	1960	1993	-0.10728	235.173	0.00758	14.973
Namibia	1	1942	1960	0.15304	-273.597	0.07480	146.522
Namibia	2	1960	1993	-0.09467	211.800	0.00833	16.459
Niger	1	1942	1970	0.10460	-181.826	0.02732	53.651
Niger	2	1970	1993	-0.00487	33.779	0.02094	41.443
Nigeria	1	1949	1969	0.05574	-85.424	0.02436	47.851
Nigeria	2	1969	1993	-0.06874	160.114	0.00619	12.275
Rwanda	1	1950	1983	0.09824	-170.491	0.00809	15.968
Rwanda	2	1983	1993	-0.39047	798.872	0.04558	90.556
Senegal	1	1943	1990	-0.05086	123.772	0.00691	13.631
Sierra Leone	1	1958	1993	0.00578	13.624	0.01826	36.151
South Africa	1	1928	1983	-0.05067	126.519	0.00627	12.301
Swaziland	1	1956	1992	-0.10185	228.668	0.01649	32.618
Tanzania	1	1947	1969	0.03593	-47.580	0.01458	28.623
Tanzania	2	1969	1987	-0.05654	134.297	0.00839	16.592
Togo	1	1948	1983	-0.04292	107.733	0.02553	50.290
Uganda	1	1945	1991	0.05169	-77.683	0.01083	21.379
Zambia	1	1942	1971	-0.01192	46.626	0.01189	23.348
Zambia	2	1971	1993	0.05292	-81.084	0.00897	17.767
Zimbabwe	1	1945	1991	-0.04091	105.725	0.00614	12.134

Table A-7 Trends in standardized BMI, rural areas

Country	Period	Begin	End	Slope	Intercept	Standard error	
						Slope	Intercept
Benin	1	1946	1991	0.01043	1.267	0.00357	7.046
Burkina Faso	1	1943	1988	0.04187	-61.922	0.00214	4.210
Cameroon	1	1948	1989	-0.00929	41.337	0.00631	12.454
Central African Rep	1	1945	1979	0.07078	-118.227	0.01023	20.133
Chad	1	1947	1989	0.01992	-18.670	0.00429	8.461
Comoro Islands	1	1946	1981	0.00043	21.097	0.02016	39.679
Congo-Kinshasa	1	1940	1978	0.08842	-153.762	0.01384	27.255
Congo-Kinshasa	2	1978	1993	0.01955	-17.487	0.02044	40.598
Congo-Brazzaville	1	1955	1990	0.00100	20.305	0.00733	14.495
Côte d'Ivoire	1	1944	1984	0.04172	-60.220	0.00600	11.799
Ethiopia	1	1950	1964	0.07048	-118.656	0.00886	17.360
Ethiopia	2	1964	1993	-0.00419	28.256	0.00291	5.744
Gabon	1	1951	1985	0.02128	-19.357	0.01845	36.413
Ghana	1	1944	1966	0.08634	-147.534	0.01809	35.468
Ghana	2	1966	1993	-0.00025	22.616	0.00619	12.234
Guinea	1	1949	1990	0.04768	-72.708	0.00439	8.649
Kenya	1	1943	1966	0.05785	-91.310	0.01258	24.655
Kenya	2	1966	1993	-0.01014	42.316	0.00410	8.116
Lesotho	1	1955	1989	-0.04394	111.929	0.00957	18.913
Liberia	1	1957	1992	0.00120	19.539	0.00554	10.953
Madagascar	1	1948	1994	0.00355	13.368	0.00222	4.393
Malawi	1	1942	1965	0.05822	-92.238	0.00896	17.542
Malawi	2	1965	1993	-0.03641	93.709	0.00354	7.006
Mali	1	1946	1991	0.02422	-26.301	0.00216	4.264
Mozambique	1	1947	1960	0.09313	-160.076	0.04153	81.293
Mozambique	2	1960	1993	-0.03002	81.154	0.00424	8.363
Namibia	1	1942	1970	0.09757	-169.254	0.01610	31.601
Namibia	2	1970	1993	-0.05556	132.445	0.00919	18.223
Niger	1	1942	1991	0.03222	-42.778	0.00296	5.832
Nigeria	1	1949	1965	0.07875	-132.216	0.02700	52.950
Nigeria	2	1965	1993	-0.02477	71.251	0.00336	6.649
Rwanda	1	1950	1985	0.06857	-113.115	0.00259	5.105
Rwanda	2	1985	1993	-0.24552	509.777	0.04018	79.869
Senegal	1	1943	1965	0.04535	-66.883	0.02186	42.827
Senegal	2	1965	1993	-0.05462	129.621	0.00831	16.426
Sierra Leone	1	1958	1993	0.03000	-36.545	0.01119	22.122
South Africa	1	1928	1983	-0.01790	61.098	0.00691	13.537
Swaziland	1	1956	1992	-0.11857	261.268	0.00850	16.816
Tanzania	1	1947	1969	0.02698	-30.725	0.01152	22.615
Tanzania	2	1969	1987	-0.02893	79.173	0.00703	13.903
Togo	1	1948	1983	0.04520	-67.654	0.00779	15.336
Uganda	1	1945	1991	0.04869	-74.188	0.00327	6.456
Zambia	1	1942	1966	0.06074	-97.915	0.01065	20.877
Zambia	2	1966	1993	0.01778	-13.470	0.00432	8.538
Zimbabwe	1	1945	1991	0.01750	-11.470	0.00354	6.991

Appendix B: Country Studies

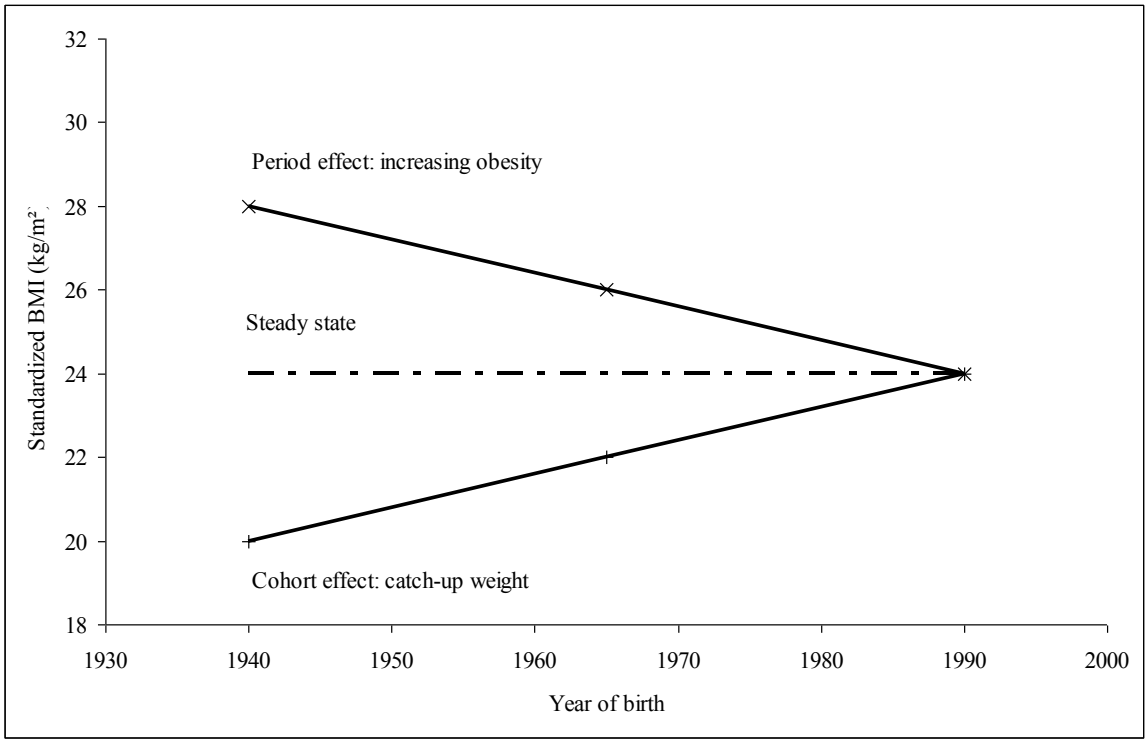
Introduction to country studies

This section provides a detailed analysis of trends in height and in standardized Body Mass Index (BMI) country by country. Data from different surveys in the same country were aggregated as described in the "Methods" section of the report. Trends were tested using standard linear regression models (OLS). Each country study follows the same plan: presentation of available data in the country, with a brief discussion of consistency between surveys if more than one survey is available; trends in height, for urban and rural areas separately; trends in standardized BMI, for urban and rural areas separately; and when applicable a brief comment on the peculiarity of the country.

The first table presents the raw data for women age 20-49 at time of survey. All the other information in text and figures refer to age standardized values—that is, values of height corrected for women age 15-19, and age standardized BMI, as defined in the "Methods" section. The standardized BMI can be interpreted as the BMI at age 30 assuming the pattern of weight increase prevalent in the same group of body shape, and same area of residence (urban or rural). Numeric values of trends, with standard errors, are presented in Appendix A, for each country as a whole, and for urban and rural areas separately. Trends are presented for all cohorts available born between 1942 and 1993, depending on the survey dates.

The interpretation of trends in standardized BMI is delicate. A flat trend usually indicates no change over time in level and age pattern. An increasing trend from low values usually indicates catch-up weight: it implies that older cohorts were rather underweight for their height, and that the weight of younger cohorts is greater for the same height. A decreasing trend at high values usually indicates increasing obesity: it implies that the age pattern is changing over time, with more obesity among older persons than expected from the underlying age pattern (Figure B.0). Other interactions between age, period and cohort may also happen in certain countries. A declining trend from low values may indicate worsening nutritional status, defined as lower than expected weight for height. An increasing trend from high values may indicate increasing obesity among very young adults.

Figure B-0 ***Typical patterns of changes in standardized BMI***



1. Benin

Benin conducted three surveys with anthropometric data on adult women, in 1996, 2001 and 2006. All three were consistent in terms of mean and standard deviation, with some minor differences. Differences in period estimates of height and BMI were significant (P <0.001 in both cases). Some of the differences in BMI are due to low values of weight in the first survey, possibly due to a systematic bias.

Table B-1 Sample size and basic anthropometric characteristics, adult women, Benin

	Year of survey		
	1996	2001	2006
Number of women	2337	5113	14351
Height, women 20-49			
Mean (cm)	158.5	158.5	159.1
Standard deviation	6.07	6.17	6.27
BMI, women 20-49			
Mean (kg/m²)	21.4	22.8	22.9
Standard deviation	3.28	4.27	4.27

Trends in cohort height were not steady: average height increased from 158.1 cm (cohort 1940) to 159.5 cm (cohort 1969), and declined as fast afterwards, reaching 157.6 cm for cohort 1990. The change occurred for women who were adolescent in the mid-1980s, and seemed to have continued ever since. Both slopes were highly significant (P=0.001 for 1940-1969, and P<0.001 for 1969-1990), and the change in slopes even more so (P<E-10). Trends were similar for urban and rural areas (Figure B-1.1). There were some significant differences in average height by survey, but all three surveys showed a significant declining trend since cohort 1970 (slopes= -0.107, -0.096, -0.120 respectively), the differences between the slopes being not significant.

At the national level, the standardized BMI tended to increase slowly over time, with a significant slope, from 21.5 for cohort 1947 to 22.8 for cohort 1990. In urban areas, the standardized BMI increased first up to cohort 1964, then declined slowly, the change in slope being significant (P=0.0001). In rural areas, it remained almost steady, with only a very mild significant increase (P=0.003) (Figure B-1.2).

Figure B-1.1 ***Trends in average height, adult women, Benin***

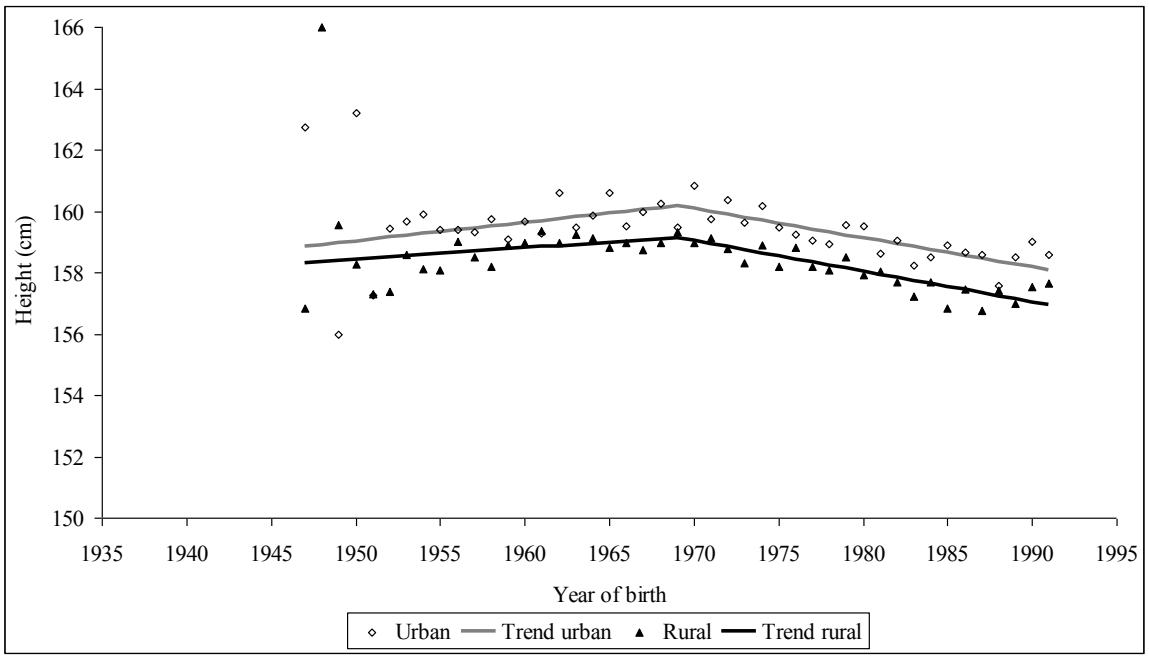
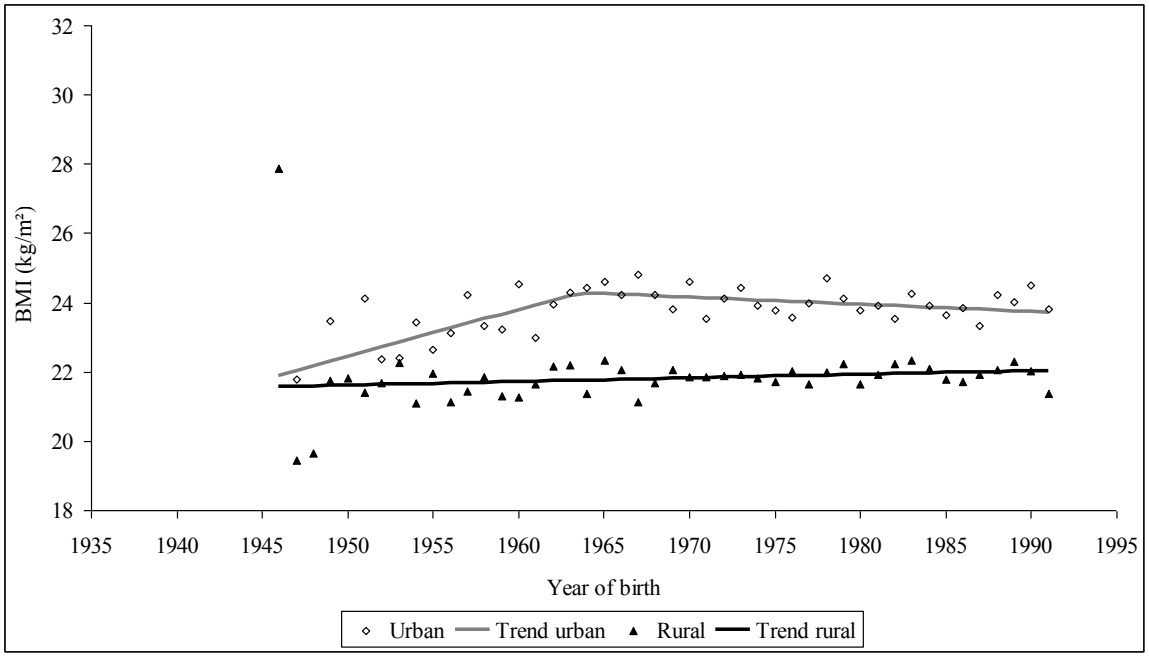


Figure B-1.2 ***Trends in standardized BMI, adult women, Benin***



2. Burkina Faso

Burkina-Faso conducted three surveys with anthropometric data on adult women, in 1993, 1999 and 2003. All three were consistent in terms of mean and standard deviation, with no differences between surveys.

Table B-2 Sample size and basic anthropometric characteristics, adult women, Burkina Faso

	Year of survey		
	1993	1999	2003
Number of women	3873	3693	9723
Height, women 20-49			
Mean (cm)	161.6	161.6	161.6
Standard deviation	5.92	5.87	5.99
BMI, women 20-49			
Mean (kg/m²)	21.2	21.0	21.2
Standard deviation	2.86	2.55	3.53

Trends in cohort height were not steady: average height increased from 160.9 cm (cohort 1940) to 161.8 cm (cohort 1966), and declined afterwards, reaching 161.0 cm for cohort 1990. The change occurred for women who were adolescent in the mid-1980s, but seemed to have continued ever since. Both slopes were highly significant (P=0.001 for 1940-1965, and P<0.001 for 1965-1990), and the change even more so (P<2E-05). Trends were changing only in rural areas, but not in urban areas (Figure B-2.1). There were no differences in levels and trends by survey.

At the national level, the standardized BMI tended to increase steadily over time, from 19.3 cohort 1943 to 22.4 for cohort 1988. The standardized BMI increased more rapidly in urban than in rural areas, in both cases from low values for cohort 1943, increasing the gap between both areas, the difference in slopes being highly significant (P<E-10) (Figure B-2.2).

Figure B-2.1 ***Trends in average height, adult women, Burkina Faso***

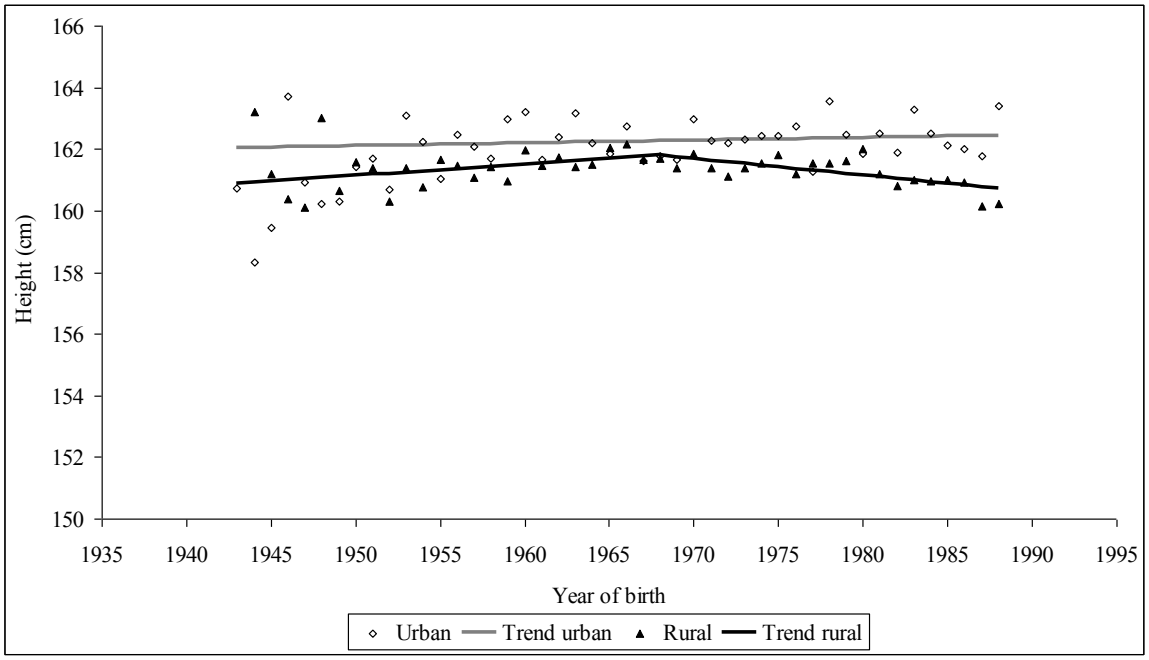
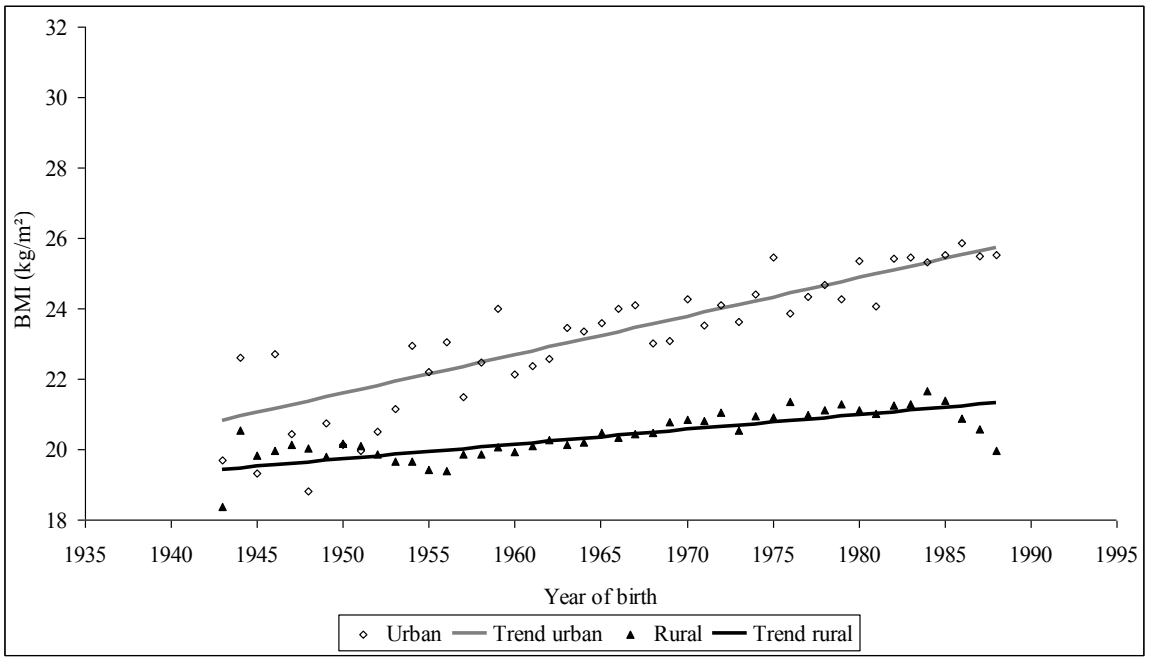


Figure B-2.2 ***Trends in standardized BMI, adult women, Burkina Faso***



3. Cameroon

Cameroon conducted two surveys with anthropometric data on adult women, in 1998 and 2004. Both were consistent in terms of mean and standard deviation, with no difference between surveys for height, but a higher BMI in the second survey (P <E-10).

Table B-3 Sample size and basic anthropometric characteristics, adult women, Cameroon

Year of survey	1998	2004
Number of women	1722	3857
Height, women 20-49		
Mean (cm)	160.1	160.4
Standard deviation	6.31	6.18
BMI, women 20-49		
Mean (kg/m²)	22.9	24.1
Standard deviation	3.71	4.44

There was no trend in cohort height at the national level (P=0.145), and average height remained basically constant at 160.4 cm. Both surveys showed the same level and trend. Urban and rural trends were basically identical, with only a small gap between them (Figure B-3.1).

At the national level, the standardized BMI remained overall steady around 23.7. In urban areas, the standardized BMI was decreasing slowly and steadily (P <E-07), whereas it was steady in rural areas (P=0.141) (Figure B-3.2).

Figure B-3.1 ***Trends in average height, adult women, Cameroon***

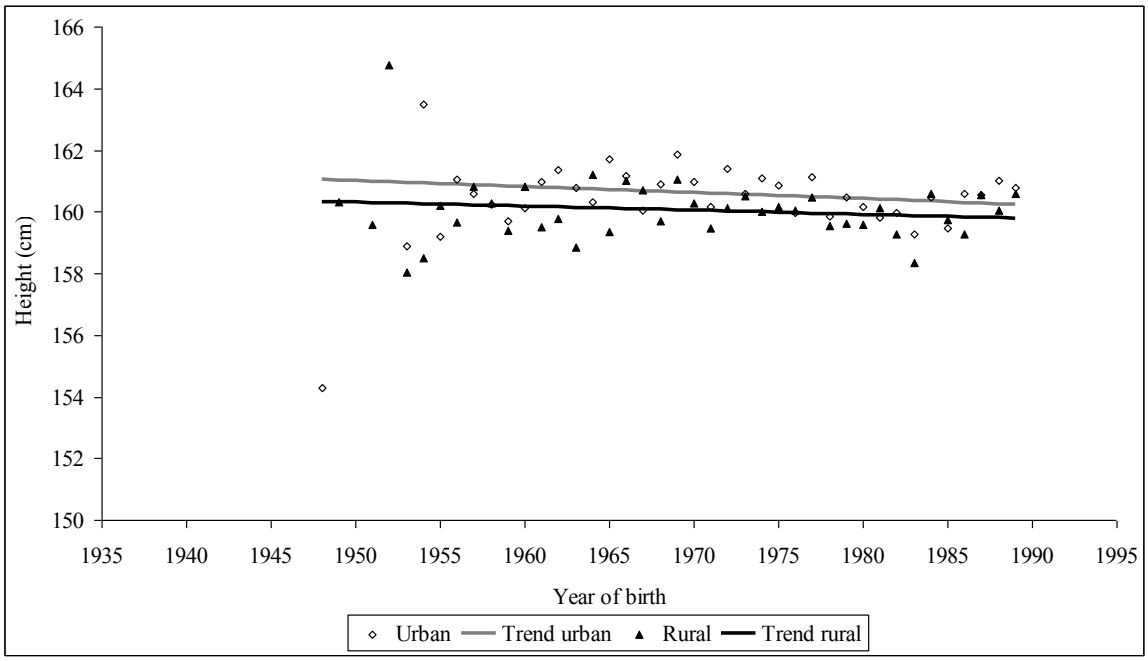
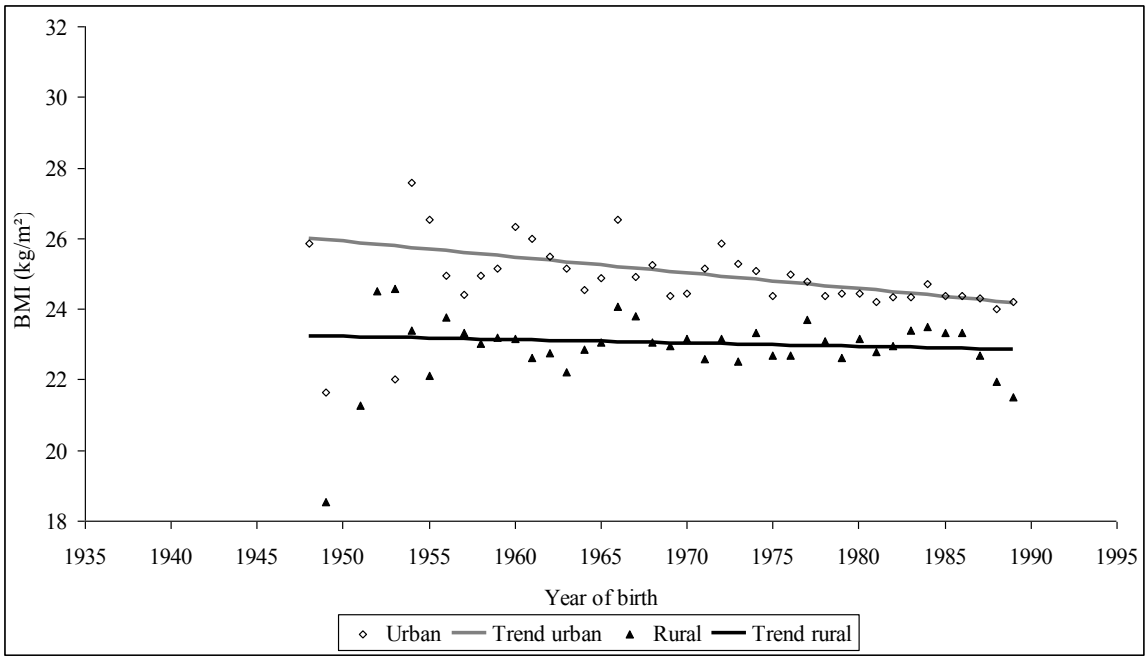


Figure B-3.2 ***Trends in standardized BMI, adult women, Cameroon***



4. Central African Republic

The Central African Republic conducted one survey with anthropometric data on adult women, in 1994.

