International Journal of Pediatric Obesity, 2011; 6: e225–e232

informa healthcare

ORIGINAL ARTICLE

Child obesity and fitness levels among Kenyan and Canadian children from urban and rural environments: A KIDS-CAN Research Alliance Study

KRISTI BREE ADAMO[1,2,3], ANDREW WILLIAM SHEEL[4], VINCENT ONYWERA[5], JUDITH WAUDO[5], MICHAEL BOIT[5] & MARK STEPHEN TREMBLAY[1,2,3,5]

[1]*Healthy Active Living and Obesity Research Group-Children's Hospital of Eastern Ontario Research Institute, Ottawa, Canada,* [2]*University of Ottawa, Faculty of Medicine, Department of Pediatrics,*[3]*University of Ottawa, Faculty of Health Sciences, School of Human Kinetics,* [4]*University of British Columbia, School of Human Kinetics, Vancouver, Canada,* [5]*Kenyatta University, Nairobi, Kenya*

Abstract

Objective. This study was designed to gather anthropometric and fitness-related data on Kenyan children living in urban (UKEN) and rural (RKEN) environments and to compare them with previous data collected on Canadian children in order to examine the potential nutrition-physical activity transition. *Methods.* Height, weight, waist circumference, triceps skinfolds were directly measured on rural (RKEN) and urban Kenyan (UKEN) children (n = 179, 9–13 years) and compared with existing data from Canadian children living in urban and rural environments (n = 274, 9–13 years). Aerobic fitness was measured using the 20 m shuttle run, flexibility using the sit-and-reach test and isometric handgrip strength was assessed. *Results.* None of the RKEN children were overweight or obese (OWO). However, 6.8% of UKEN boys and 16.7% of girls were OWO. The RKEN children had lower BMI, waist circumference, and triceps skinfolds than all other groups (UKEN, and Canadian: $p < 0.05$). UKEN children were leaner than Canadian children ($p < 0.05$). Male and female RKEN children had higher running speeds, and aerobic fitness than UKEN children ($p < 0.001$). Isometric strength was not different between Kenyan groups and was not different from urban living Canadian children. UKEN children were the least flexible group, and girls were more flexible than boys in all groups. *Conclusions.* Urban Kenyan children appear to be showing signs of the nutrition-physical activity transition, as judged by the anthropometric similarities to contemporary living Canadian children. Further support is provided by examining the difference in prevalence of overweight/obesity among UKEN compared with their RKEN counterparts and their lower aerobic fitness level.

Key words: *Physical activity transition, Kenya, Canada, obesity, fitness, children, urban, rural.*

Introduction

As developing nations become more prosperous, they acquire some of the benefits of industrialized nations (i.e., a reduction in mortality and morbidity due to infectious diseases), along with some of the problems (i.e., increased prevalence of chronic non-communicable diseases and associated risks) (1,2). Chronic diseases are associated with being overweight and obese (3) and are now rising in developing countries at a faster rate than that experienced by developed countries (4). It has been suggested that growing affluence and urbanization in Kenya is associated with a nutrition-physical activity transition. While the nutrition-transition, defined by a series of changes including the movement away from more traditional agrarian subsistence dietary practices towards those influenced by Western cultures and market forces that may lead to the overconsumption of cheap, energy-dense food (5), has been described for several years, the concomitant physical activity transition is a more recently described phenomenon (6,7). The physical activity transition refers to a shift away from the high energy expenditure activities such as farming, herding, gathering

Correspondence: Kristi B. Adamo, Healthy Active Living and Obesity Research Group (HALO) Children's Hospital of Eastern Ontario Research Institute, 401 Smyth Rd, Ottawa, ON K1H 8L1, Canada. Fax: +1 613 738 4800. E-mail: kadamo@cheo.on.ca

(Received 19 March 2010; accepted 21 November 2010)

ISSN Print 1747-7166 ISSN Online 1747-7174 © 2011 Informa Healthcare
DOI: 10.3109/17477166.2010.543683

firewood, hunting, mining, and forestry towards more sedentary occupations together with less active modes of transportation and activity patterns during leisure hours.