Table B-4 Sample size and basic anthropometric characteristics, adult women, Central African Republic

	Year of survey
	1994
Number of women	2058
Height, women 20-49	
Mean (cm)	158.8
Standard deviation	6.70
BMI, women 20-49	
Mean (kg/m²)	21.2
Standard deviation	2.72

The trend in height was not steady at the national level. Women's height increased from cohort 1945 (156.8 cm) to cohort 1964 (159.3 cm), then decreased to reach 158.0 for the last cohort available (1980). The first increasing slope was significant (P=0.006), but the second was not (P=0.091). However the change in slope was highly significant (P<0.001). Trends were the same in urban and rural areas, with no significant differences between the two areas (Figure B-4.1).

At the national level, the standardized BMI increased over time from low values for cohort 1945 (19.5 kg/m²). Trends were similar in both areas of residence, perhaps somewhat faster in urban areas, although the difference between slopes was borderline (P=0.060) (Figure B-4.2).

Figure B-4.1 ***Trends in average height, adult women, Central African Republic***

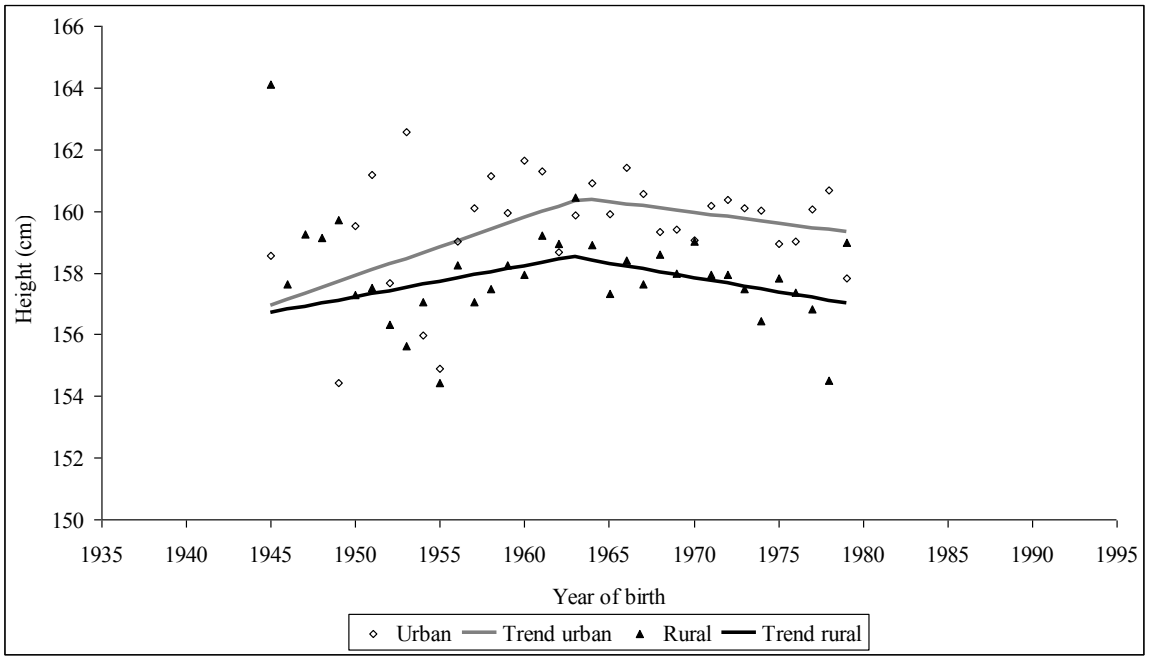
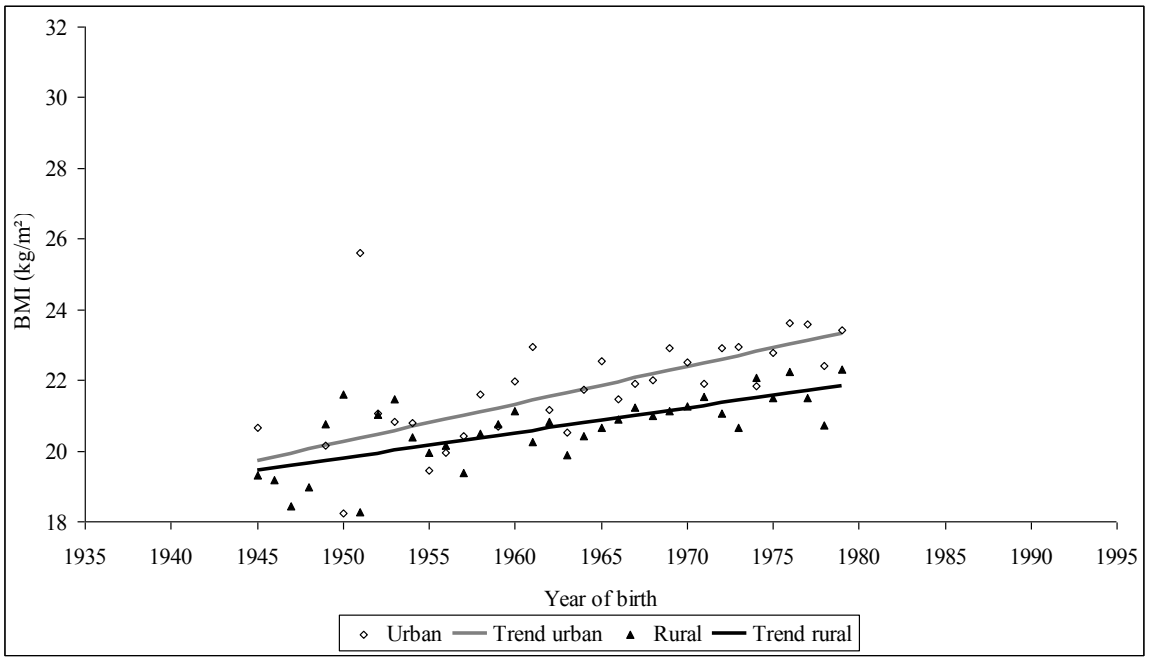


Figure B-4.2 ***Trends in standardized BMI, adult women, Central African Rep.***



5. Chad

Chad conducted two surveys with anthropometric data on adult women, in 1997 and 2004. Both led to very similar estimates for height and BMI.

Table B-5 Sample size and basic anthropometric characteristics, adult women, Chad

	Year of survey	
	1997	2004
Number of women	4019	3396
Height, women 20-49		
Mean (cm)	162.8	162.4
Standard deviation	6.33	6.26
BMI, women 20-49		
Mean (kg/m²)	20.8	20.9
Standard deviation	2.74	3.04

The trend in height was not steady at the national level. Women's height was high (163.0 cm) from cohort 1945 to cohort 1965, then decreased to reach 161.2 for cohort 1990. The decreasing slope was significant (P<E-10), as was the change in slopes (P=0.015). Trends were the same in urban and rural areas, with no significant differences between the two areas (Figure B-5.1).

At the national level, the standardized BMI increased slowly over time from low values, with a significant slope (P<0.001), from 19.9 for cohort 1947 to 21.4 for cohort 1989. Trends were similar in both areas of residence up to cohort 1977, then the standardized BMI increased rapidly (P<E-10) in urban areas for the recent cohorts, to reach 24.4 kg/m² in 1989 (Figure B-5.2).

Figure B-5.1 ***Trends in average height, adult women, Chad***

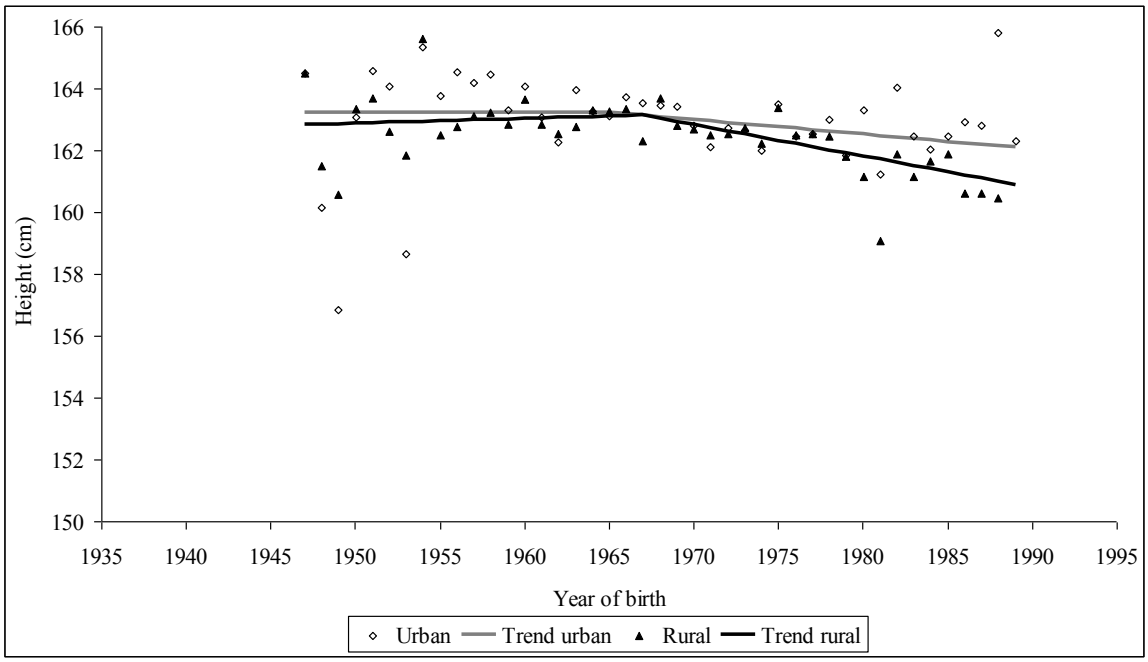
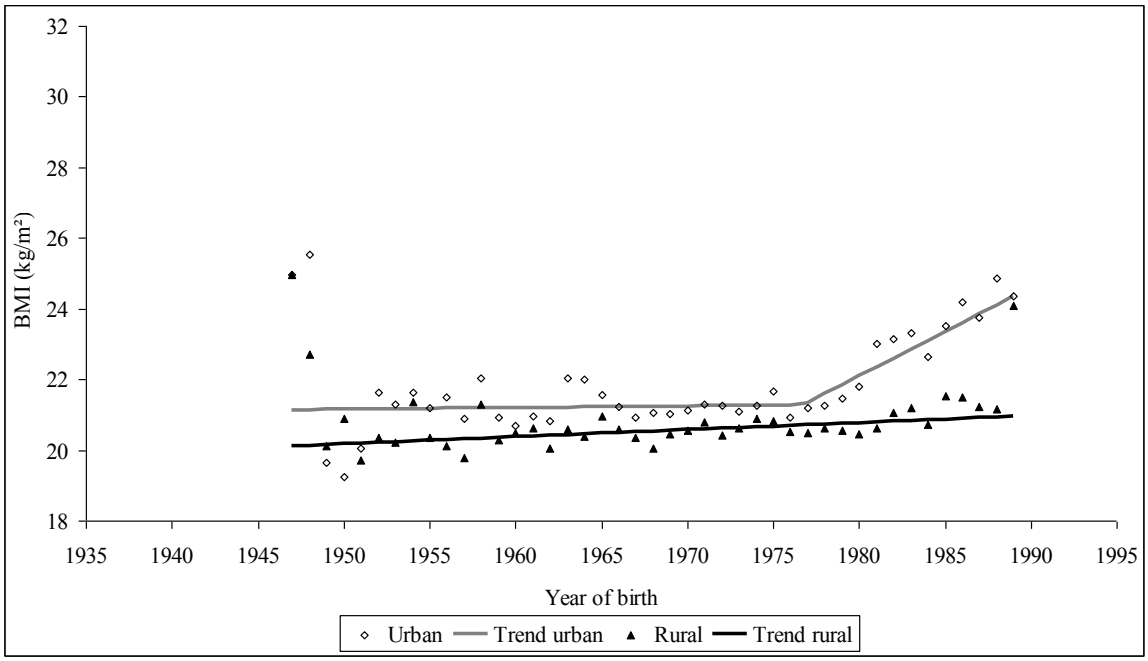


Figure B-5.2 ***Trends in standardized BMI, adult women, Chad***



6. Comoro Islands

Comoro Islands conducted one survey with anthropometric data on adult women, in 1996, on a tiny sample.

Table B-6 Sample size and basic anthropometric characteristics, adult women, Comoro Islands

	Year of survey
	1996
Number of women	832
Height, women 20-49	
Mean (cm)	154.7
Standard deviation	5.57
BMI, women 20-49	
Mean (kg/m²)	22.7
Standard deviation	3.82

Due to the small sample size, no trend was statistically significant. Height averaged 154.5 cm, and standardized BMI 22.4 kg/m². The apparent profile was the same in urban and rural areas, with only a small gap between both areas (Figures B-6.1 and B-6.2).

Figure B-6.1 ***Trends in average height, adult women, Comoro Islands***

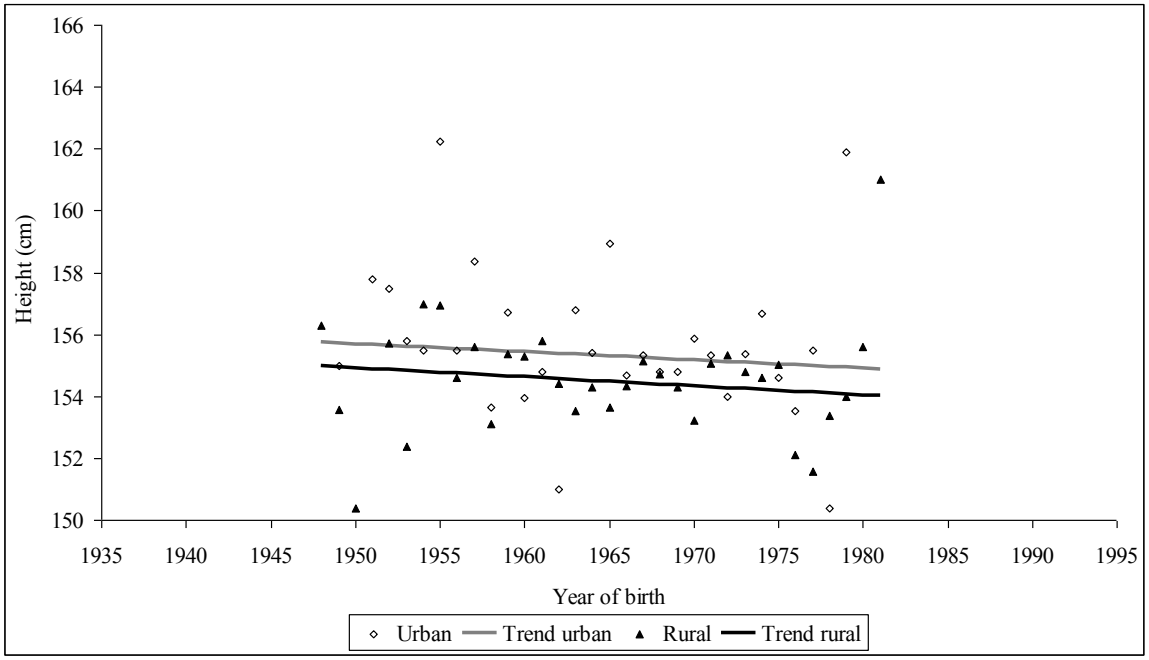
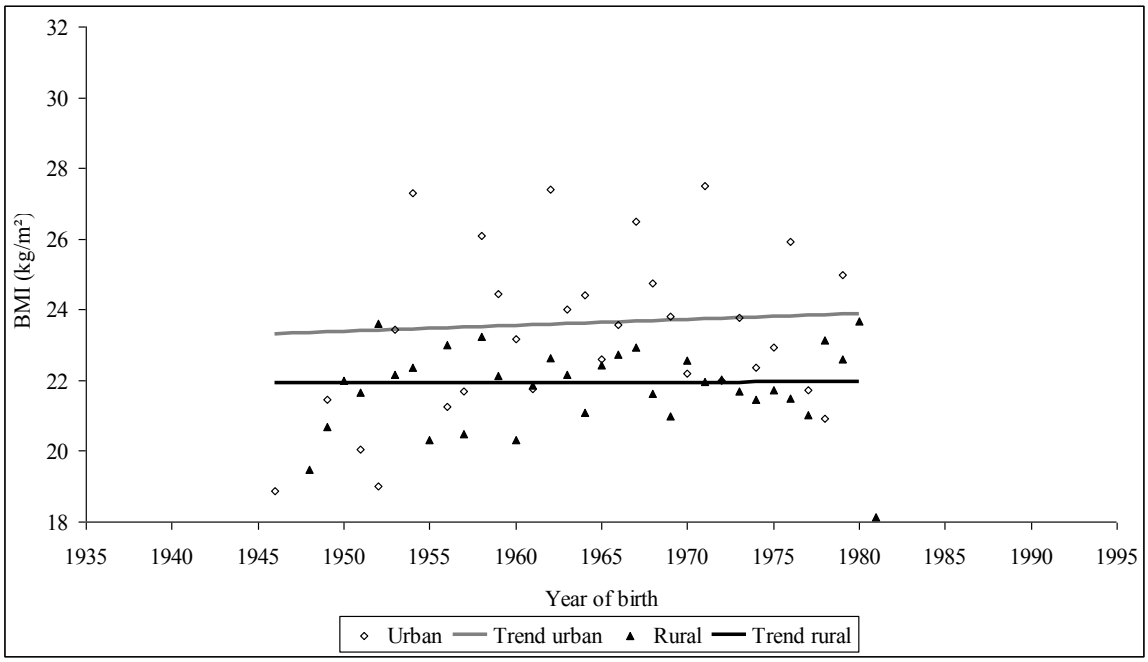


Figure B-6.2 ***Trends in standardized BMI, adult women, Comoro Islands***



7. Congo-Kinshasa (Democratic Republic of Congo)

The Democratic Republic of Congo conducted one survey with anthropometric data on adult women, in 2007.

Table B-7 Sample size and basic anthropometric characteristics, adult women, Congo-Kinshasa

	Year of survey
	2007
Number of women	4034
Height, women 20-49	
Mean (cm)	157.4
Standard deviation	7.56
BMI, women 20-49	
Mean (kg/m²)	21.5
Standard deviation	3.45

At the national level, height was first increasing from 157.5 (cohort 1957) to 158.4 (cohort 1972), then it declined to reach 155.9 in 1990. The first slope was not significant from zero, the second slope was highly significantly negative (P=2E-07), as well as the change in slopes (P=2E-06). Trends were similar in urban and rural areas, although the decline in the second period was more pronounced in rural areas than in urban areas (P=0.026), reaching a low 153.4 for cohort 1990 (Figure B-7.1).

Contrary to height, trends in standardized BMI were positive for the country as a whole, with a highly significant slope (P<E-10). Trends seemed somewhat different in urban and rural areas. In urban areas, trends were steady at first, then increased for the recent cohorts, whereas the opposite was true in rural areas. The first difference in slopes between urban and rural was statistically significant (P=0.005), but not the second (P=0.110) (Figure B-7.2).

Figure B-7.1 ***Trends in average height, adult women, Congo-Kinshasa***

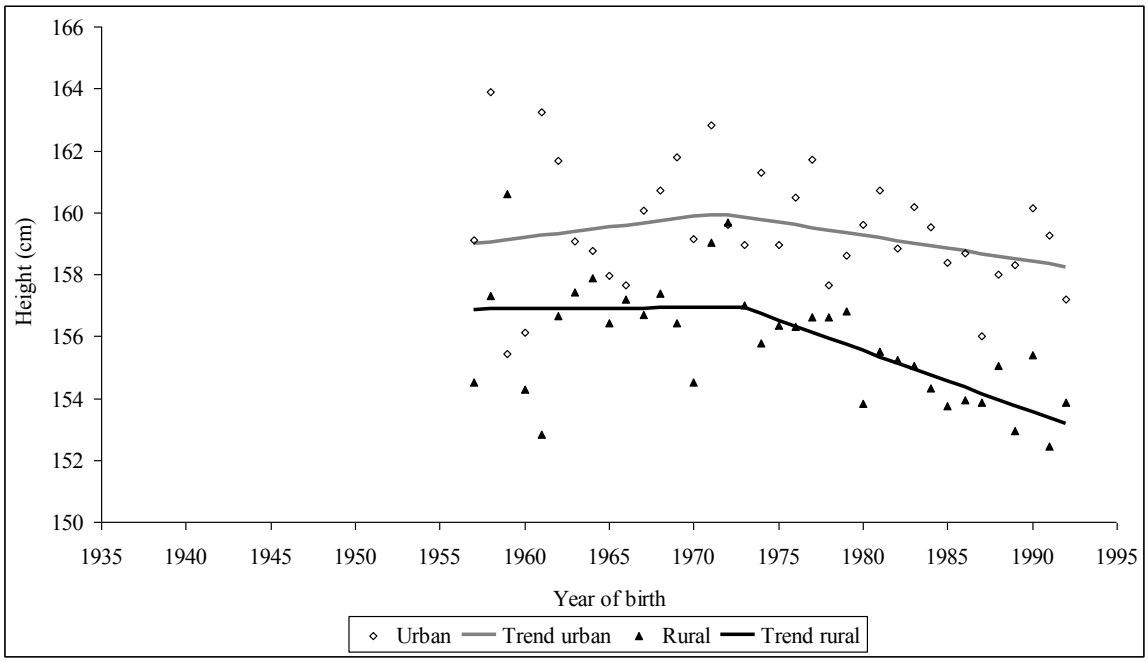
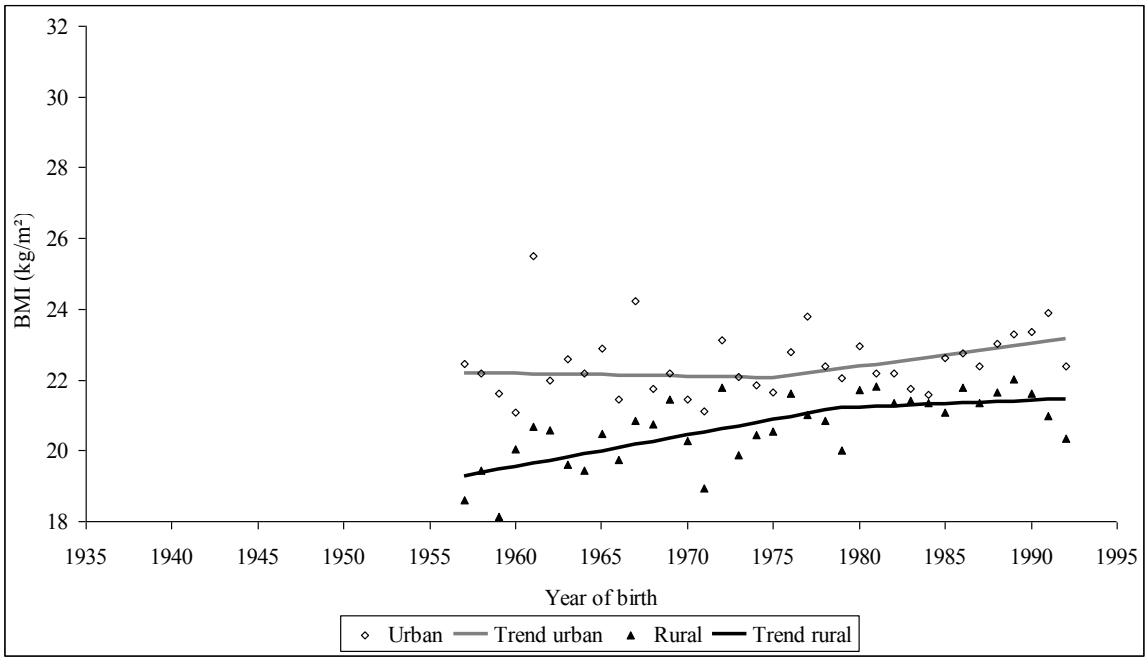


Figure B-7.2 ***Trends in standardized BMI, adult women, Congo-Kinshasa***



8. Congo-Brazzaville (People's Republic of Congo)

The People's Republic of Congo conducted one survey with anthropometric data on adult women, in 2005.

Table B-8 Sample size and basic anthropometric characteristics, adult women, Congo-Brazzaville

	Year of survey
	2005
Number of women	5344
Height, women 20-49	
Mean (cm)	158.2
Standard deviation	8.16
BMI, women 20-49	
Mean (kg/m^2)	23.4
Standard deviation	4.47

At the national level, height was steady from cohort 1955 to cohort 1967 at 158.2 cm, then it declined to reach 157.5 cm in 1990, which are trends similar to those of Congo-Kinshasa, although much less pronounced. The first slope was not significant from zero (P=0.212), but the second slope was highly significantly negative (P=0.0002), and the change in slopes was borderline (0.068). Trends were similar in urban and rural areas (Figure B-8.1).

Unlike Congo-Kinshasa, trends in standardized BMI were negative for the country as a whole, with a highly significant slope (P<2E-09). However, trends diverged between the urban and rural areas. In rural areas, there was no change over time (P=0.892), whereas the standardized BMI tended to decrease steadily in urban areas, with a highly significant slope (P<E-07). The difference in slopes between urban and rural areas was also highly significant (P<E-10) (Figure B-8.2).

Figure B-8.1 ***Trends in average height, adult women, Congo-Brazzaville***

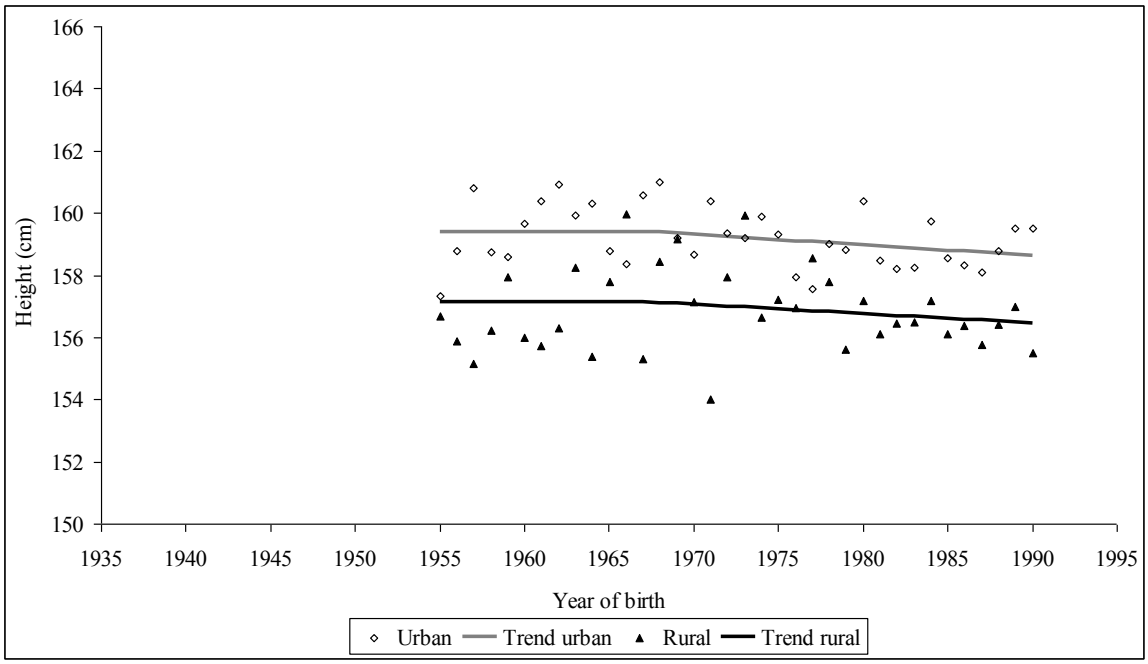
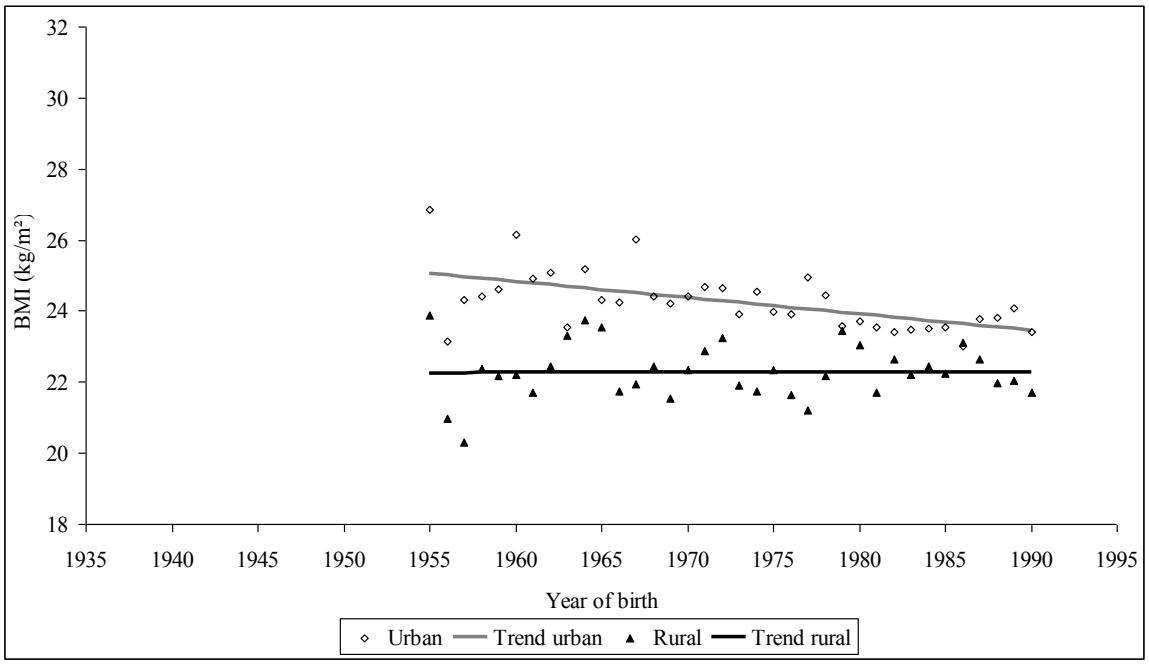


Figure B-8.2 ***Trends in standardized BMI, adult women, Congo-Brazzaville***



9. Côte d'Ivoire

Côte d'Ivoire conducted two surveys with anthropometric data on adult women, in 1994 and 1999. Both surveys were compatible in levels and trends, although both height and BMI were somewhat higher in the second survey (P=0.009 and P<E-10 respectively).

Table B-9 Sample size and basic anthropometric characteristics, adult women, Côte d'Ivoire

	Year of survey	
	1994	1999
Number of women	3004	2248
Height, women 20-49		
Mean (cm)	159.0	159.5
Standard deviation	5.89	6.20
BMI, women 20-49		
Mean (kg/m²)	22.2	22.9
Standard deviation	3.41	4.09

At the national level, height was increasing slowly from 158.8 (cohort 1945) to 159.5 (cohort 1984), the slope being significant (P=0.023). Trends were significant in urban areas, but not in rural areas (Figure B-9.1).

The standardized BMI tended to increase for the country as a whole, with a highly significant slope (P<E-10). Trends were similar in urban and rural areas, with no difference between the two (P=0.44) (Figure B-9.2).

Figure B-9.1 ***Trends in average height, adult women, Côte d'Ivoire***

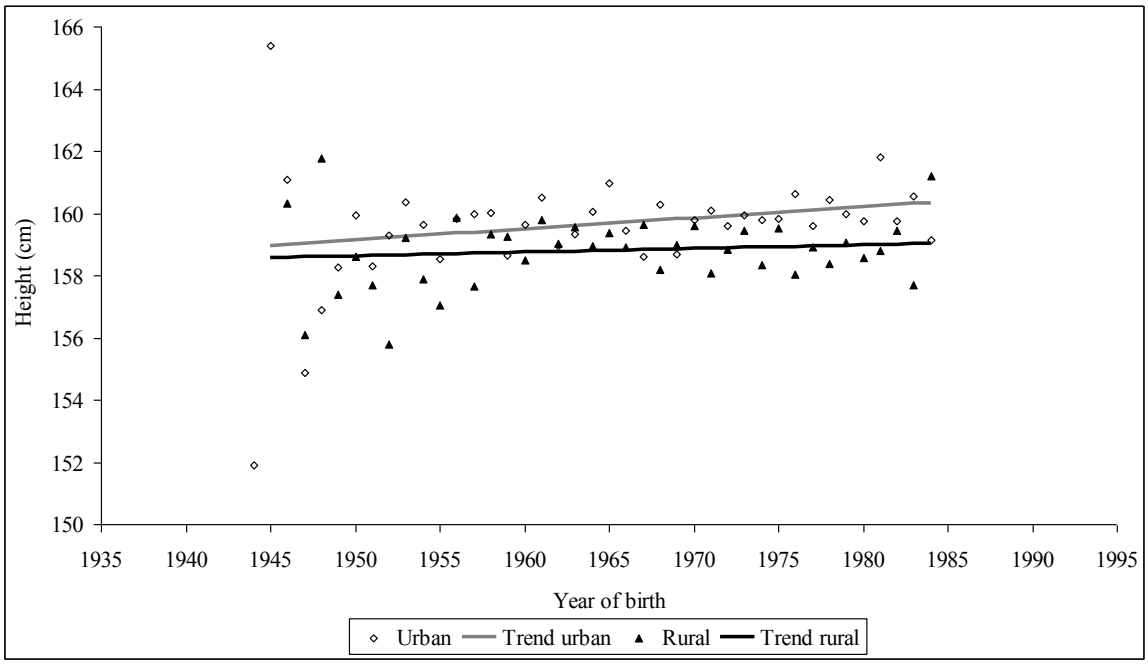
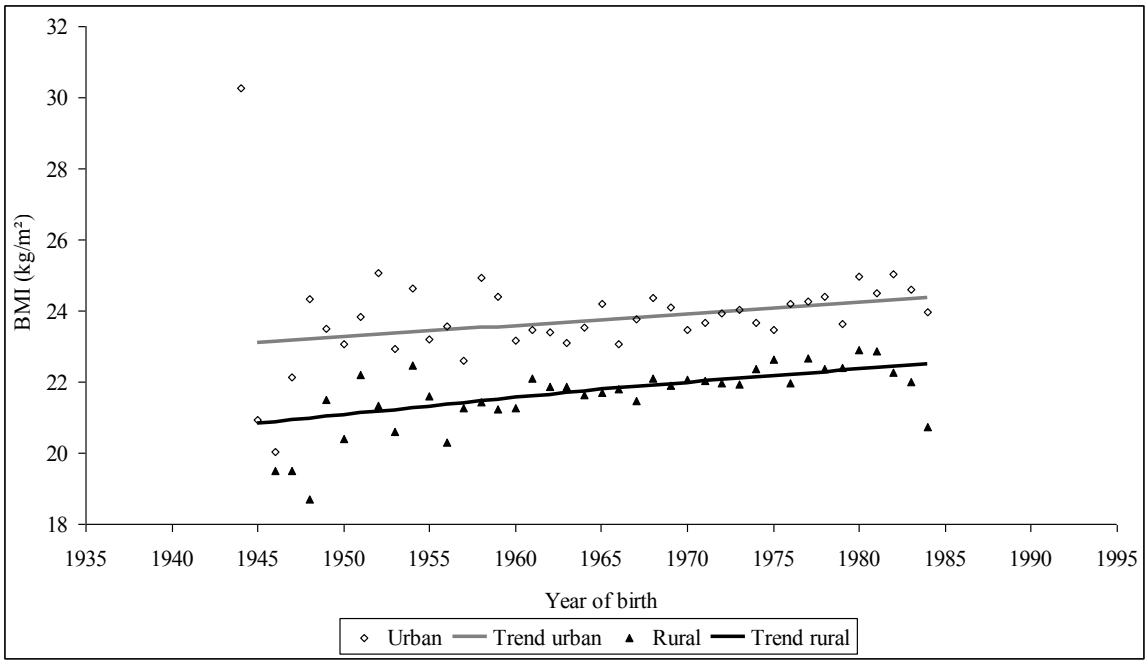


Figure B-9.2 ***Trends in standardized BMI, adult women, Côte d'Ivoire***



10. Ethiopia

Ethiopia conducted two surveys with anthropometric data on adult women, in 2000 and 2005. Both surveys were compatible in levels and trends, although both height and BMI were somewhat higher in the second survey (P=2E-06 and P<E-10 respectively).

Table B-10 Sample size and basic anthropometric characteristics, adult women, Ethiopia

	Year of survey	
	2000	2005
Number of women	11851	5018
Height, women 20-49		
Mean (cm)	156.4	156.9
Standard deviation	6.00	6.35
BMI, women 20-49		
Mean (kg/m²)	20.1	20.4
Standard deviation	2.46	2.68

At the national level, height was very steady, contrasting with most other countries, and this was the same in both urban and rural areas (Figure B-10.1).

The standardized BMI was very low, and tended to increase for the country as a whole, with a highly significant slope up to cohort 1965, but not after, the change in slopes being highly significant (P<E-10). Trends were similar in urban and rural areas, although the cut-off point of changing slopes was possibly earlier in urban areas (1962) than in rural areas (1967) (Figure B-10.2).

Figure B-10.1 ***Trends in average height, adult women, Ethiopia***

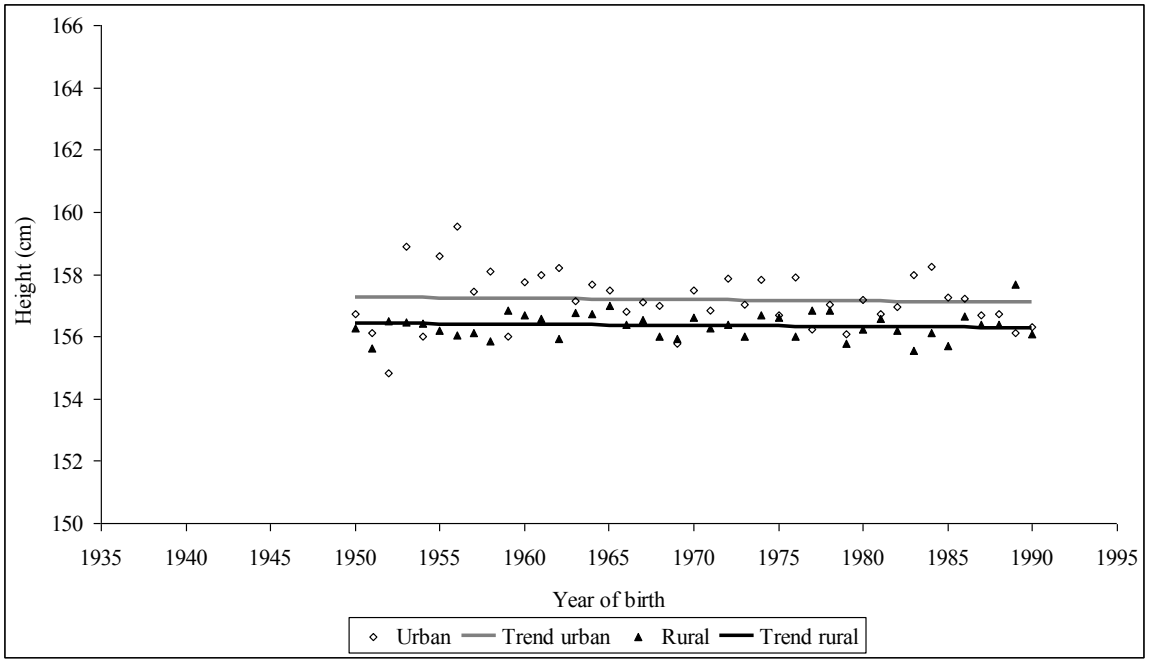
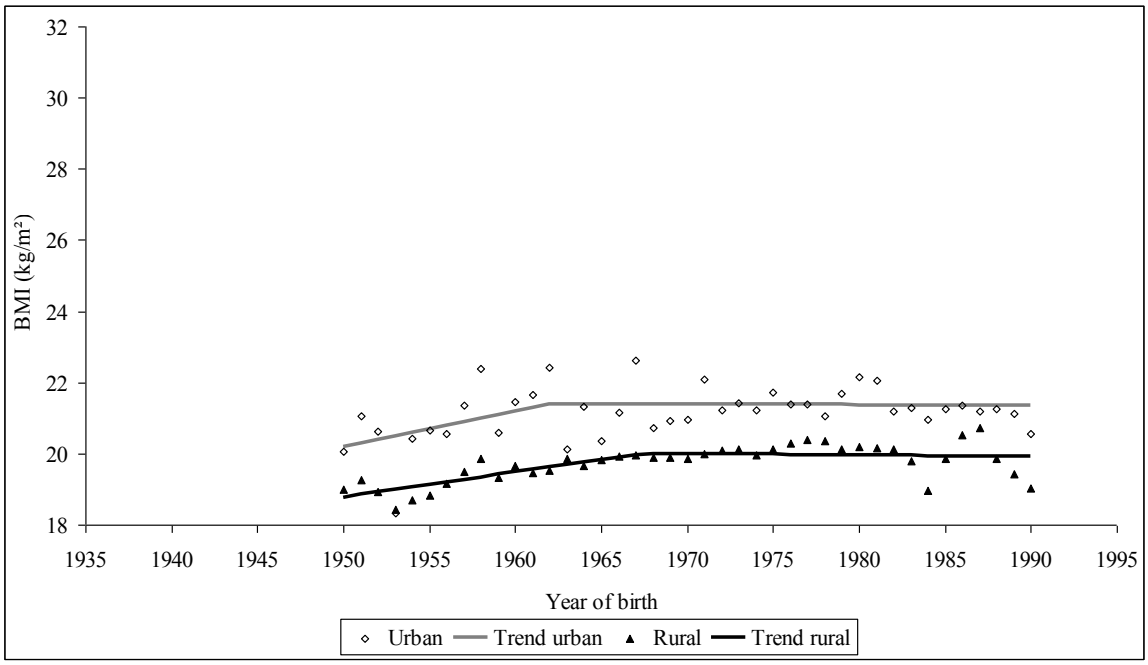


Figure B-10.2 ***Trends in standardized BMI, adult women, Ethiopia***



11. Gabon

Gabon conducted one survey with anthropometric data on adult women, in 2000.

Table B-11 Sample size and basic anthropometric characteristics, adult women, Gabon

	Year of survey
	2000
Number of women	2170
Height, women 20-49	
Mean (cm)	159.0
Standard deviation	6.28
BMI, women 20-49	
Mean (kg/m²)	23.9
Standard deviation	4.26

At the national level, height was very steady, and this was the same in both urban and rural areas (Figure B-11.1).

The standardized BMI was steady over time, around a mean of 24.1 kg/m², hiding divergent trends between areas of residence. In urban areas, the standardized BMI tended to decline, whereas the opposite trend occurred in rural areas. Both slopes were borderline significant, one negative, the other positive, the difference between urban and rural areas being significant (P=0.036) (Figure B-11.2).

Figure B-11.1 ***Trends in average height, adult women, Gabon***

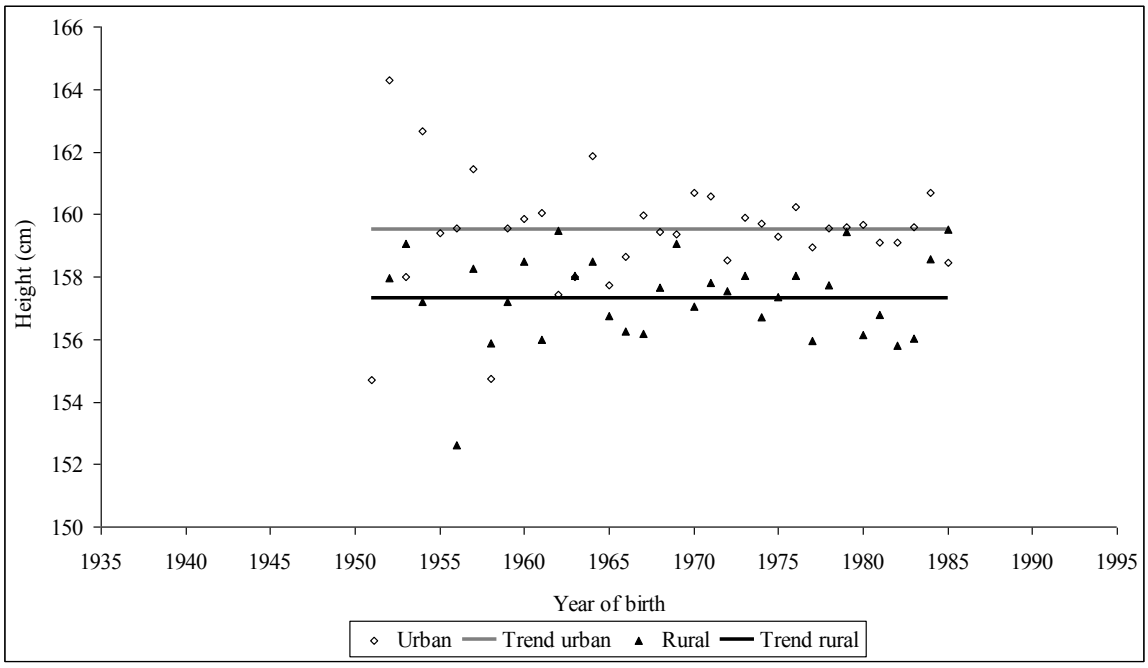
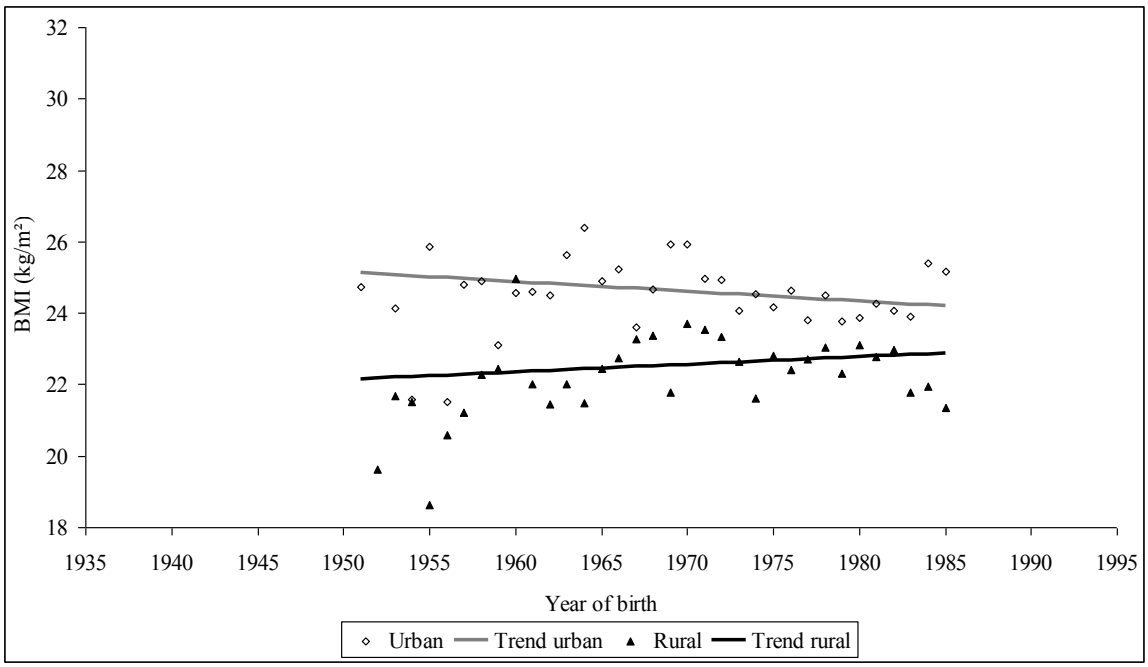


Figure B-11.2 ***Trends in standardized BMI, adult women, Gabon***



12. Ghana

Ghana conducted four surveys with anthropometric data on adult women, in 1993, 1999, 2003 and 2008. All four surveys were compatible in levels and trends. There were some minor differences between successive surveys: height was higher in 2003 than in 1999 (P=0.018), and the BMI was always higher than at previous survey (P=0.007, P<E-10, P=7E-0.9 in 1999, 2003 and 2008 respectively).

Table B-12 Sample size and basic anthropometric characteristics, adult women, Ghana

	Year of survey			
	1993	1999	2003	2008
Number of women	1789	2146	4253	3818
Height, women 20-49				
Mean (cm)	158.7	158.7	159.1	159.1
Standard deviation	6.02	6.26	6.12	6.42
BMI, women 20-49				
Mean (kg/m²)	21.9	22.2	23.6	24.2
Standard deviation	3.59	3.80	4.62	4.79

At the national level, height was very steady, with a very mild declining slope which was not significant, and this was the same in both urban and rural areas, although the slope was significantly lower than zero in rural areas (P=0.027), and borderline in urban areas (P=0.079) (Figure B-12.1).

The standardized BMI tended to increase rapidly for cohorts 1945-1962, then became steady for the country as a whole, the change in slope being highly significant (P<E-09). Dynamics were similar in urban and rural areas. In rural areas, the standardized BMI tended to increase steadily, from 20.4 to 22.1 (cohorts 1945-1966), then remained steady. In urban areas, the standardized BMI increased from 21.7 to 24.8 (cohorts 1945-1963), then remained steady. Differences in slopes between urban and rural areas were not significant (Figure B-12.2).