The prevalence of child overweight and obesity is increasing in most countries across the globe (8), and it is reported that the rates of obesity have tripled in developing countries that have been adopting a Western lifestyle (9). However, among African countries maintaining a traditional lifestyle the populus view is that the prevalence of obesity is low. Despite this, anecdotal evidence and media reports suggest that the nutrition and physical activity transition is in fact emerging in many developing countries (10–14) and evidence from other African nations indicate that child overweight and obesity is on the rise and is increasingly becoming a public health problem in such countries (8,15,16), including East Africa (17). While there are reports indicating that in some parts of Africa fatness and obesity affects more children than malnutrition does (www.iotf.org), the potential adverse effects of rapid modernization on body weight and fitness in Kenyan children is not known.

Childhood obesity gives rise to a complex interplay between co-morbidities, detrimental psychosocial aspects, a reduction in life expectancy and is linked with both economic and societal burdens. Having already experienced, and continuing to cope with the effects of the nutrition-physical activity transition in Canada, the Kenyan International Development Study-Canadian Activity Needs (KIDS-CAN) Research Alliance was established to develop a research programme to explore correlates of child obesity (e.g., physical activity, fitness and nutrition) in Kenya, a country at risk of rapid transition, with the hope that research and surveillance efforts will raise awareness of the nutrition-physical activity transition and lead to preventive interventions.

An early indicator of the economic transition of developing countries is urbanization. A comparison between urban and rural Kenyan children provides a model for the KIDS-CAN Research Alliance to detect the emergence of the nutrition and physical activity transition. Comparisons with a developed country, like Canada, allows for a further assessment of this public health concern. Therefore, the purpose of this study was to gather anthropometric and fitness-related data on Kenyan children living in both urban (UKEN) and rural (RKEN) environments and to compare them with previous data collected on Canadian children (18). We hypothesized that RKEN children would be leaner than their urban counterparts, who would be closer in similarity to contemporary living Canadian children, and that RKEN children would be more aerobically fit and stronger than an UKEN population.

Methods

Subject selection

Kenyan children aged 9–13 years (n = 179) from two urban and two rural schools participated (86 boys, 93 girls). This study employed a convenience sample of one public and one private school from a rural Kenyan (RKEN, Rift Valley Province) and urban Kenyan (UKEN, Nairobi Province) population. The schools were contacted based on an existing relationship with Kenyatta University as well as their representation of the rural-urban sample being targeted. Children and parents completed written informed assent and consent (available in English and Swahili), respectively, prior to participating in the study. A verbal explanation was also given and any queries answered by study staff. The study protocol received ethical approval from the Kenya Medical Research Institute and the research ethics boards of the Canadian research institutes. The study was designed to test 50 children per school (n = 200) and thus our sample of 179 indicates a successful recruitment, consent and compliance to measurement rate.

Anthropometric measures

Direct measures of height, weight, waist circumference and skinfold thickness were taken according to the procedures outlined in the Canadian Physical Activity, Fitness and Lifestyle Approach (19). Height was measured to the nearest 0.1 cm, using a stadiometer, as the maximum distance from the ground to the highest point on the head positioned in the Frankfurt plane with shoes off, feet together, and arms by the sides. Body mass was measured using a calibrated scale (BWB-800 MA TANITA, Netherlands) and recorded to the nearest 0.1 kg and body mass index (BMI, kg/m^2) was calculated. Waist circumference was assessed while children were standing erect with their arms hanging loosely at their sides. The measure was taken against the skin at the end of a normal expiration with the tape positioned horizontally mid-way between the bottom floating rib and the iliac crest. The measurement was recorded to the nearest 0.5 cm. Skinfold thickness measures were taken from the right side at two standard anatomical sites (triceps and subscapular regions) (19). The mean of two measurements was taken and if the two measurements differed by greater than 0.4 mm, a third measure was performed and the mean of the two closest measures was used.

Fitness measures

Cardiorespiratory fitness was measured among the Kenyan children using the 20 m Multistage

Endurance Shuttle-Run Test (or 'beep test'), currently the most widely used aerobic fitness field test with children and adolescents (20). The test has been shown to be a reliable and valid method of estimating peak oxygen consumption (Vo_2) in children and adolescents (21). This test involved continuous running between two lines 20 m apart in time to recorded beeps, which get closer together after every minute or level (i.e., increased speed). The test was stopped when the subject failed to keep pace for two consecutive shuttles.

Flexibility was measured using the sit-and-reach test (19). Participants sat on a mat with their legs out, straight ahead, and the soles of their feet (shoulder-width apart) flat against the flexometer. With legs flat against the mat and hands on top of each other the subjects were asked to reach forward along the measuring line as far as possible. After a standard stretching routine two attempts were made and the greatest stretch distance was recorded.