Figure B-12.1 ***Trends in average height, adult women, Ghana***

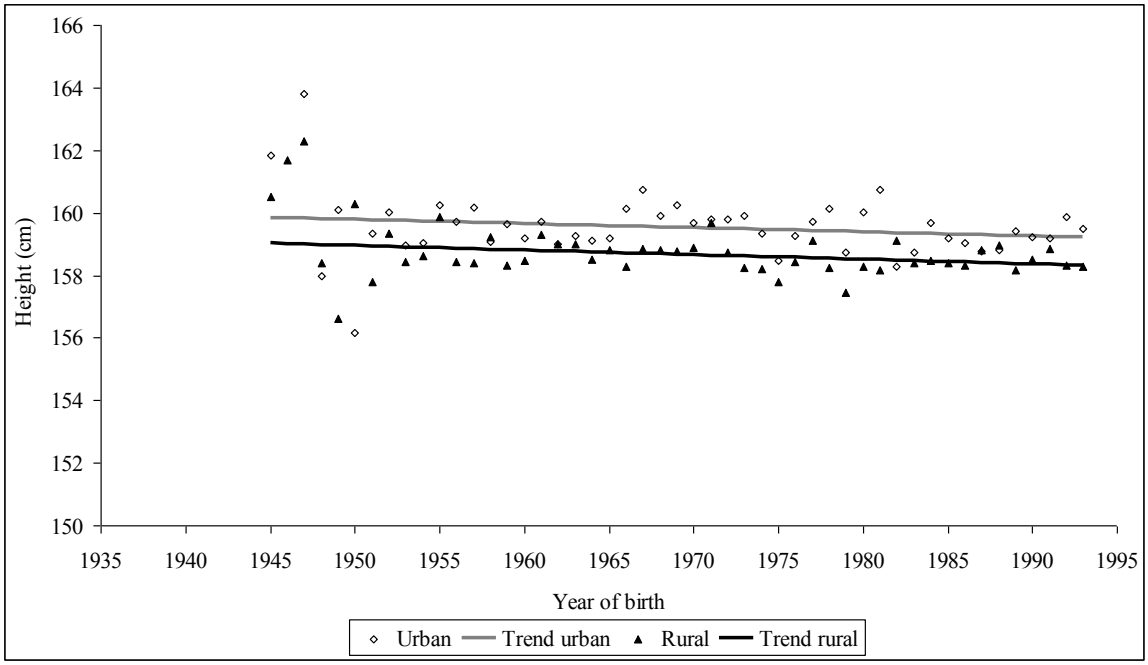
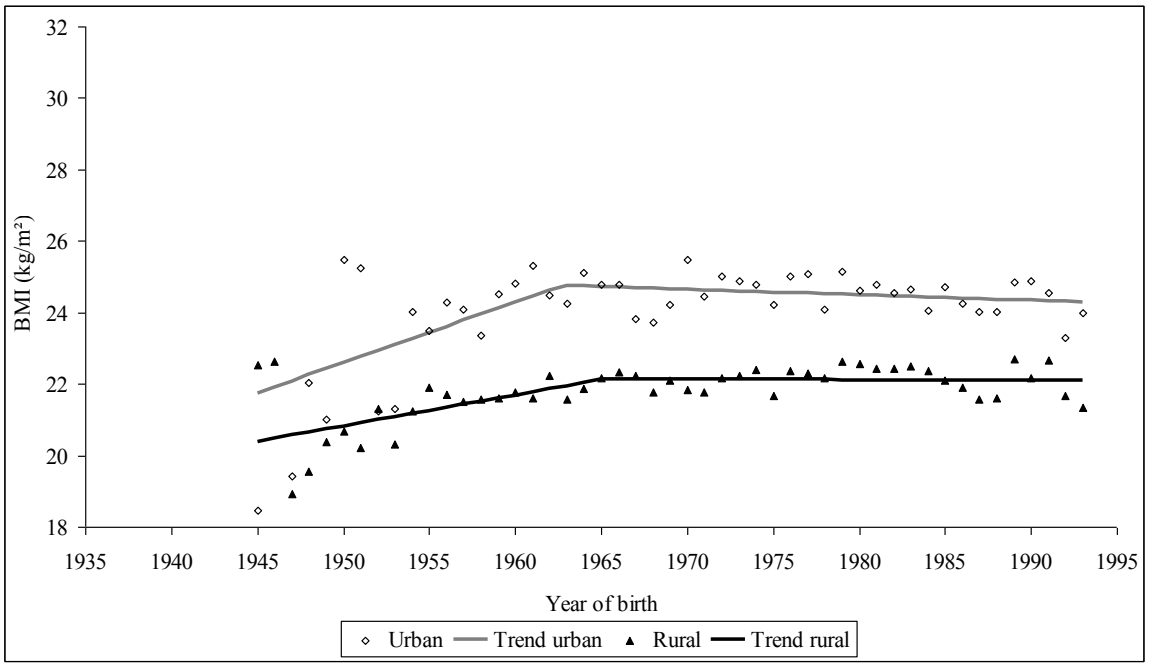


Figure B-12.2 ***Trends in standardized BMI, adult women, Ghana***



13. Guinea

Guinea conducted two surveys with anthropometric data on adult women, in 1999 and 2005. Both surveys were compatible in levels and trends. There was a minor difference between successive surveys: the BMI was higher in the second survey (P=0.005).

Table B-13 Sample size and basic anthropometric characteristics, adult women, Guinea

	Year of survey	
	1999	2005
Number of women	3405	3134
Height, women 20-49		
Mean (cm)	158.8	158.8
Standard deviation	6.19	6.34
BMI, women 20-49		
Mean (kg/m²)	21.8	22.1
Standard deviation	3.25	3.50

At the national level, height was very steady, with a very mild declining slope, which was not significant, and this was the same in both urban and rural areas (Figure B-13.1).

The standardized BMI tended to increase steadily for the country as a whole from 20.9 kg/m² (cohort 1950) to 22.8 (cohort 1990). However, dynamics were different in urban and rural areas. In urban areas, the standardized BMI remained at the same level (about 23.5 kg/m²), whereas it increased in rural areas, from 20.3 to 22.2 kg/m² (Figure B-13.2).

Figure B-13.1 ***Trends in average height, adult women, Guinea***

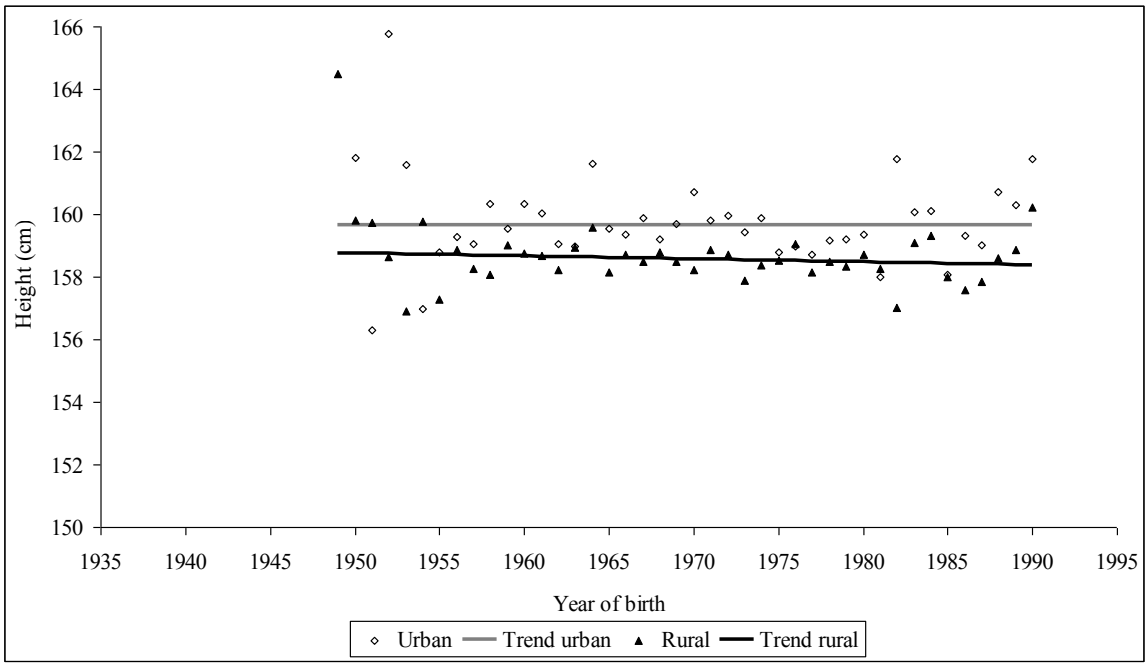
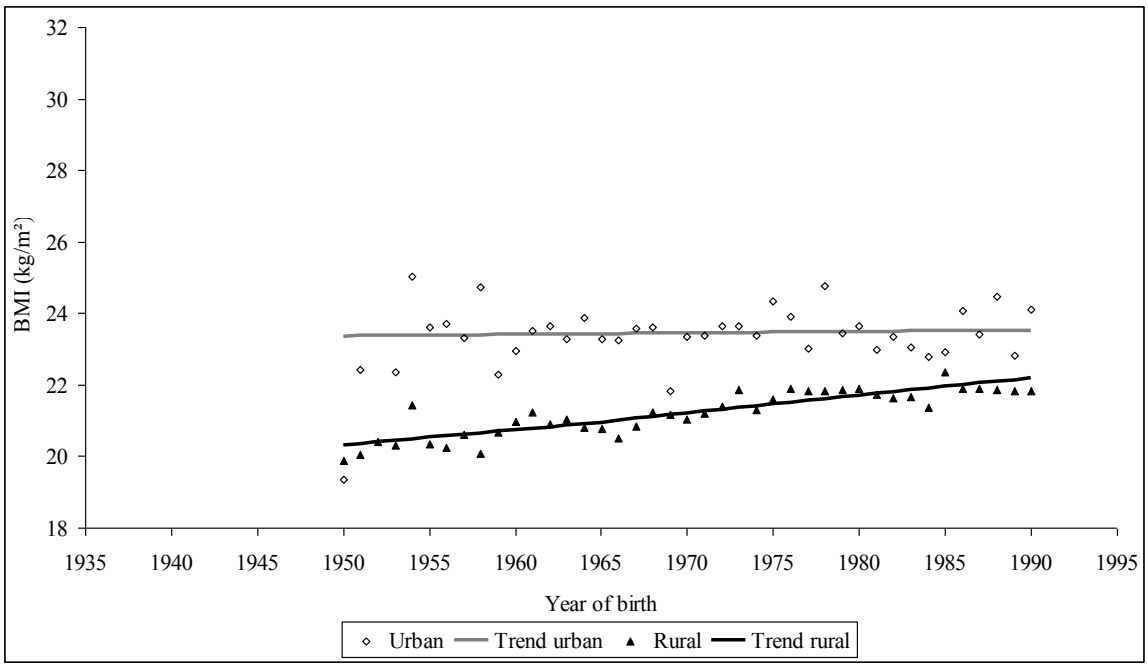


Figure B-13.2 ***Trends in standardized BMI, adult women, Guinea***



14. Kenya

Kenya conducted four surveys with anthropometric data on adult women, in 1993, 1998, 2003 and 2008. The four surveys were compatible in levels and trends. There were some minor differences between successive surveys: differences in height in successive surveys in 1998, 2003 and 2008 (P=1E-08, P=0.050 and P=0.003 respectively); and BMI was higher in the third survey than in the second (P<E-10).

Table B-14 Sample size and basic anthropometric characteristics, adult women, Kenya

	Year of survey			
	1993	1998	2003	2008
Number of women	3521	3333	5973	6708
Height, women 20-49				
Mean (cm)	159.3	160.1	159.8	159.5
Standard deviation	6.14	6.41	6.36	6.37
BMI, women 20-49				
Mean (kg/m²)	22.1	22.1	23.2	23.3
Standard deviation	3.22	3.55	4.31	4.36

At the national level, height was first increasing, from 157.8 (cohort 1943) to 160.1 (cohort 1969), then decreasing to reach 159.1 (cohort 1990). Trends were similar in urban and rural areas, with only a minor difference between the two (Figure B-14.1).

The standardized BMI tended to increase slowly for the country as a whole between cohort 1943 (21.0 kg/m²) and cohort 165 (23.0 kg/m²), then it remained stable. BMI dynamics were in the opposite direction in urban and rural areas. In rural areas, the standardized BMI followed the national pattern, and increased then stabilized after cohort 1965. In contrast, in urban areas, the standardized BMI decreased steadily from 25.4 to 24.4 (cohorts 1943-1990) (Figure B-14.2).

Figure B-14.1 ***Trends in average height, adult women, Kenya***

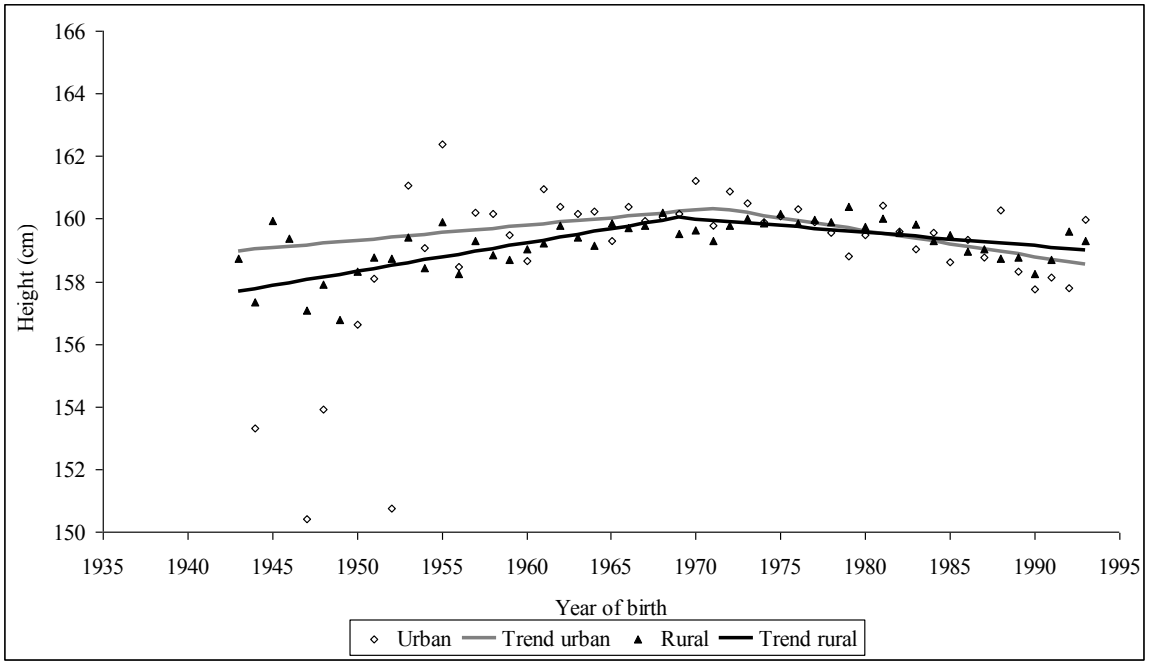
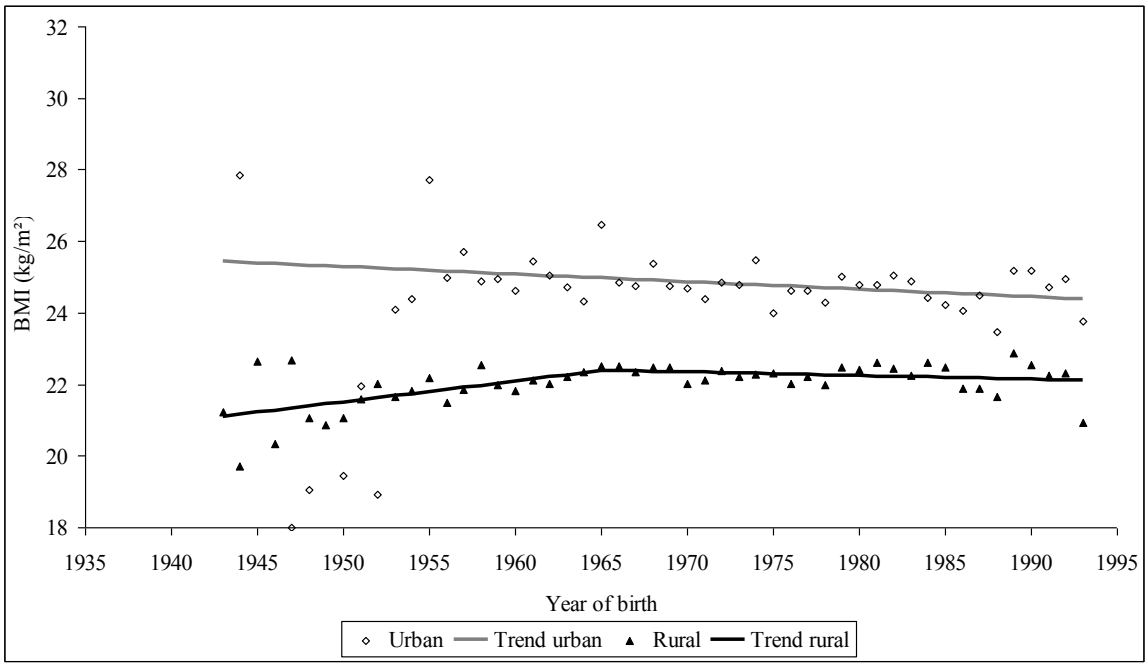


Figure B-14.2 ***Trends in standardized BMI, adult women, Kenya***



15. Lesotho

Lesotho conducted one survey with anthropometric data on adult women, in 2004.

Table B-15 Sample size and basic anthropometric characteristics, adult women, Lesotho

	Year of survey
	2004
Number of women	2574
Height, women 20-49	
Mean (cm)	157.5
Standard deviation	6.54
BMI, women 20-49	
Mean (kg/m²)	26.0
Standard deviation	5.59

At the national level, height was slowly decreasing, from 157.9 (cohort 1955) to 157.0 (cohort 1990), the trend being significant (P=0.013). Trends were similar in urban and rural areas, but significantly negative only in urban areas (P=0.035) and not in rural areas (P=0.182) (Figure B-15.1).

The standardized BMI tended to decrease slowly for the country as a whole, from 26.5 (cohort 1955) to 24.8 (cohort 1989) (P<E-08). Trends were similar in urban and rural areas, with a stronger effect in urban areas (Figure B-15.2).

Figure B-15.1 ***Trends in average height, adult women, Lesotho***

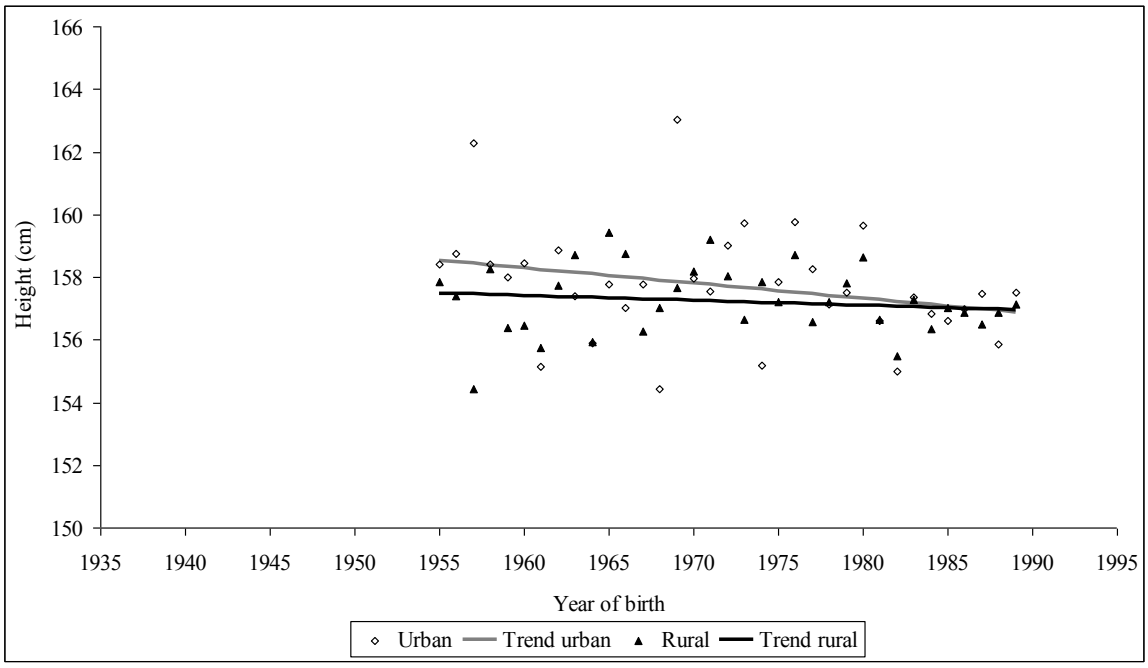
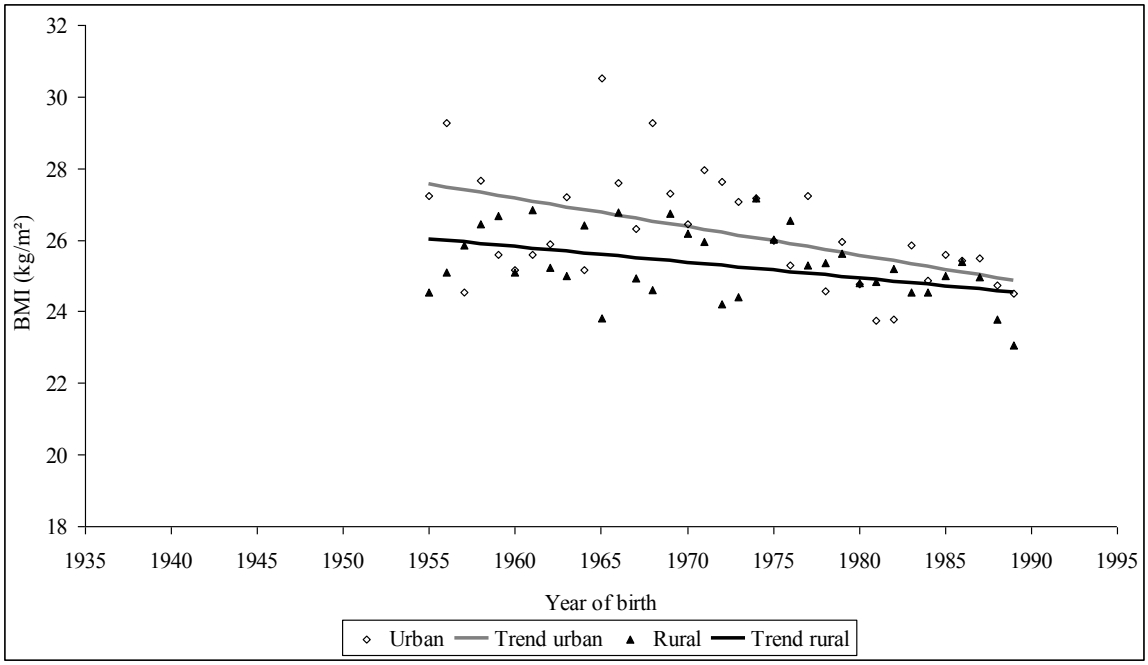


Figure B-15.2 ***Trends in standardized BMI, adult women, Lesotho***



16. Liberia

Liberia conducted one survey with anthropometric data on adult women, in 2007.

Table B-16 Sample size and basic anthropometric characteristics, adult women, Liberia

	Year of survey
	2007
Number of women	5982
Height, women 20-49	
Mean (cm)	157.4
Standard deviation	6.31
BMI, women 20-49	
Mean (kg/m²)	22.9
Standard deviation	4.20

At the national level, height was slowly decreasing, from 158.0 (cohort 1960) to 156.6 (cohort 1990), the trend being significant (P=1E-10). Trends were similar in urban and rural areas, and highly significant in both cases (P=3E-08 and P=3E-07 respectively) (Figure B-16.1).

The standardized BMI was steady for the country as a whole, hiding divergent trends by area of residence. In urban areas the standardized BMI tended to decrease from 24.7 (cohort 1957) to 23.4 (cohort 1992) (P<E-10), whereas no trend was visible in rural areas, with an average of 21.9 kg/m² (Figure B-16.2).

Figure B-16.1 ***Trends in average height, adult women, Liberia***

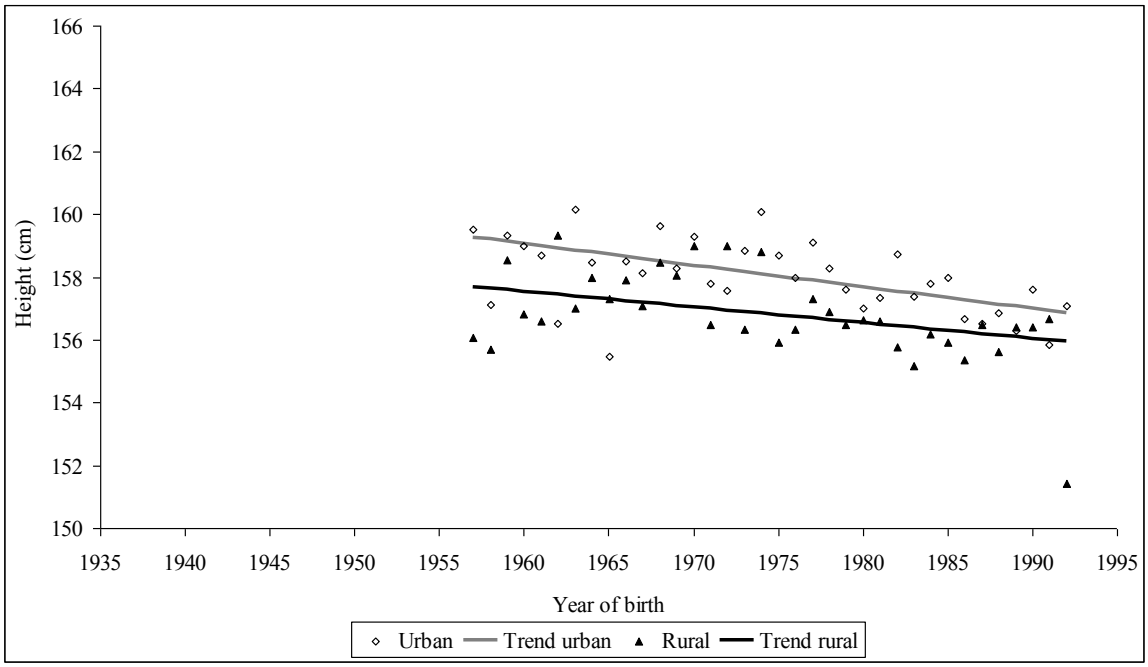
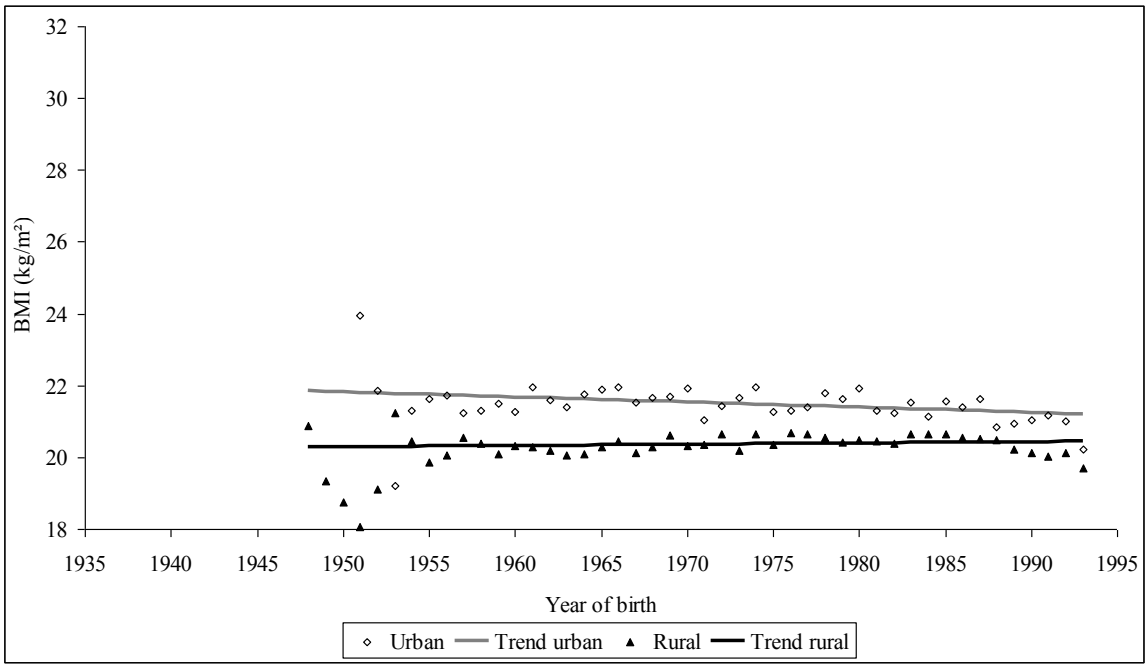


Figure B-16.2 ***Trends in standardized BMI, adult women, Liberia***



17. Madagascar

Madagascar conducted three surveys with anthropometric data on adult women, in 1997, 2003 and 2008. All three were compatible in terms of levels and trends in height and BMI. However, heights were significantly lower at first survey (P=1E-07), and BMI higher at second survey (P<E-10).

Table B-17 Sample size and basic anthropometric characteristics, adult women, Madagascar

	Year of survey		
	1997	2003	2008
Number of women	2767	6308	6514
Height, women 20-49			
Mean (cm)	153.1	153.8	153.7
Standard deviation	5.79	5.83	5.87
BMI, women 20-49			
Mean (kg/m²)	20.6	21.0	20.6
Standard deviation	2.46	2.95	3.10

At the national level, height was low, and at first slowly increasing, from 153.7 (cohort 1950) to 154.5 (cohort 1964), then decreasing to reach 152.4 for cohort 1991. Both trends were significant, as was the change in slopes (P=8E-06). Trends were similar in urban and rural areas, with only a small gap in between, and the change in trends was also significant in both cases (P=0.009 for urban and P=0.0004 for rural areas) (Figure B-17.1).

The standardized BMI was also low, and steady for the country as a whole (at about 20.6 kg/m²), hiding somewhat divergent trends by area of residence. In urban areas, the trend in standardized BMI was somewhat negative (P=0.008), whereas the trend was positive in rural areas, although not different from zero (P=0.111). The difference between the two slopes was statistically significant (P=0.003) (Figure B-17.2).

Note that Madagascar had the lowest height, and the next-to-lowest BMI in the sample considered for this study.

Figure B-17.1 ***Trends in average height, adult women, Madagascar***

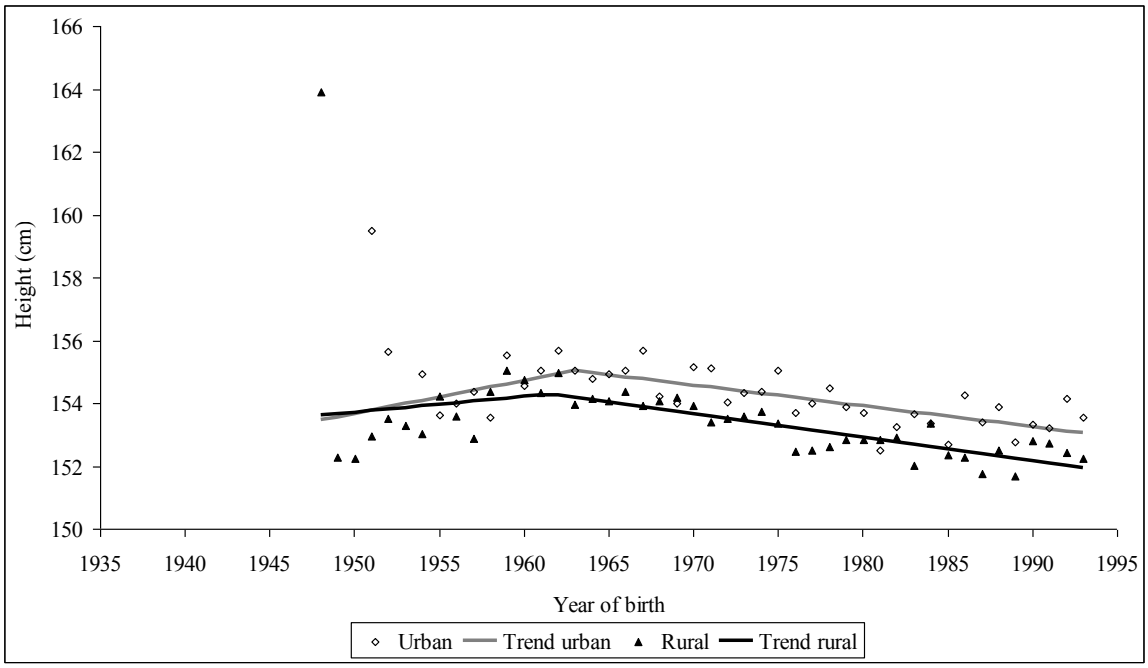


Figure B-17.2 ***Trends in standardized BMI, adult women, Madagascar***

18. Malawi

Malawi conducted three surveys with anthropometric data on adult women, in 1992, 2000 and 2004. All three were compatible in terms of levels and trends in height and BMI. However, BMI was somewhat lower at the first survey (P<E-10).

Table B-18 Sample size and basic anthropometric characteristics, adult women, Malawi

	Year of survey		
	1992	2000	2004
Number of women	2482	10296	8687
Height, women 20-49			
Mean (cm)	156.2	156.1	156.2
Standard deviation	5.77	5.90	6.12
BMI, women 20-49			
Mean (kg/m²)	21.9	22.3	22.3
Standard deviation	2.82	3.10	3.25

At the national level, height was almost constant, with only a very mild increase from 1945 to 1965 and then a decline, the change in trends being statistically significant (P=1E-06). The mild increase then decrease seemed to be due almost entirely to the rising then falling trends in urban areas, since rural areas exhibited basically no change. The change in slope in urban areas was highly significant (P=3E-05) (Figure B-18.1).

The standardized BMI was steady for the country as a whole at about 22.0, hiding divergent trends by area of residence for cohorts 1945-1990. In urban areas the standardized BMI tended to decrease from 24.8 (cohort 1944) 22.6 (cohort 1990) (P<E-10). In rural areas, the standardized BMI tended first to increase from 20.8 (cohort 1942) to 22.2 (cohort 1965), then to decline down to 21.3 (cohort 1989); both slopes were significant (P<E-10 in both cases). The decline in the BMI in the rural areas is surprising, and seems to indicate a worsening of the nutritional status of the recent cohorts (Figure B-18.2).

Figure B-18.1 ***Trends in average height, adult women, Malawi***

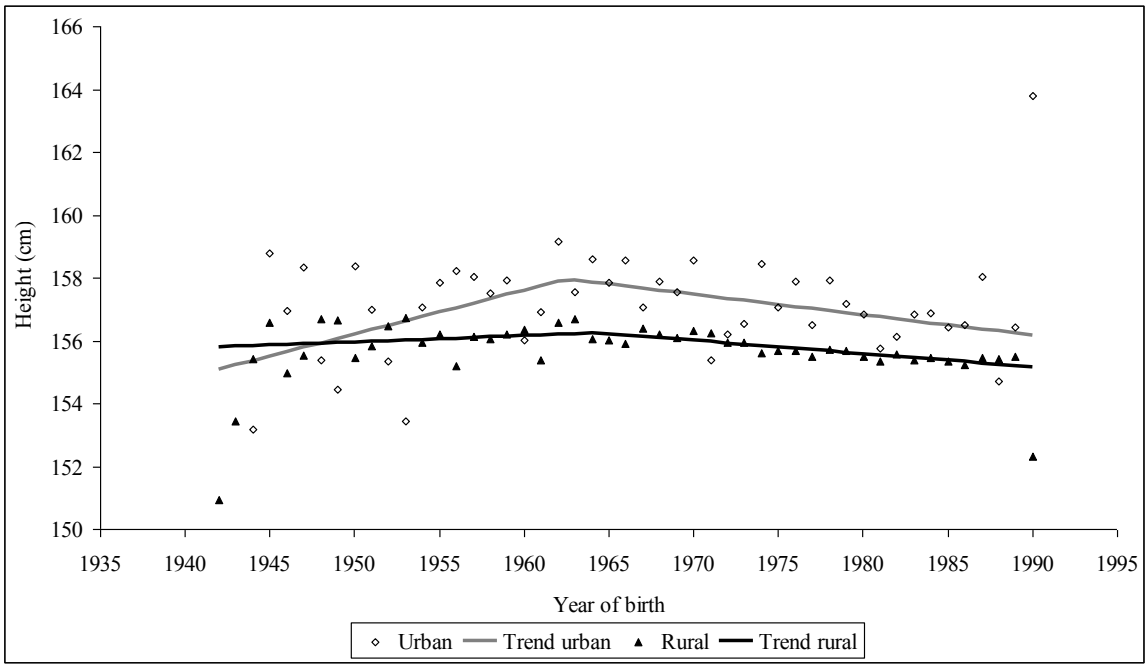
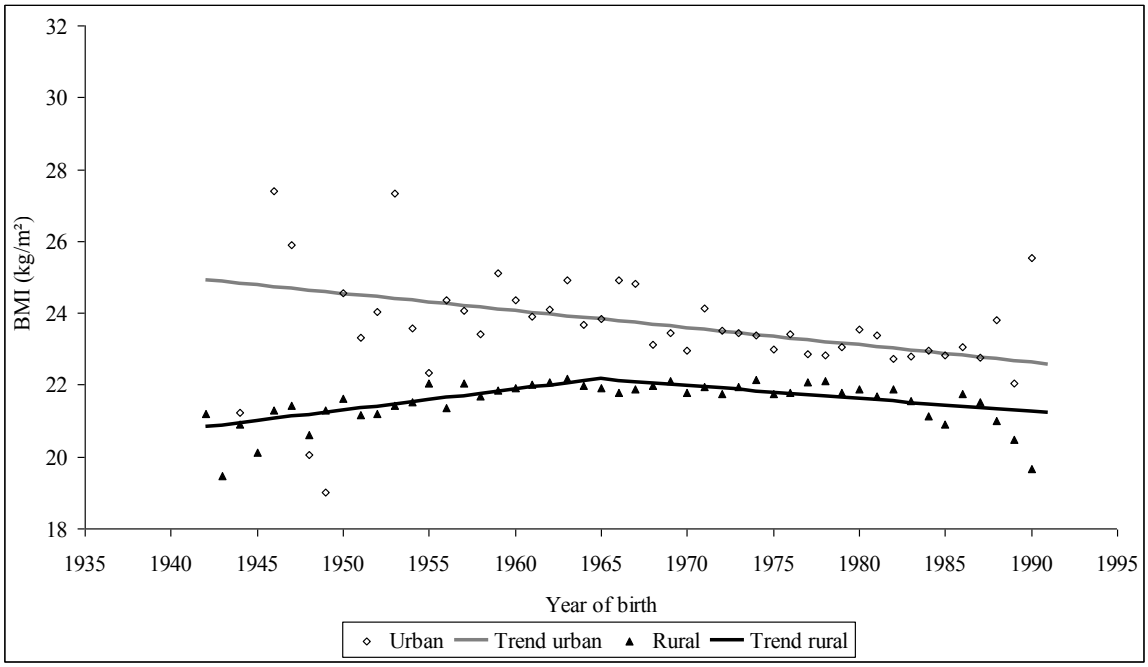


Figure B-18.2 ***Trends in standardized BMI, adult women, Malawi***



19. Mali

Mali conducted three surveys with anthropometric data on adult women, in 1995, 2001 and 2006. All three were compatible in terms of levels and trends in height and BMI. However, height was somewhat lower in the last survey (P=0.009), and BMI tended to increase from survey to survey (P<E-07 in both cases).

Table B-19 Sample size and basic anthropometric characteristics, adult women, Mali

	Year of survey		
	1995	2001	2006
Number of women	4458	9896	11818
Height, women 20-49			
Mean (cm)	161.5	161.6	161.4
Standard deviation	6.12	6.10	6.30
BMI, women 20-49			
Mean (kg/m²)	21.3	22.3	22.6
Standard deviation	3.03	3.65	4.04

At the national level, height was decreasing steadily from 162.3 to 160.7 (1945 to 1990), the slope being highly significant (P<E-10). The declining trend was significant in both urban and rural areas (P=8E-05 and P<E-10 respectively), and the decline was more pronounced in rural areas (P=0.001) (Figure B-19.1).

The standardized BMI was steadily increasing for the country as a whole, from 21.0 (cohort 1946) to 23.2 (cohort 1990). Trends were in the same direction in both areas, but more pronounced in urban areas. In urban areas the standardized BMI tended to decrease from 22.7 (cohort 1950) to 25.2 (cohort 1990) (P<E-10); in rural areas it increased only from 20.9 to 21.9 for the same cohorts (P<E-10) (Figure B-19.2).

Figure B-19.1 ***Trends in average height, adult women, Mali***

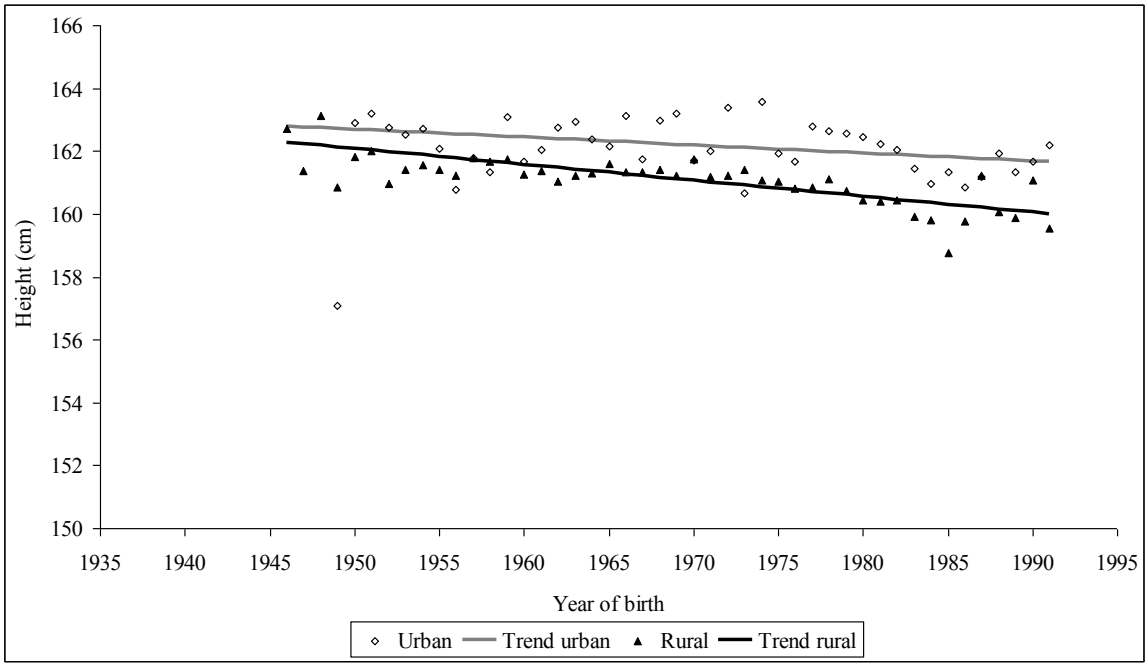
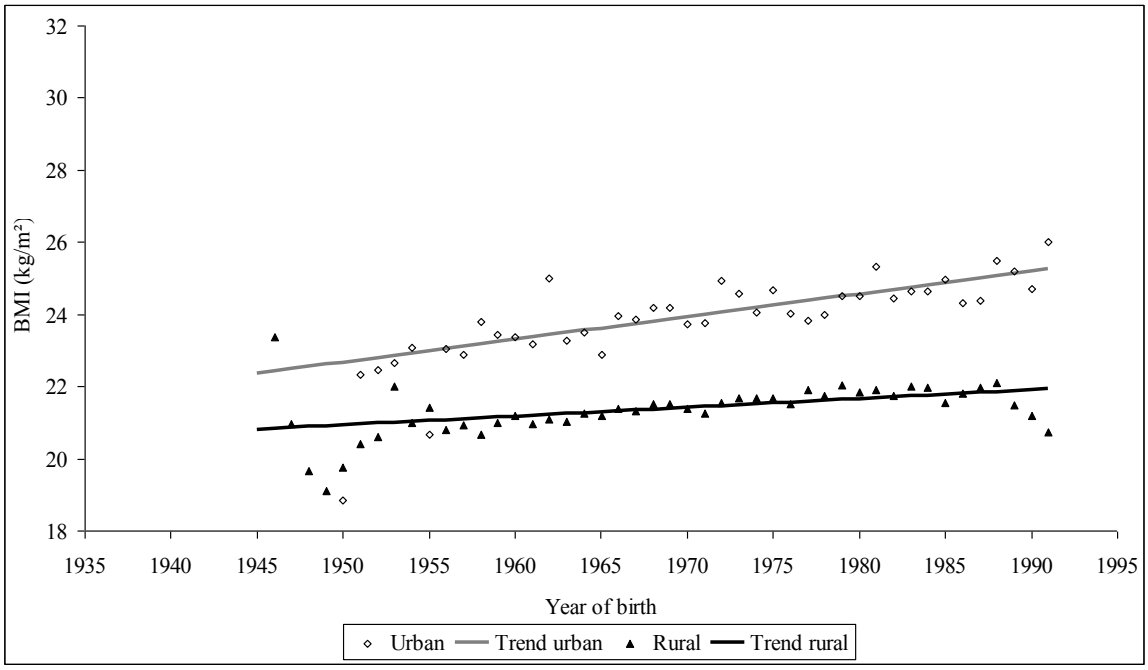


Figure B-19.2 ***Trends in standardized BMI, adult women, Mali***



20. Mozambique

Mozambique conducted two surveys with anthropometric data on adult women, in 1997 and 2003. Both were compatible in terms of levels and trends in height and BMI. However, BMI was higher in the second survey (P<E-10).

Table B-20 Sample size and basic anthropometric characteristics, adult women, Mozambique

	Year of survey	
	1997	2003
Number of women	3226	9451
Height, women 20-49		
Mean (cm)	155.5	155.4
Standard deviation	6.25	6.19
BMI, women 20-49		
Mean (kg/m²)	21.8	22.4
Standard deviation	2.93	3.60

At the national level, height was first increasing from 154.4 to 156.1 (cohort 1947 to 1958), the slope being significant (P=0.006), then it declined to reach 155.0 (cohort 1988), with again a significant negative slope (P=1E-06), and a significant change (P=0.001). In urban areas, the trend was steady and mildly declining, from 157.2 to 156.7, although the slope was not significantly different from zero (cohorts 1947-1988; P=0.217). Rural areas showed an increase (P=0.004) followed by a decrease (P=0.0002), with a significant change in slope (P=0.001) (Figure B-20.1).

The standardized BMI for the country as a whole was first increasing, then decreasing, and the trends were the same in urban and rural areas. In urban areas, the standardized BMI increased from 22.3 (cohort 1948) to 24.8 (cohort 1961), then decreased to 21.9 (cohort 1988). Corresponding values in rural areas were 21.3, 22.3 and 21.5 respectively. Changes in slopes were significant in both cases (P=0.004 in urban areas, and P=0.003 in rural areas). The gap between both areas was particularly small for the recent cohorts (Figure B-20.2).

Figure B-20.1 ***Trends in average height, adult women, Mozambique***

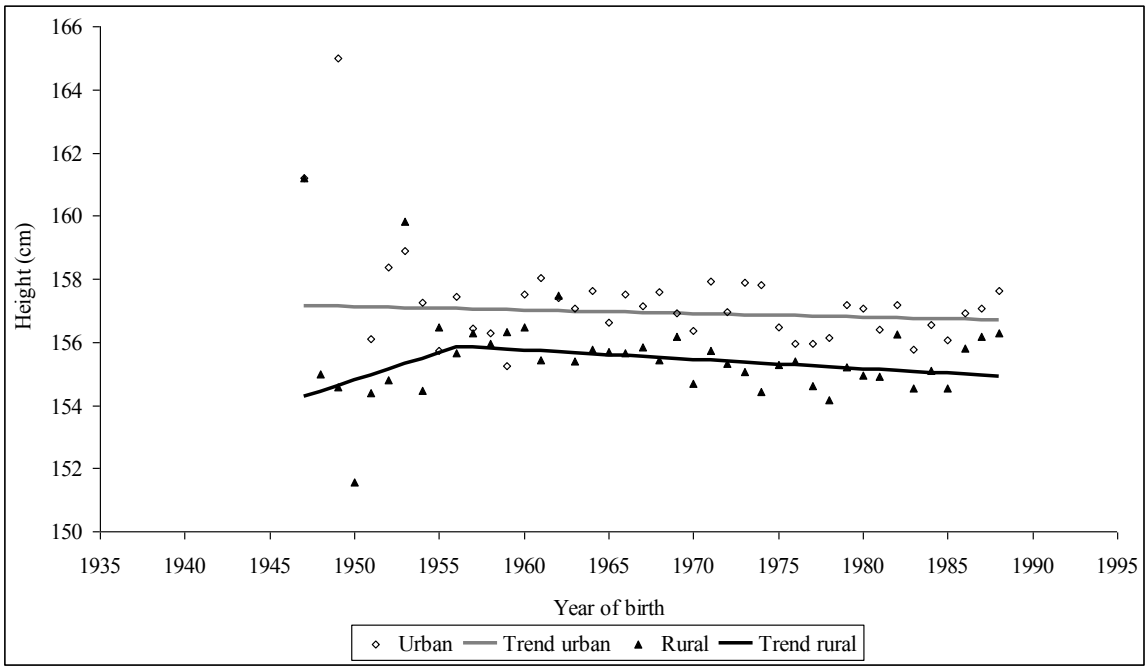
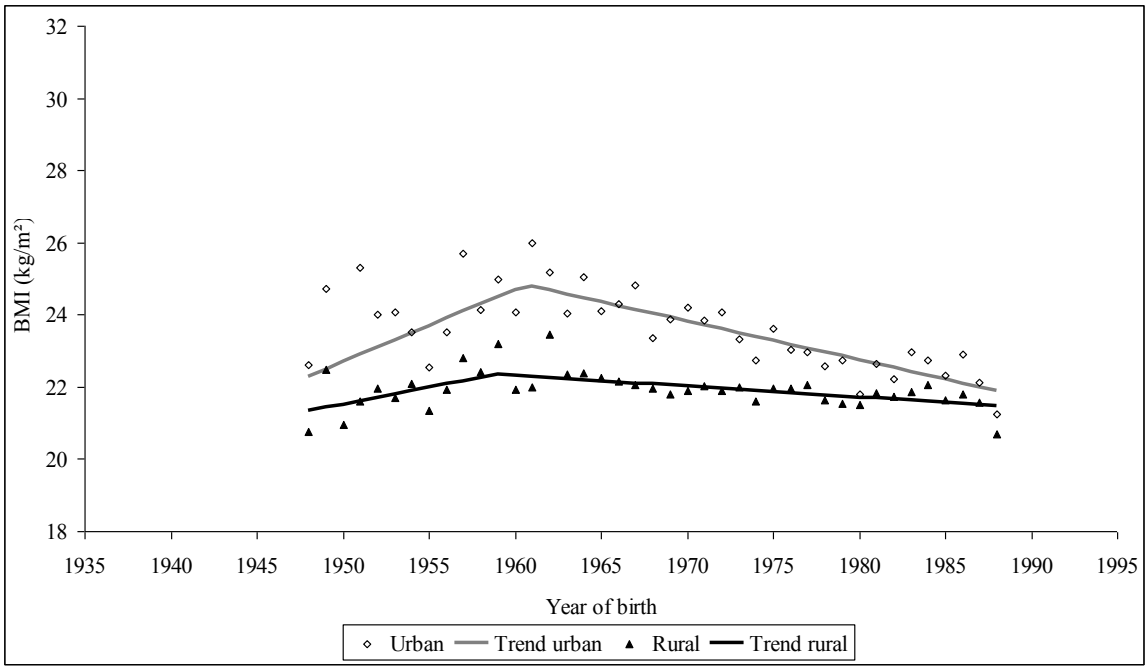


Figure B-20.2 ***Trends in standardized BMI, adult women, Mozambique***



21. Namibia

Namibia conducted two surveys with anthropometric data on adult women, in 1992 and 2007. Both were compatible in terms of levels and trends in height and BMI. However, BMI was higher in the second survey (P<E-10).

Table B-21 Sample size and basic anthropometric characteristics, adult women, Namibia

	Year of survey	
	1992	2007
Number of women	2288	7757
Height, women 20-49		
Mean (cm)	160.7	160.9
Standard deviation	6.44	6.57
BMI, women 20-49		
Mean (kg/m²)	22.8	24.0
Standard deviation	4.42	5.53

At the national level, height was slowly declining, from 161.3 to 160.6 (cohort 1942 to 1990), the slope being significant (P=0.008). There was hardly any significant difference in slope and in trends between urban and rural areas, although the declining trend was slightly more pronounced in rural areas (P=0.040) (Figure B-21.1).

The standardized BMI increased rapidly for the first cohorts (1942-1964), from 20.2 to 24.3 kg/m², then declined steadily, to reach 22.6 in 1990, the change being highly significant (P<E-10). The BMI dynamics were similar in urban and rural areas, but with a time gap. In urban areas, the standardized BMI increased from 23.8 (cohort 1943) to 26.2 (cohort 1960), then decreased to reach 23.2 (cohort 1992), with a significant change in slopes (P=0.001). In rural areas, the increase lasted longer, from 20.3 (cohort 1943) to 23.0 (cohort 1970), then also declined to reach 21.8 (cohort 1992), again with a significant change in slopes (P<E-10) (Figure B-21.2).

Figure B-21.1 ***Trends in average height, adult women, Namibia***

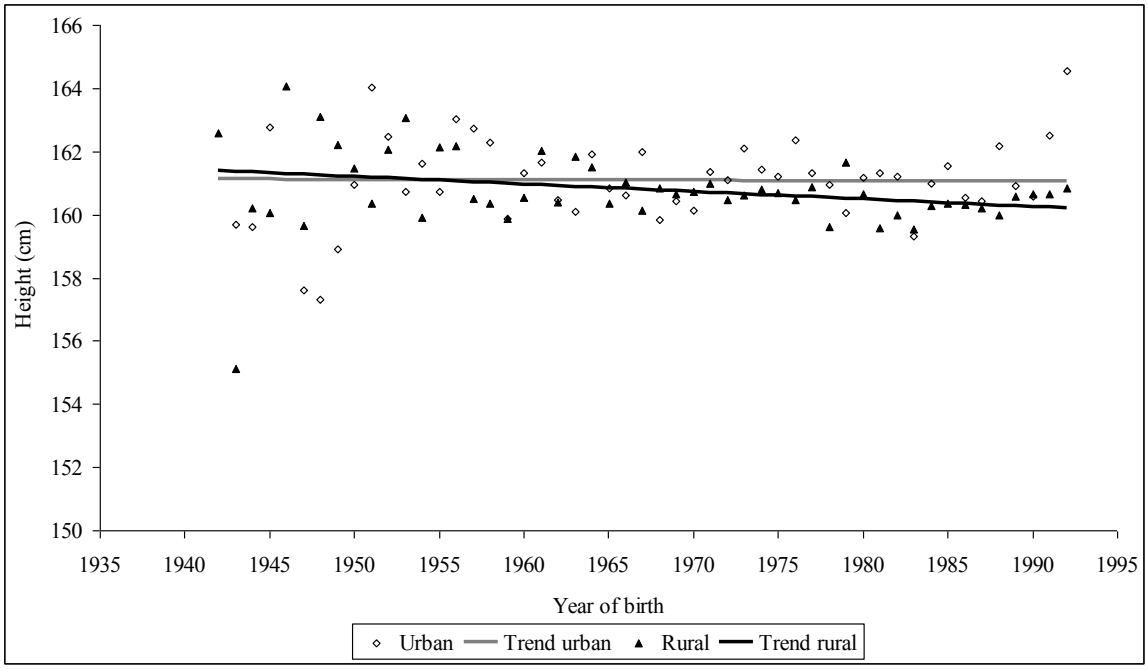
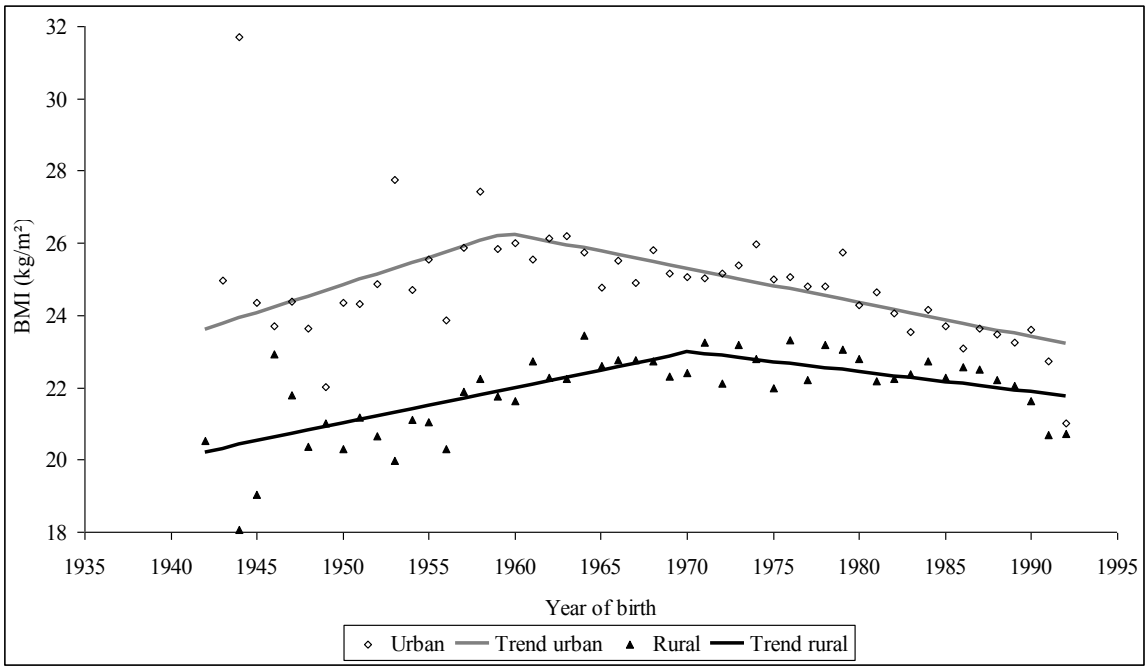


Figure B-21.2 ***Trends in standardized BMI, adult women, Namibia***



22. Niger

Niger conducted three surveys with anthropometric data on adult women, in 1992, 1998 and 2006. All three were compatible in terms of levels and trends in height and BMI. However, BMI was higher in the last survey (P<E-10).

Table B-22 Sample size and basic anthropometric characteristics, adult women, Niger

	Year of survey		
	1992	1998	2006
Number of women	3674	3583	3709
Height, women 20-49			
Mean (cm)	160.3	160.4	160.2
Standard deviation	6.06	5.97	5.90
BMI, women 20-49			
Mean (kg/m²)	21.0	20.9	21.8
Standard deviation	2.98	2.99	3.60

At the national level, height was slowly declining, from 161.1 to 159.5 (cohort 1942 to 1990), the slope being significant (P=4E-10). There was no change in height in urban areas (P=0.287), and the decline in height was concentrated in rural areas (P<E-10) (Figure B-22.1).

The standardized BMI increased slowly over time for the country as a whole, from low values: 20.2 for cohort 1942 to 22.0 for cohort 1990. Trends were somewhat different in urban and rural areas. In urban areas the standardized BMI tended to decrease first, from 21.3 to 24.2 (cohorts 1942-1970), then stabilized, with a significant change in slopes (P=0.001). In rural areas on the contrary, the BMI remained steadily increasing over time, from 19.8 (cohort 1942) to 21.4 (cohort 1991), the slope being highly significant (P<E-10) (Figure B-22.2).

Figure B-22.1 ***Trends in average height, adult women, Niger***

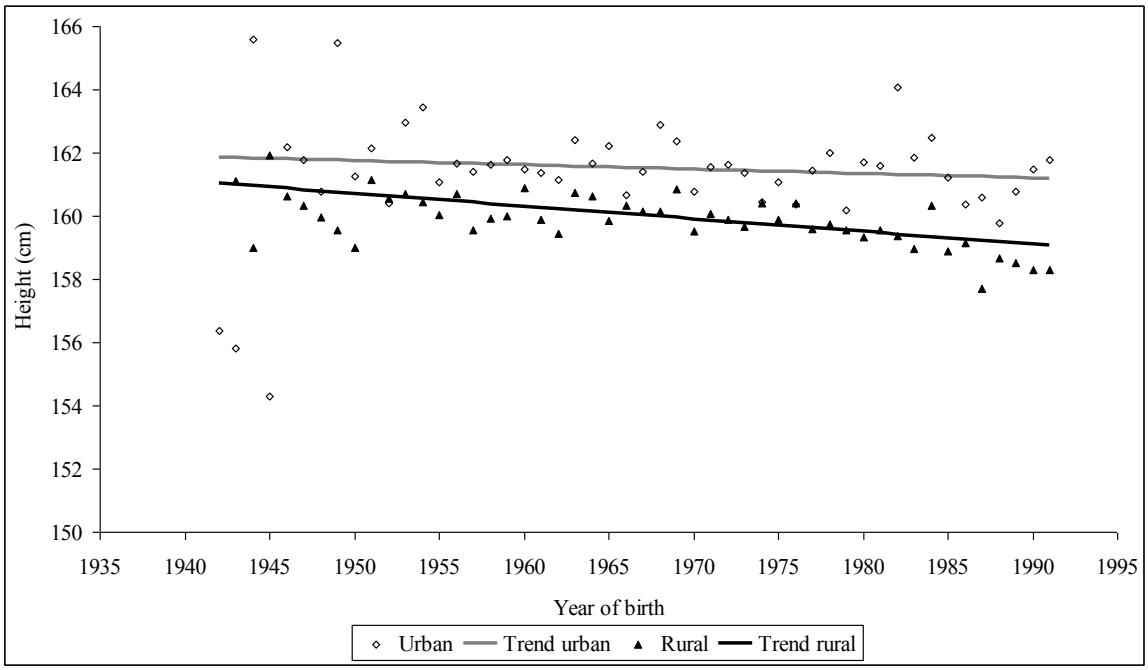
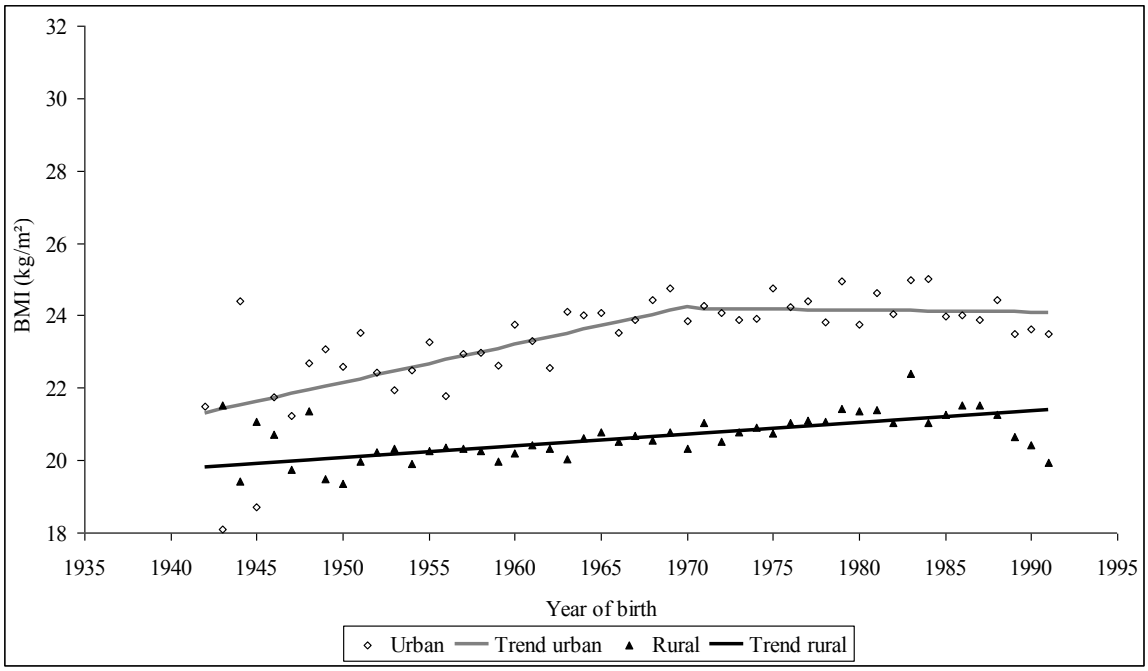


Figure B-22.2 ***Trends in standardized BMI, adult women, Niger***



23. Nigeria

Nigeria conducted three surveys with anthropometric data on adult women, in 1999, 2003 and 2008. All three were compatible in terms of levels and trends in height and BMI. However, height was somewhat lower (P=0.006) and BMI was somewhat higher in the last survey (P=0.005).

Table B-23 Sample size and basic anthropometric characteristics, adult women, Nigeria

	Year of survey		
	1999	2003	2008
Number of women	2195	5749	25861
Height, women 20-49			
Mean (cm)	158.9	158.7	158.4
Standard deviation	10.46	6.23	6.82
BMI, women 20-49			
Mean (kg/m²)	22.7	22.9	23.1
Standard deviation	4.77	4.41	4.48

At the national level, height was first increasing, from 157.5 to 159.6 (cohort 1950 to 1967), then decreasing to reach 157.0 for cohort 1991, both slopes being significant (P=0.006 and P<E-10 respectively). Trends were identical in urban and rural areas, and there were no differences in slopes for either time period (P=0.811, and P=0.981 respectively) (Figure B-23.1).

The standardized BMI was slowly decreasing from 21.8 (cohort 1950) to 23.3 (cohort 1967), to decline thereafter and reach 22.4 (cohort 1993) for the country as a whole. Trends were similar in urban and rural areas, with an increasing phase and a decreasing phase, and a gap between both. In both urban and rural areas, positive and negative slopes were significantly different from zero, and the changes in slope were highly significant (P<E-06 in urban and P<E-04 in rural) (Figure B-23.2).

Figure B-23.1 ***Trends in average height, adult women, Nigeria***

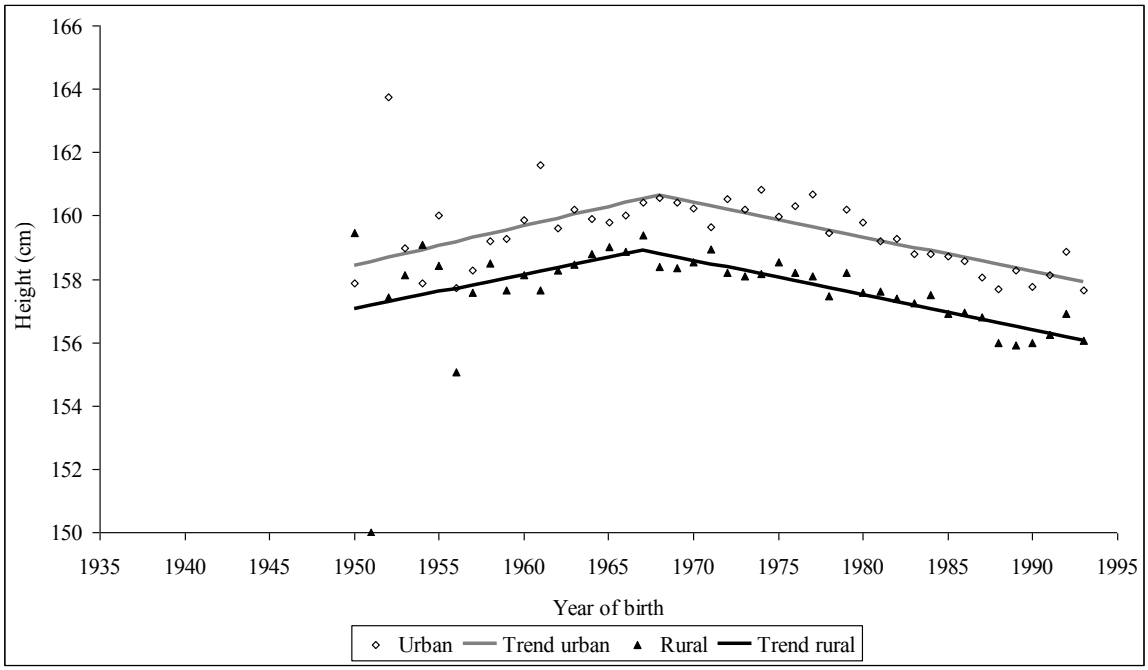
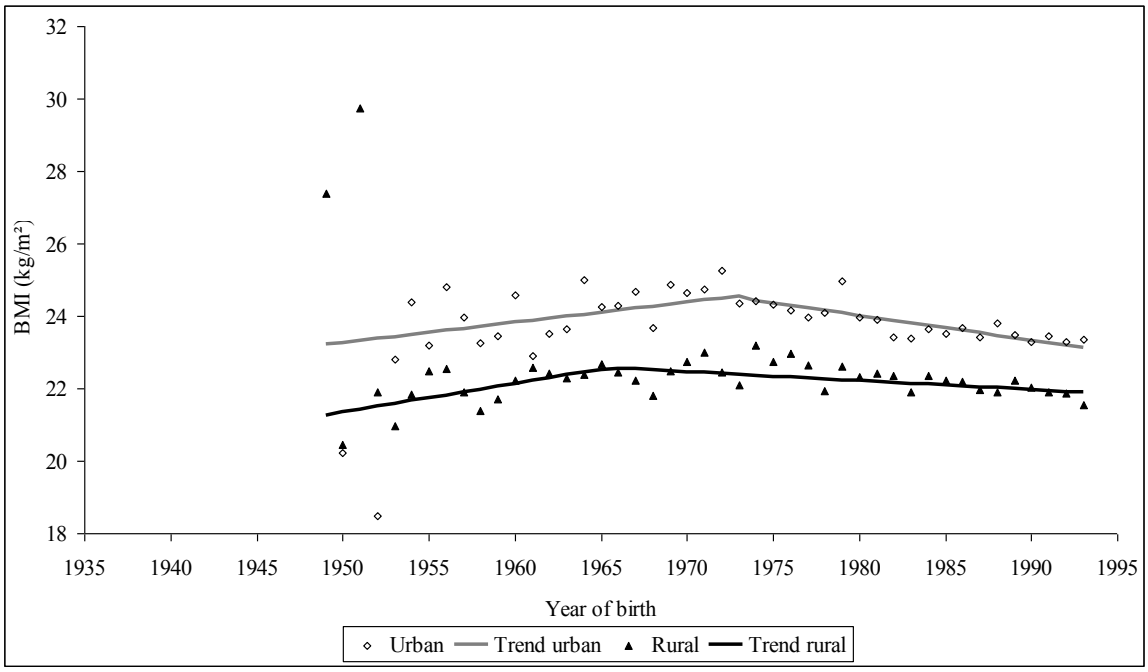


Figure B-23.2 ***Trends in standardized BMI, adult women, Nigeria***



24. Rwanda

Rwanda conducted two surveys with anthropometric data on adult women, in 2000 and 2005. Both were compatible in terms of levels and trends in height and BMI, although the second survey showed a systematic gap in BMI by cohort, which may indicate a fast change in the age pattern associated with the political turmoil of the 1990s. Both differences in height (P<E-10) and BMI (P=3E-05) were significant.

Table B-24 Sample size and basic anthropometric characteristics, adult women, Rwanda

	Year of survey	
	2000	2005
Number of women	7451	4342
Height, women 20-49		
Mean (cm)	157.9	157.3
Standard deviation	6.38	6.37
BMI, women 20-49		
Mean (kg/m²)	22.4	22.2
Standard deviation	2.90	2.83

At the national level, height was increasing very slowly, from 158.0 to 158.3 (cohort 1950 to 1971), then decreased rapidly to reach 154.1 for cohort 1990, the second slope being highly significant (P<E-10), and the change as well (P<E-10). Trends were identical in urban and rural areas, and there were no differences in slopes for either time period (P=0.813, and P=0.356 respectively). The decline in height started long before the civil war (Figure B-24.1).

The standardized BMI was increasing steadily from 20.4 to 23.4 for the country as a whole for a long time (cohorts 1950-1981), then declined very rapidly to reach 21.8 for cohort 1990, the change in slopes being highly significant (P<E-10). Trends were similar in urban and rural areas, although the increasing slope between cohort 1965 and 1983 was somewhat higher in urban areas (P=0.0005). The

cohorts the most affected by the decline in standardized BMI were also the ones who were adolescent or older children during the civil war years (1994-1997). It seems that this crisis had lasting effects for cohorts 1983-1990. This case in unique among the countries studied (Figure B-24.2).

Figure B-24.1 ***Trends in average height, adult women, Rwanda***

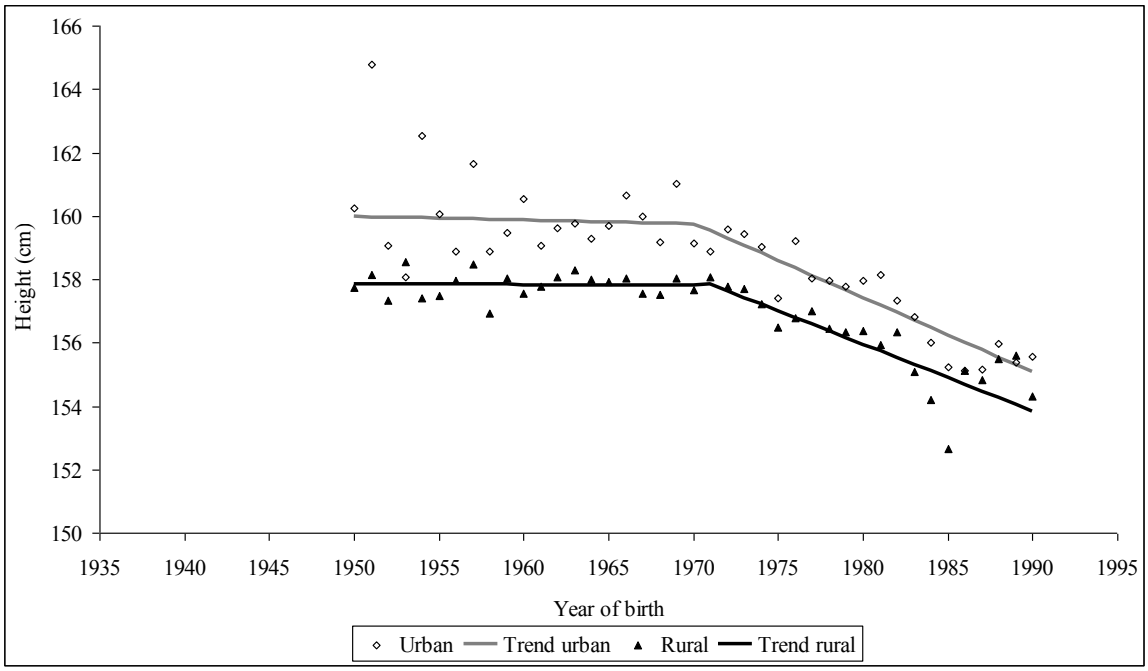
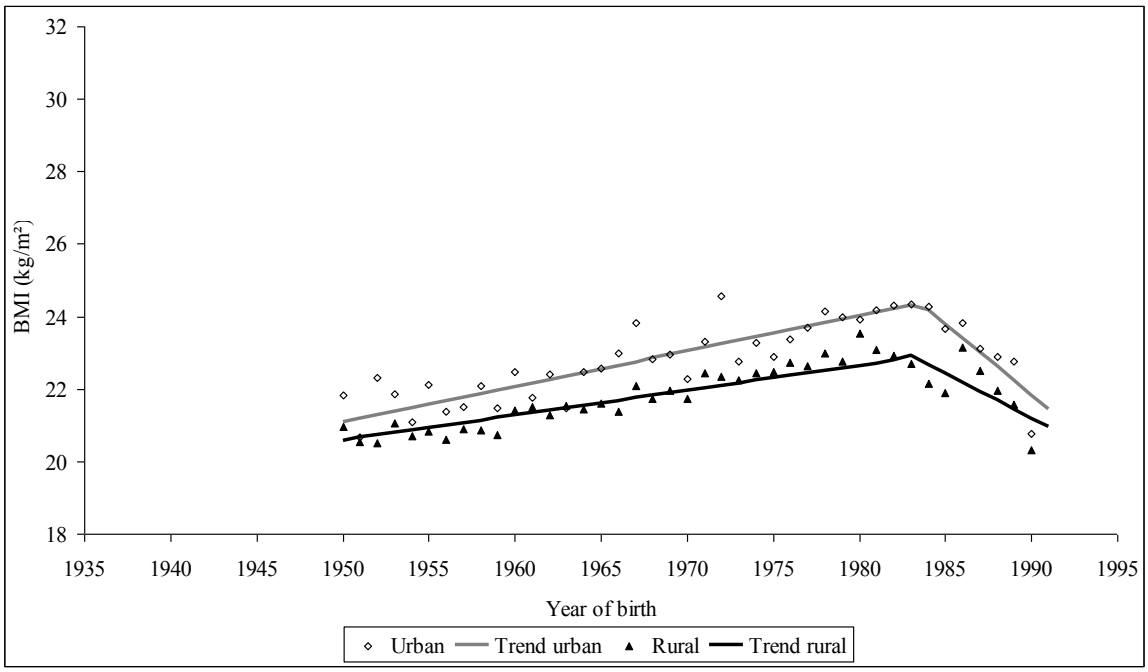


Figure B-24.2 ***Trends in standardized BMI, adult women, Rwanda***



25. Senegal

Senegal conducted two surveys with anthropometric data on adult women, in 1993 and 2005. Both were compatible in terms of levels and trends in height and trends for BMI. Both the average height and the average BMI were higher in the second survey (P=7E-06 and P<E-10 respectively).

Table B-25 Sample size and basic anthropometric characteristics, adult women, Senegal

	Year of survey	
	1993	2005
Number of women	3163	3456
Height, women 20-49		
Mean (cm)	162.4	163.1
Standard deviation	6.08	6.52
BMI, women 20-49		
Mean (kg/m²)	22.0	23.1
Standard deviation	3.63	4.72

At the national level, height was increasing slowly, from 162.0 to 163.5 (cohort 1945 to 1990), reaching the level of the USA or Western Europe, the slope being highly significant (P<5E-08). Levels and trends were similar in urban and rural areas, and the difference between urban and rural slopes was not significant (P=0.118) (Figure B-25.1).

The standardized BMI was increasing slowly from 22.0 (cohort 1943) to 22.8 (cohort 1966), then declined also slowly to come back to its original value of 22.0 for cohort 1990. Trends were different in urban and rural areas. In urban areas, the trend was declining steadily from 25.0 to 22.6, with a highly significant slope (P<E-10). In rural areas, the trend followed the national pattern, with a mild increase followed by a mild decline, the change in slope being highly significant (P<2E-05) (Figure B-25.2).

Figure B-25.1 ***Trends in average height, adult women, Senegal***

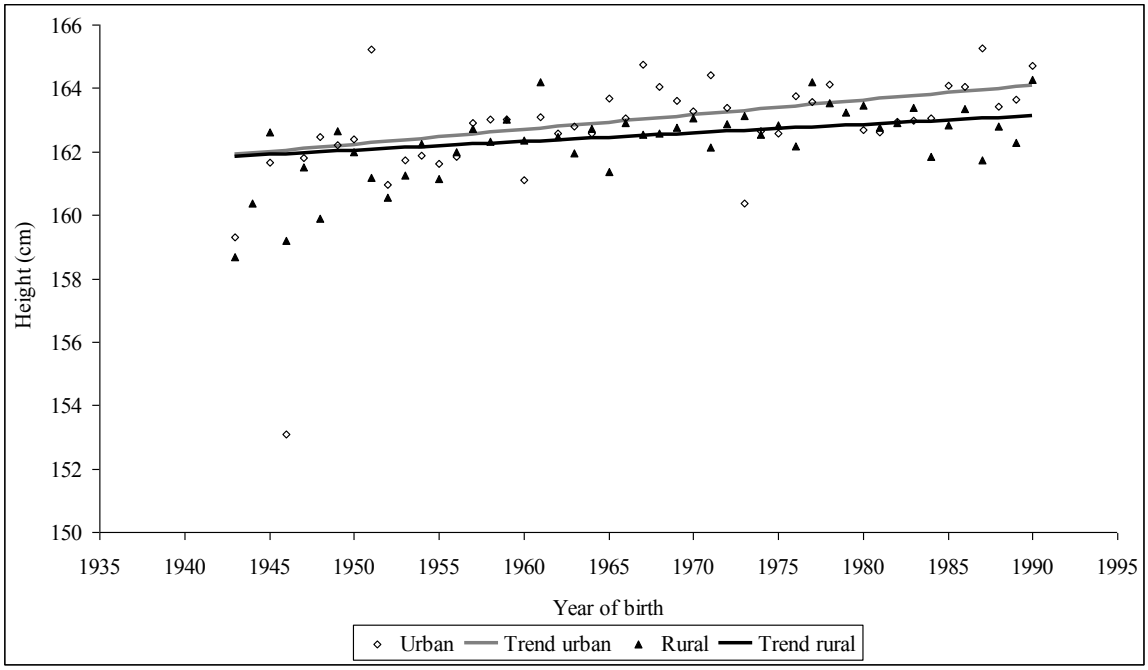
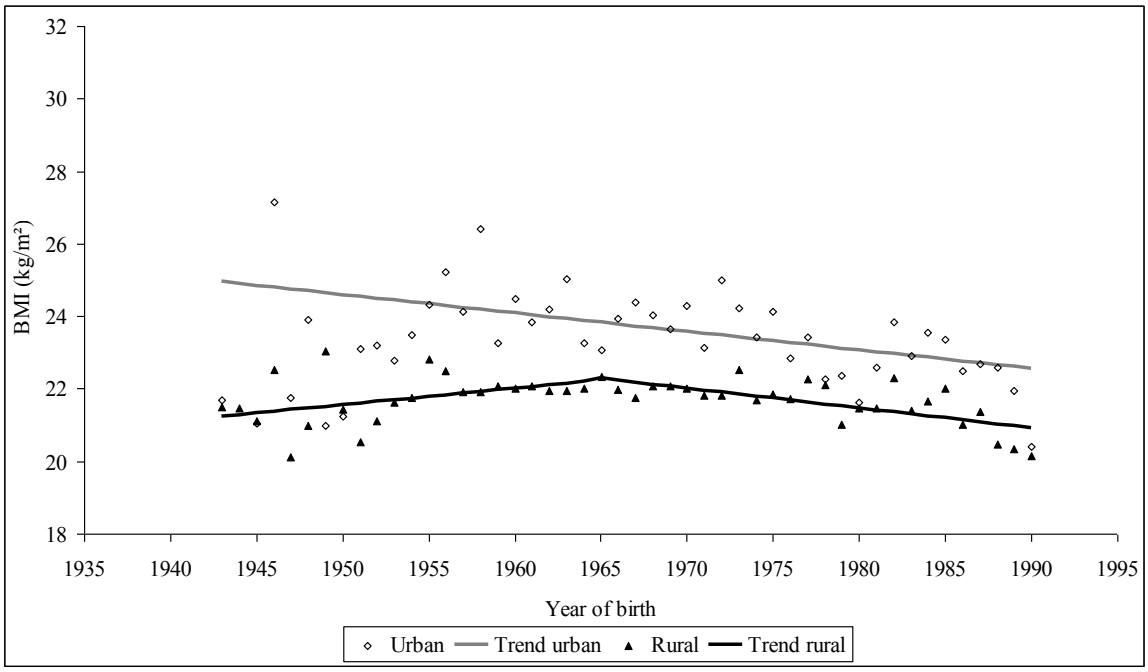


Figure B-25.2 ***Trends in standardized BMI, adult women, Senegal***



26. Sierra Leone

Sierra Leone conducted one survey with anthropometric data on adult women, in 2008. The anthropometric data were very heterogeneous in Sierra Leone: data plotted by year of birth were very erratic, outstanding values of height and weight were found, and the standard deviation of height and BMI was much higher than in the other surveys, suggesting poor quality of anthropometric data.

Table B-26 Sample size and basic anthropometric characteristics, adult women, Sierra Leone

	Year of survey
	2008
Number of women	3000
Height, women 20-49	
Mean (cm)	156.4
Standard deviation	10.30
BMI, women 20-49	
Mean (kg/m²)	23.5
Standard deviation	4.77

At the national level, height seemed to be declining slowly for available cohorts, from 157.5 to 155.4 (cohort 1960 to 1990). Trends were similar in urban and rural areas, the difference between urban and rural slopes being not significant (P=0.077) (Figure B-26.1).

The standardized BMI was increasing steadily from 22.9 (cohort 1958) to 24.1 (cohort 1993) for the country as a whole. However, trends were divergent in urban and rural areas. In urban areas the standardized BMI remained steady, at about 25.0 kg/m², whereas it tended to increase in rural areas, the difference between the two slopes being significant (P=0.0003) (Figure B-26.2).

Figure B-26.1 ***Trends in average height, adult women, Sierra Leone***

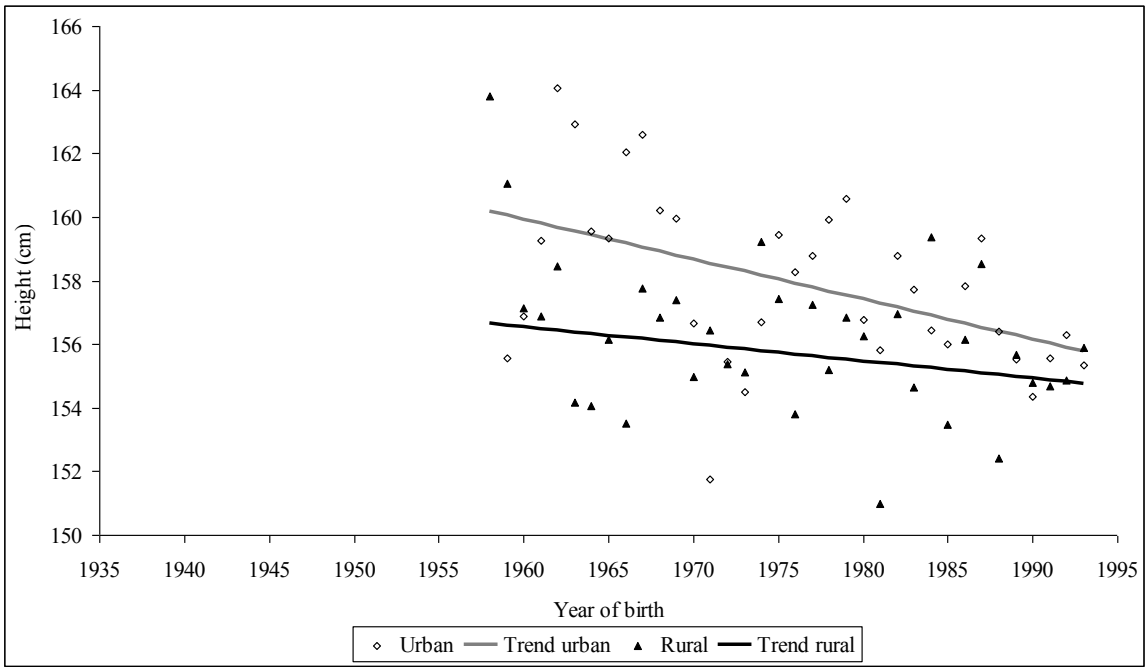
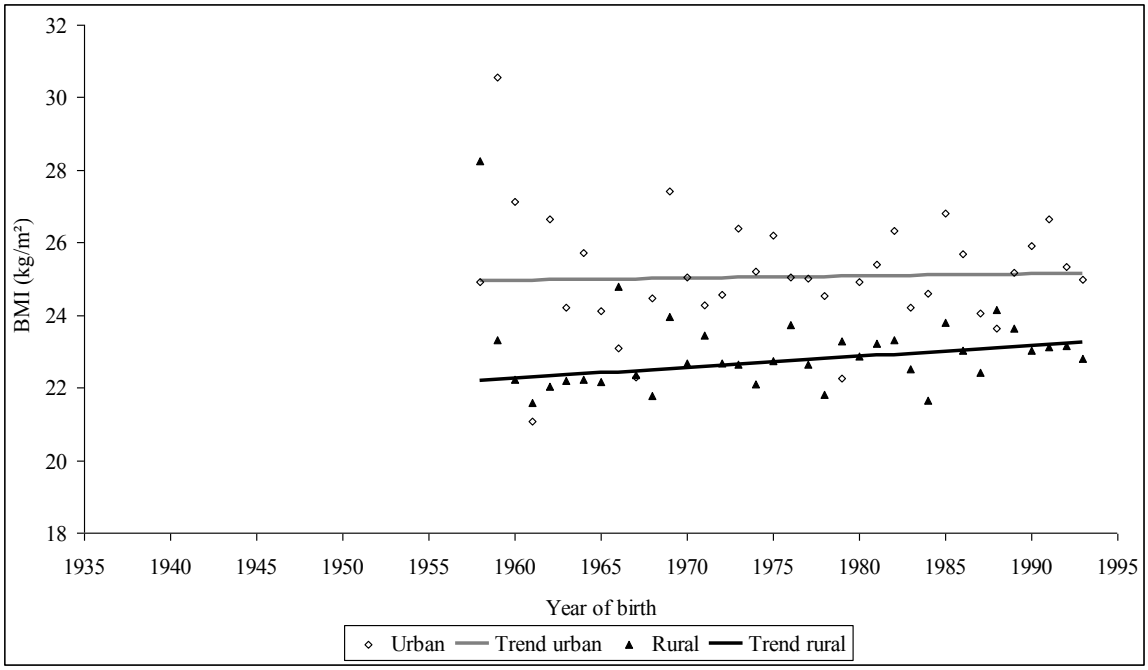


Figure B-26.2 ***Trends in standardized BMI, adult women, Sierra Leone***



27. South Africa

South Africa conducted one survey with anthropometric data on adult women, in 1998. The peculiarity of this survey is that adult women of all ages were taken weight and height, even above age 50, which provides more stability for trends of the earlier cohorts.

Table B-27 Sample size and basic anthropometric characteristics, adult women, South Africa

	Year of survey
	1998
Number of women	4568
Height, women 20-49	
Mean (cm)	158.9
Standard deviation	7.02
BMI, women 20-49	
Mean (kg/m²)	27.3
Standard deviation	6.40

At the national level, height was increasing slowly for the earlier cohorts (1940-1953), then became almost stable afterwards. The change in slopes was significant (P=3E-05). Levels and trends were similar in urban and rural areas, with more increase in the urban areas for the most recent cohorts, the difference between urban and rural slopes being significant (P=0.030) (Figure B-27.1).

The standardized BMI was very high, and for a long time, with a mild decline from 27.2 (cohort 1948) to 25.9 (cohort 1983). Trends were similar in urban and rural areas, although more pronounced in urban areas. In urban areas the standardized BMI tended to decline, from 27.8 to 26.0, but in rural areas from 26.2 to 25.6. The high values of BMI in rural areas are outstanding for Africa, except in the Southern area (South Africa, Swaziland, Lesotho). For the most recent cohort, the difference between urban and rural areas had vanished, although the age-period interaction (the increasing obesity) remains stronger in urban areas (Figure B-27.2).

Figure B-27.1 ***Trends in average height, adult women, South Africa***

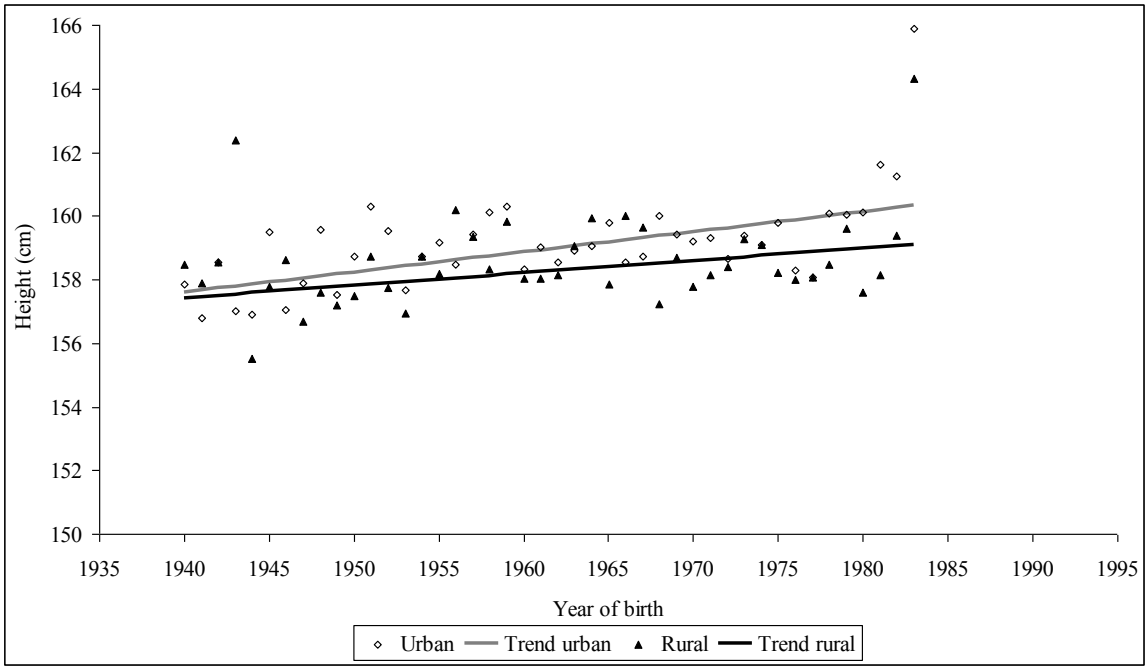
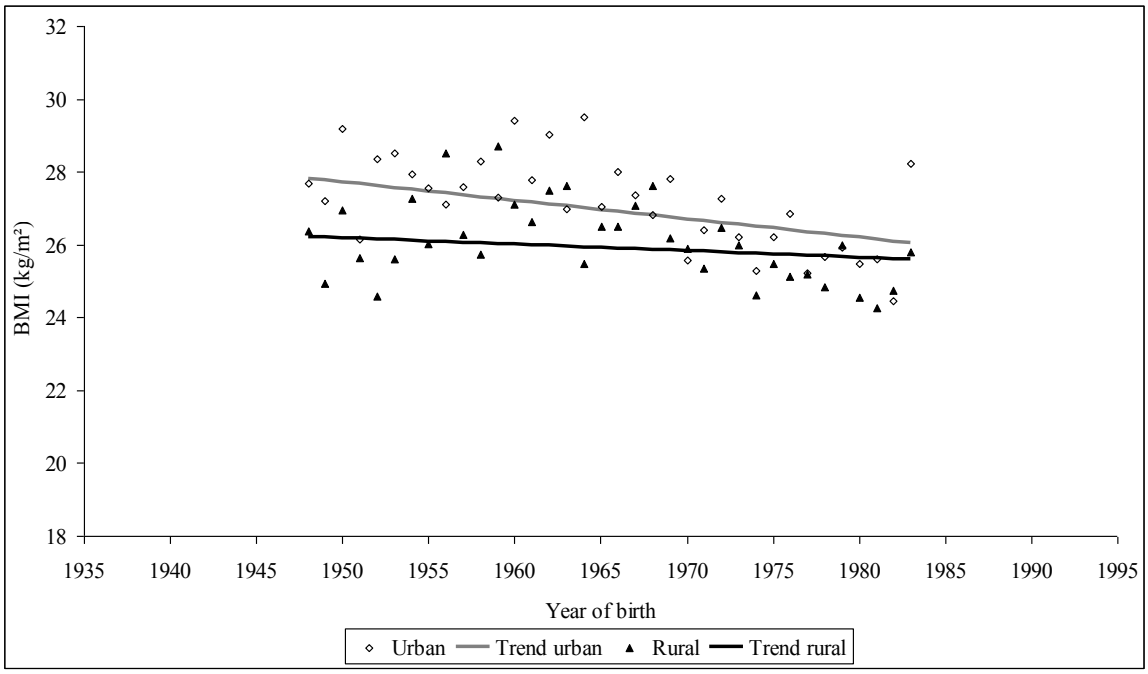


Figure B-27.2 ***Trends in standardized BMI, adult women, South Africa***



28. Swaziland

Swaziland conducted one survey with anthropometric data on adult women, in 2007. Swaziland bears many similarities with South Africa, for geographical and historical reasons.

Table B-28 Sample size and basic anthropometric characteristics, adult women, Swaziland

	Year of survey
	2007
Number of women	3833
Height, women 20-49	
Mean (cm)	159.0
Standard deviation	6.14
BMI, women 20-49	
Mean (kg/m²)	27.5
Standard deviation	5.94

At the national level, height was constant for the cohorts considered (1955-1990). The same was true in urban and rural areas, and the apparent very small difference between urban and rural slopes was not significant (P=0.133) (Figure B-28.1).

The standardized BMI was record high in both urban and rural areas. It tended to decline at the national level, from 29.4 to 25.5 for the time frame investigated (cohorts 1956-1990), and similarly in urban and rural areas, all slopes being highly significant (P<E-10 in both cases). The lack of difference between urban and rural areas is remarkable for sub-Saharan Africa (Figure B-28.2).

Figure B-28.1 ***Trends in average height, adult women, Swaziland***

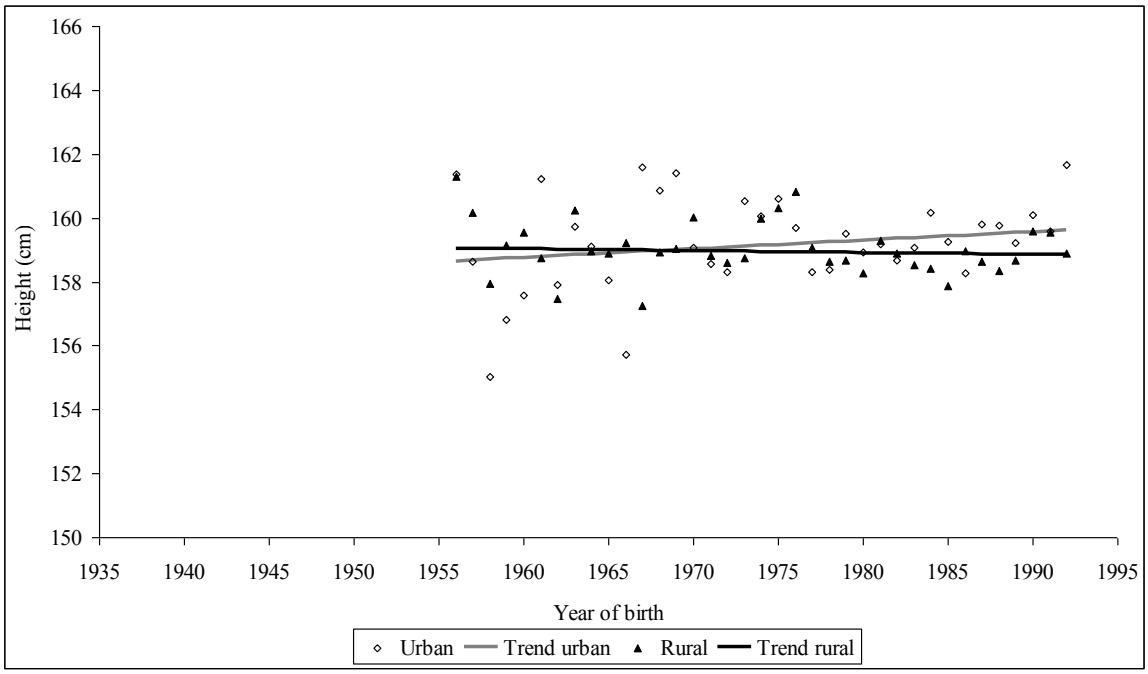
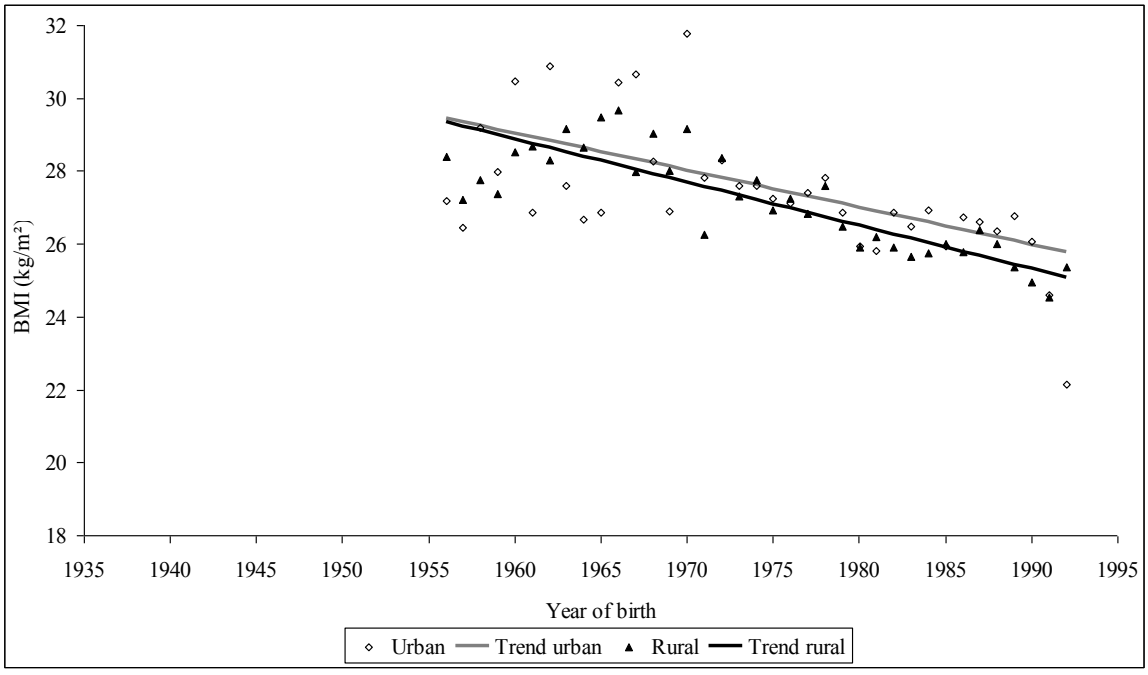


Figure B-28.2 ***Trends in standardized BMI, adult women, Swaziland***



29. Tanzania

Tanzania conducted two surveys with anthropometric data on adult women, in 1996 and 2004. Both surveys were compatible for levels and trends in height and BMI, with some mild differences for height of cohorts 1970-1980. In the second survey, average height was somewhat higher (P=0.007), as well as BMI (P<E-10).

Table B-29 Sample size and basic anthropometric characteristics, adult women, Tanzania

	Year of survey	
	1996	2004
Number of women	3992	8010
Height, women 20-49		
Mean (cm)	156.4	156.8
Standard deviation	6.22	6.39
BMI, women 20-49		
Mean (kg/m²)	22.1	22.8
Standard deviation	3.23	3.83

At the national level, height increased first, from 155.4 to 157.0 (1947-1967), then declined slowly to reach 156.1 for cohort 1991, the change in slope being significant (P=1E-06). The same was true in urban and rural areas, and there was no difference in slopes, and only a tiny difference in levels between urban and rural areas (Figure B-29.1).

The standardized BMI increased slowly from 22.0 (cohort 1947) to 22.9 (cohort 1969) to decline thereafter (21.2 for cohort 1990), reaching a value lower than at baseline. Trends in both areas were similar, and differences between urban and rural areas were very small. The change in slopes was significant in urban areas (P<E-07) and in rural areas (P<E-04) (Figure B-29.2).

Figure B-29.1 ***Trends in average height, adult women, Tanzania***

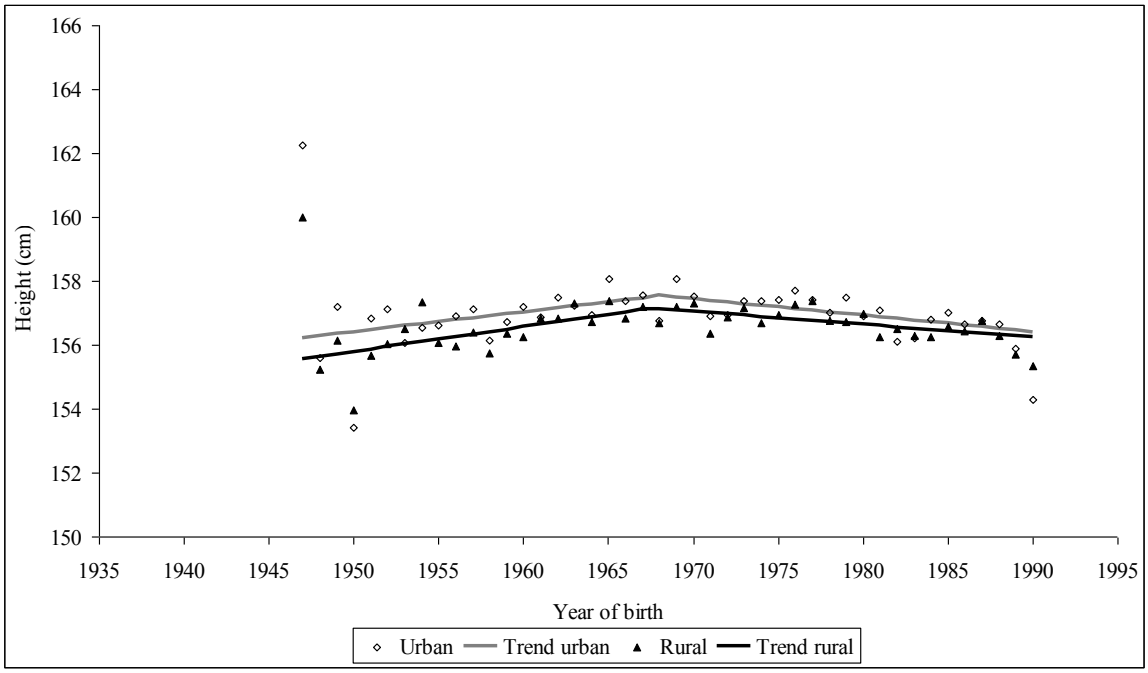
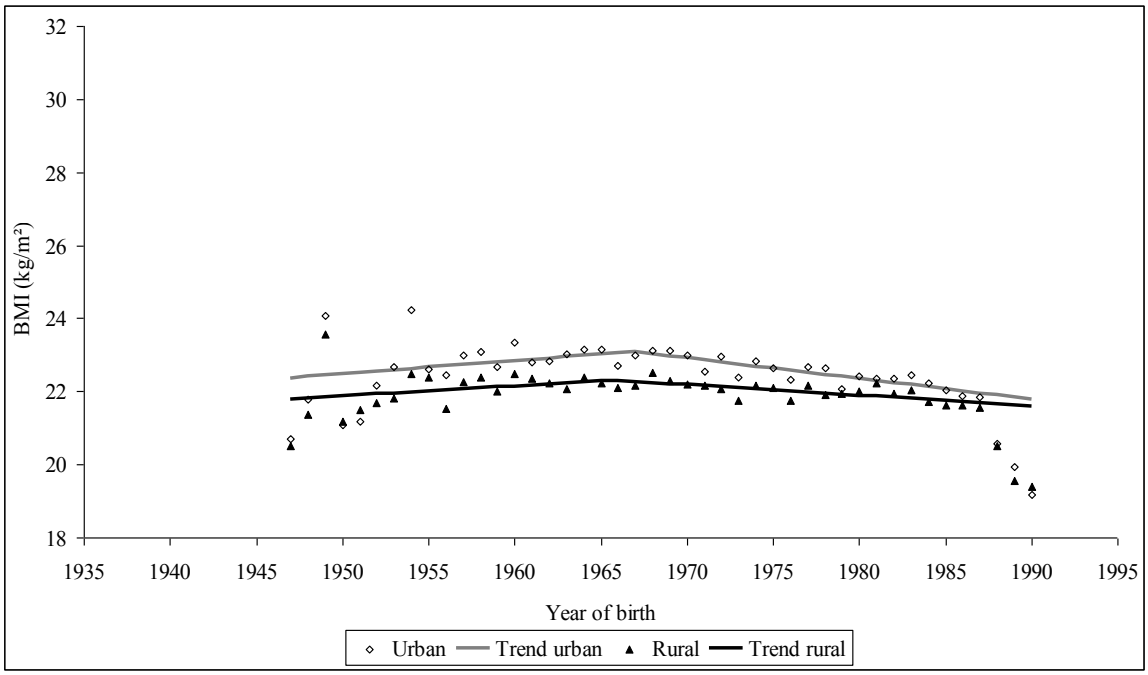


Figure B-29.2 ***Trends in standardized BMI, adult women, Tanzania***



30. Togo

Togo conducted one survey with anthropometric data on adult women, in 1998.

Table B-30 Sample size and basic anthropometric characteristics, adult women, Togo

	Year of survey
	1998
Number of women	3301
Height, women 20-49	
Mean (cm)	158.8
Standard deviation	6.11
BMI, women 20-49	
Mean (kg/m²)	21.8
Standard deviation	3.44

At the national level, height decreased slightly over the time frame considered, from 159.4 to 158.2 (1948-1983), the slope being significant (P=0.016). The same was true in urban areas, but in rural areas the pattern was different, with first a mild increase, and then a fast decline, the change in slopes being significant (P=0.046) (Figure B-30.1).

The standardized BMI increased first at the national level, from 20.5 to 21.9 (cohorts 1948-1965), then became steady. Trends diverged in urban and rural areas. In urban areas, the standardized BMI tended to decline steadily, from 24.1 (cohort 1948) to 22.8 (cohort 1982), whereas in rural areas it increased steadily from 20.4 to 21.9 for the same cohorts (1948-1982). The rural slope was highly significant (P<E-08); the urban slope was only borderline (P=0.09), and the difference between both was significant (P=0.001) (Figure B-30.2).

Figure B-30.1 ***Trends in average height, adult women, Togo***

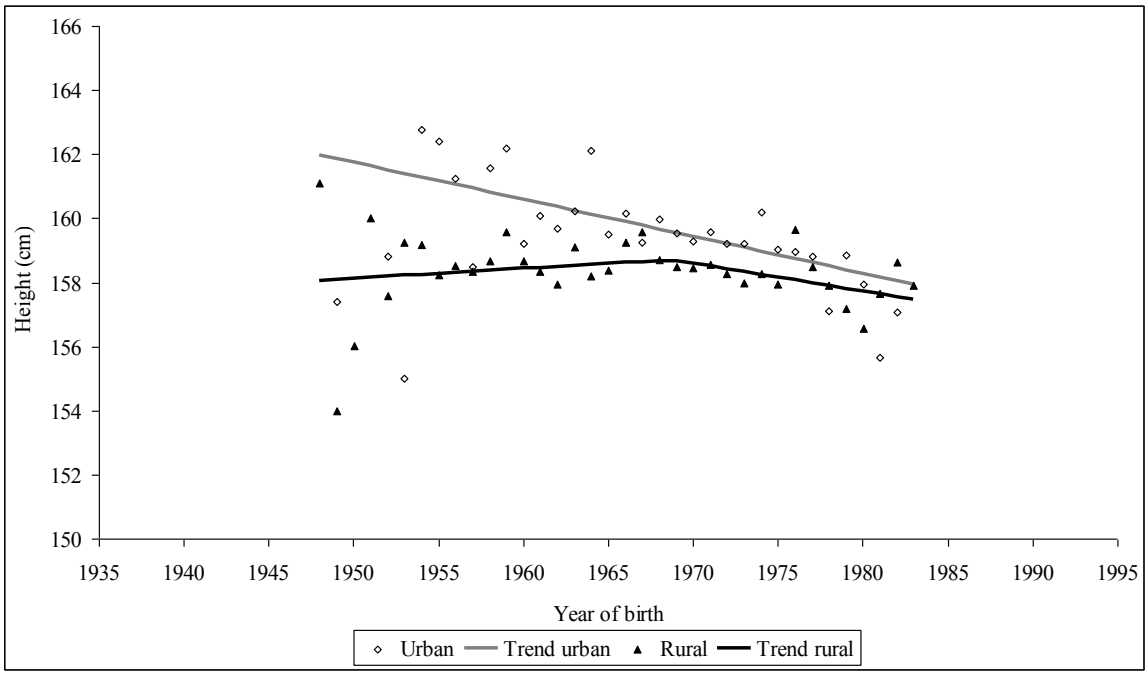
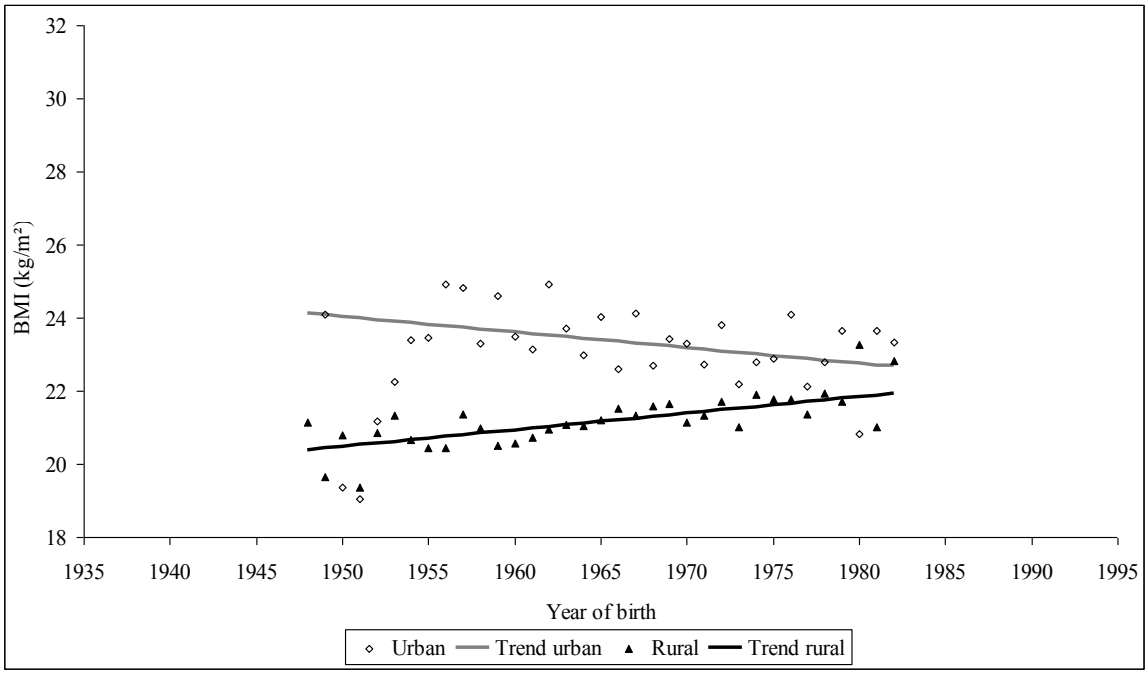


Figure B-30.2 ***Trends in standardized BMI, adult women, Togo***



31. Uganda

Uganda conducted three surveys with anthropometric data on adult women, in 1995, 2001 and 2006. All three surveys were compatible in levels and trends of height and BMI. Heights were the same in the three surveys, and BMI tended to increase from survey to survey, the differences being significant each time (P<E-10, and P=0.002 respectively).

Table B-31 Sample size and basic anthropometric characteristics, adult women, Uganda

	Year of survey		
	1995	2001	2006
Number of women	3553	5248	2303
Height, women 20-49			
Mean (cm)	158.5	158.6	158.8
Standard deviation	6.39	6.50	6.48
BMI, women 20-49			
Mean (kg/m²)	21.7	22.1	22.4
Standard deviation	2.94	3.50	3.72

At the national level, height tended to firstly increase, from 158.2 to 159.1 (1943-1964), then to decrease to reach 157.2 for cohort 1990, the change in slope being significant (P=1E-05). The same was true in urban and in rural areas, although the pattern was more pronounced in urban areas, both changes in slopes being significant (P=0.0018 and P=0.0005 respectively). Differences between urban and rural slopes were also significant (P=0.050 for the first period, and P=1E-05 for the second period) (Figure B-31.1).

The standardized BMI increased steadily at the national level, from 20.7 (cohort 1946) to 23.2 (cohort 1990). Trends were in the same direction in urban and rural areas, and very parallel, without any difference between slopes (P=0.79). In urban areas, the standardized BMI increased from 22.9 to 25.2 kg/m² (cohort 1946-1990), and from 20.7 to 22.7 in rural areas. Of course, both slopes were highly significant (P<E-05 and P<E-10 respectively) (Figure B-31.2).

Figure B-31.1 ***Trends in average height, adult women, Uganda***

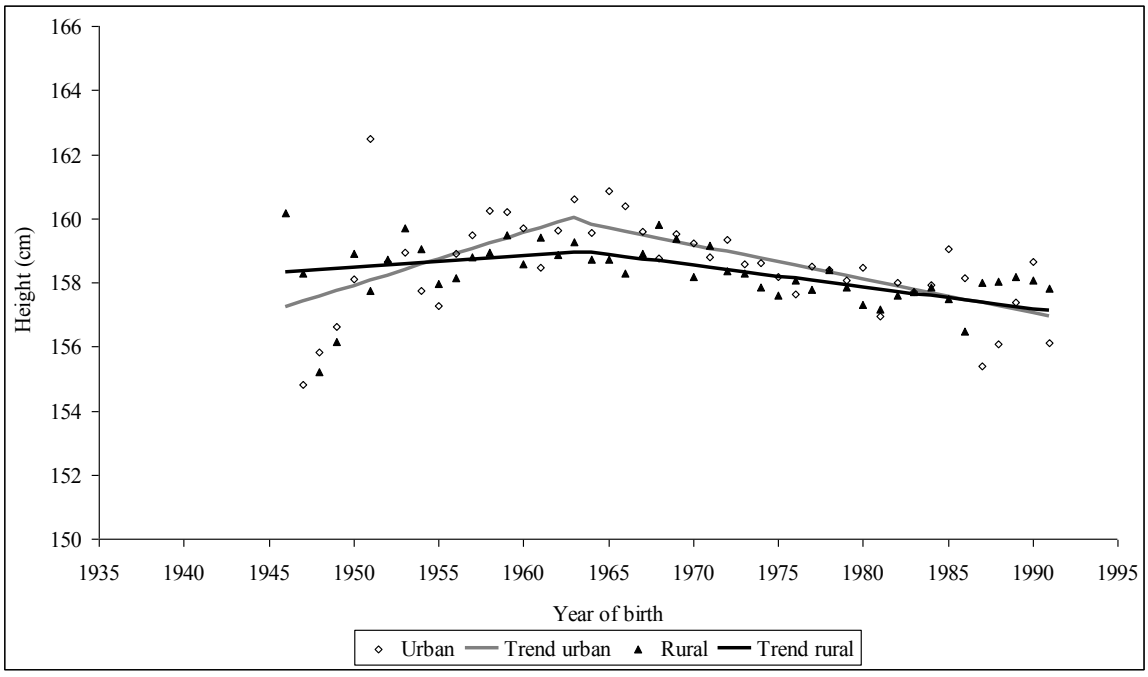
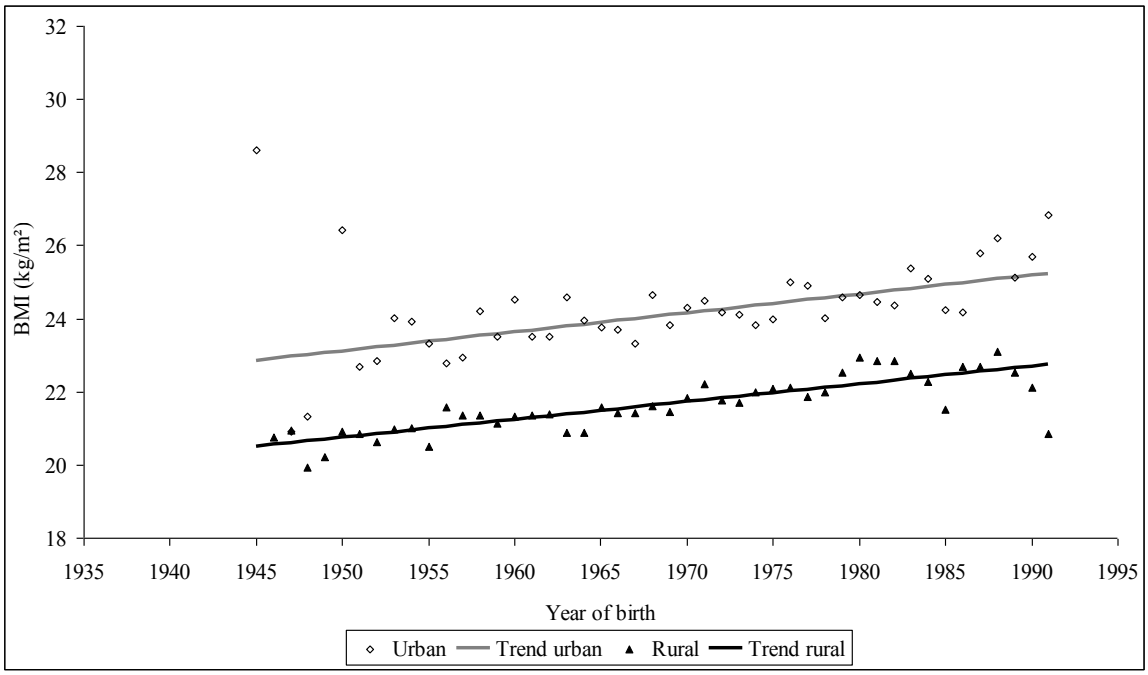


Figure B-31.2 ***Trends in standardized BMI, adult women, Uganda***



32. Zambia

Zambia conducted four surveys with anthropometric data on adult women, in 1992, 1997, 2001 and 2007. All four surveys were compatibles in levels and trends of height and BMI. Heights were the same in the four surveys, and BMI was somewhat lower in 2001 compared with 1997 and 2007 (P<4E-05, and P<E-10 respectively).

Table B-32 Sample size and basic anthropometric characteristics, adult women, Zambia

	Year of survey			
	1992	1997	2001	2007
Number of women	3362	4028	5998	5607
Height, women 20-49				
Mean (cm)	158.3	158.2	158.2	158.1
Standard deviation	6.03	6.02	6.24	6.44
BMI, women 20-49				
Mean (kg/m²)	22.1	22.2	21.9	23.0
Standard deviation	3.32	3.25	3.66	4.06

At the national level, height tended first to increase from 156.4 to 158.9 (1942-1964), then to decrease to reach 156.8 for cohort 1990, the change in slope being significant (P<E-10). The same was true in urban areas and in rural areas, both changes in slopes being significant (P<E-10 in both cases). Differences between urban and rural slopes were also significant (P=6E-06 for the first period, and P<E-10 for the second period), but of minor importance (Figure B-32.1).

The standardized BMI increased steadily at the national level from 21.4 to 22.9 (cohorts 1942-1990). Trends were divergent in urban and rural areas. In urban areas, the trend was first steady (cohort 1942-1970), then increasing, from 23.2 to 24.3 (cohorts 1970-1992), the change in slope being significant (P<E-05). In rural areas, the trend was first positive, from 20.0 (cohort 1942) to 21.5 (cohort 1966), then mildly positive, reaching 22.0 for cohort 1992, the change in slope being significant (P=0.0002) (Figure B-32.2).

Figure B-32.1 ***Trends in average height, adult women, Zambia***

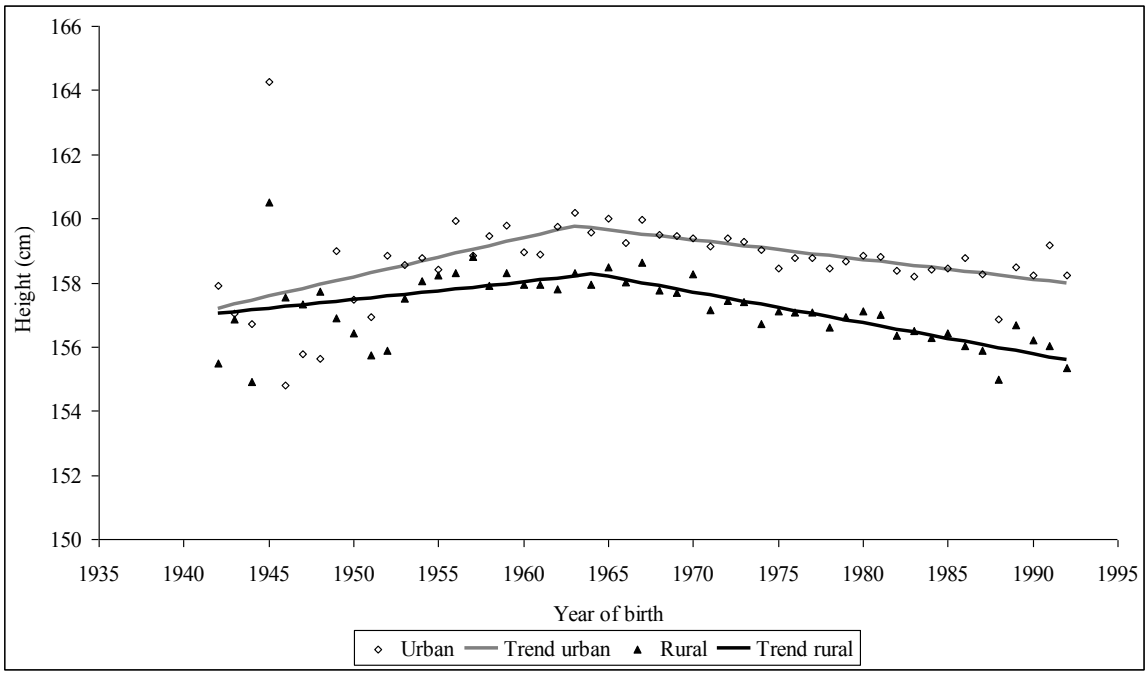
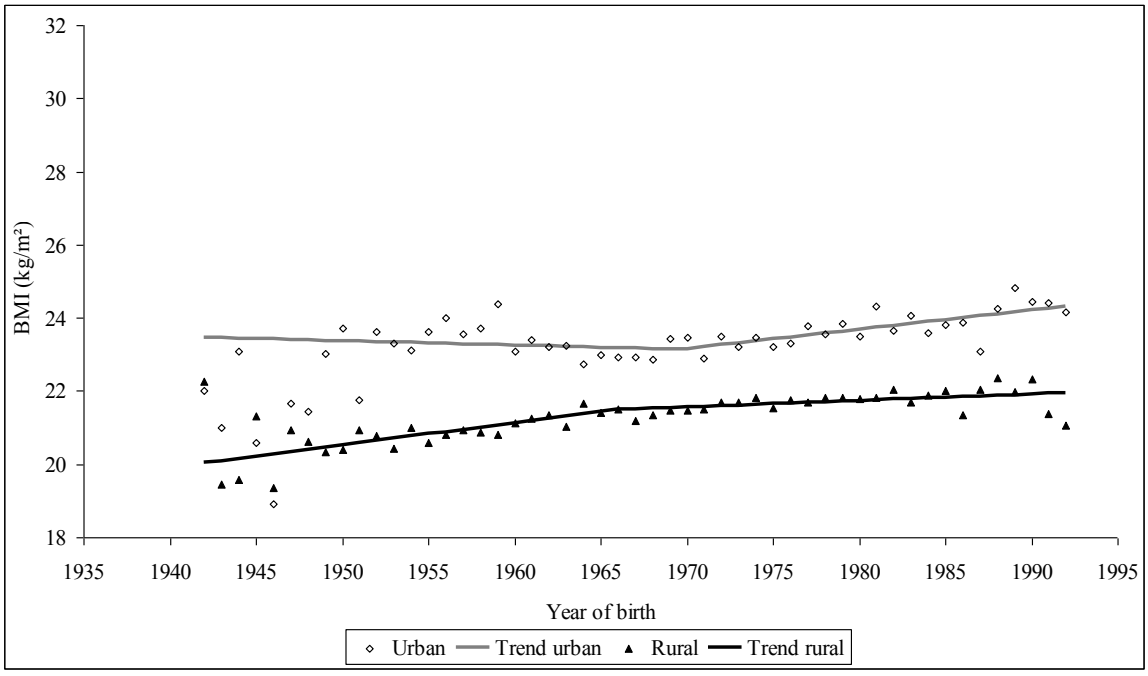


Figure B-32.2 ***Trends in standardized BMI, adult women, Zambia***



33. Zimbabwe

Zimbabwe conducted three surveys with anthropometric data on adult women, in 1994, 1999 and 2005. All three surveys were compatibles in levels and trends of height and BMI. Height was somewhat lower in the first survey (P=0.001), and BMI was somewhat higher in the second survey (P<E-10, and P<4E-08 compared with the first and third survey).

Table B-33 Sample size and basic anthropometric characteristics, adult women, Zimbabwe

	Year of survey		
	1994	1999	2005
Number of women	1893	4234	6699
Height, women 20-49			
Mean (cm)	159.4	160.0	160.1
Standard deviation	5.99	6.39	6.02
BMI, women 20-49			
Mean (kg/m²)	23.3	24.0	23.6
Standard deviation	3.72	4.25	4.28

At the national level, height was almost steady and declined very slowly, from 160.3 to 159.6 (1945-1990), the slope being significant (P=0.002). The same was true in urban areas and in rural areas, with basically the same slope, and only a minor gap of less than a centimeter between both areas (Figure B-33.1).

The standardized BMI was steady at the national level, with a mean of 23.7 (cohorts 1945-1990). Trends were divergent in urban and rural areas. In urban areas, the trend was negative (26.2 to 24.3 for the same cohorts), whereas it was positive in rural areas (22.6 to 23.4 for the same cohorts). Both trends were significantly different from zero (P<E-10 in urban, and P<E-06 in rural areas) (Figure B-33.2).

Figure B-33.1 ***Trends in average height, adult women, Zimbabwe***

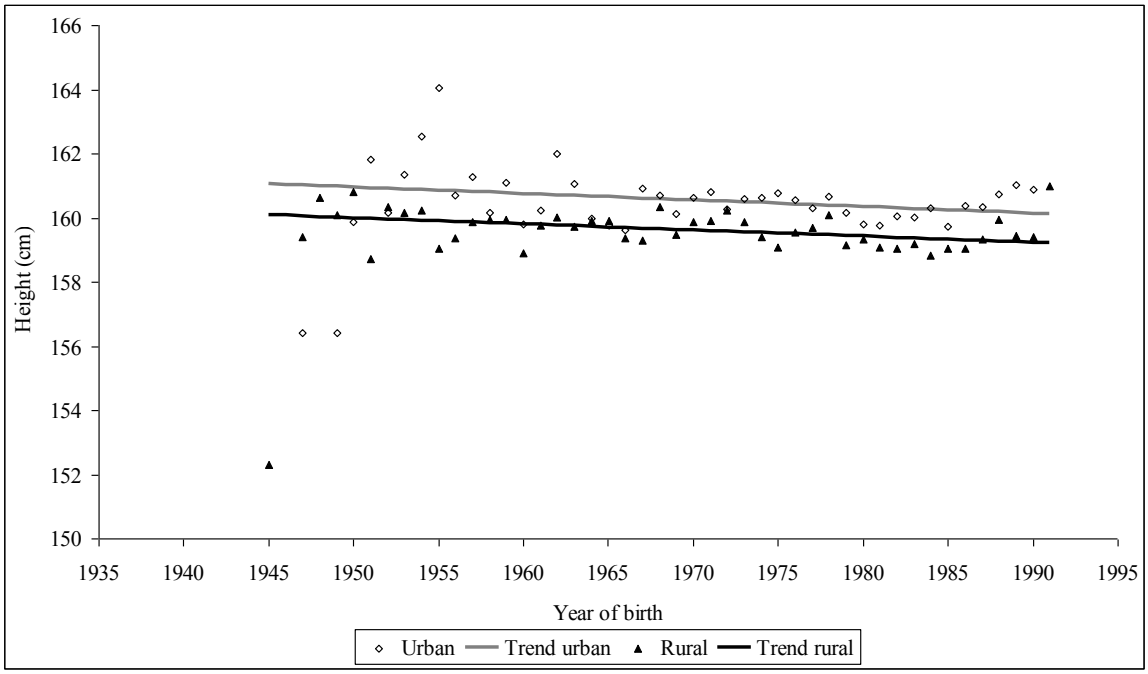
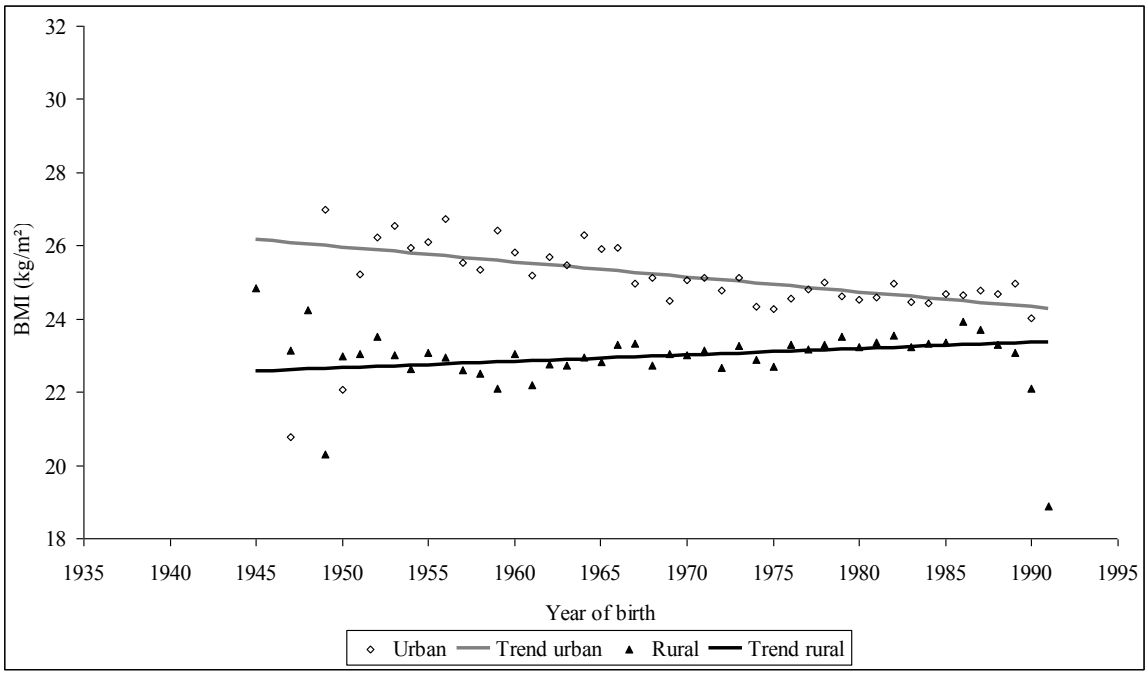


Figure B-33.2 ***Trends in standardized BMI, adult women, Zimbabwe***



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