Isometric grip strength was assessed using the handgrip test (19). The participants held the handgrip dynamometer (LB9011 Senoh, Japan) in the hand to be tested, with the arm at the side but not touching the body. The subjects were instructed to squeeze the dynamometer with maximum isometric effort while exhaling. This was performed twice with each hand (alternating) and the highest result from each hand was summed to produce the final score.

Comparisons with Canadian children

Previous studies have examined the fitness levels and anthropometric measures in contemporary living children from urban (USK) and rural (RSK) Saskatchewan, Canada (18). Identical measures to those used in the present study (except for aerobic fitness) were performed on Canadian children of the same age who live in both rural (n = 164) and urban (n = 110) areas. Assessors for both the Kenyan and Canadian populations were trained on the measurement techniques by the same individual. Utilization of these previously obtained values permits a direct comparison between rural and urban children from a developed and a developing country.

Statistical analyses

Differences in continuous variables (body composition and fitness) between comparison groups were performed using the GLM procedure with group and gender as main effects and chronological age as the covariate. When main effects were significant, post-hoc comparisons were made to determine which between-group differences were significant (with Bonferroni adjustment for multiple comparisons). Chi-squared tests were used to compare the overweight/obesity prevalence data. All statistical analyses were performed using SPSS v.17.0 software with significance set at $p < 0.05$.

Results

Anthropometrics

The assessment of anthropometric variables illustrated several interesting differences between rural and urban Kenyan children and their Canadian comparators. Shown in Table I are values for BMI, waist circumference and triceps skinfold thickness. Overall, the RKEN children were found to have lower BMI (range: –2.1 to –4–4 kg/m^2), waist circumference (range: –5.1 to –10.7 cm) and triceps skinfold thickness (range: –4.4 to –11.7 mm) compared with the other groups. Using the categorization of overweight or obese based on the cut-off points published by Cole et al. (22), none of the rural Kenyan children were overweight or obese; however, 6.8% of the boys and 16.7% of the girls in the urban school setting were considered overweight/obese (Figure 1).

Fitness

As shown in Table II, rural Kenyan children (both male and female) have significantly greater aerobic fitness relative to their urban counterparts, as measured by shuttle run laps completed and maximal speed attained (11.65 $\pm$ 0.15 vs. 10.66 $\pm$ 0.15 km/h for boys and 11.11 $\pm$ 0.13 vs. 9.86 $\pm$ 0.11 km/h for girls, $p < 0.05$). Using age- and sex-specific z-scores for maximal shuttle run speed to normalize the findings (20), these values equate to percentile rankings of 74% vs. 48% for RKEN and UKEN boys and 80% vs. 41% for rural and urban girls, respectively, ($p < 0.001$ for both males and females). The differences in predicted aerobic capacity or maximal oxygen consumption (Vo_2max, ml/kg/min), were calculated using the formula developed by Leger et al. for use in children 8–19 years of age (23). Values are shown in Table II where boys had significantly higher values ($p < 0.05$). Unfortunately, comparisons could not be made with the Canadian populations as the fitness assessment performed in these populations utilized a different field test.

Although clear differences were observed in aerobic fitness, isometric strength, as measured by handgrip dynamometry in kg adjusted to body weight (kg/kg body weight) was not different between Kenyan groups and was not significantly different from measures in urban living Canadian children (Table III). As expected (except in the rural Kenyan population) there were significant gender differences in this measure of strength.

Table I. Age and anthropometrics variables (mean + standard error (SE)). Age range = 9–13 years for all groups, *= significant gender difference, a = significant <than all groups, b = significant <RSK & USK. Statistical significance defined as $p < 0.05$.

	RKEN		UKEN		RSK		USK	
	Boys (n = 42)	Girls (n = 39)	Boys (n = 44)	Girls (n = 54)	Boys (n = 74)	Girls (n = 90)	Boys (n = 52)	Girls (n = 58)
Age (years)	11.07 ± 0.28	11.83 ± 0.29	11.0 ± 0.28	10.59 ± 0.25	10.89 ± 0.21	11.18 ± 0.19	11.33 ± 0.25	11.05 ± 0.24
median	11.11	11.44	10.87	10.55	10.85	11.18	11.44	11.03
Body mass index (kg/m^2)	15.34 ± 0.43[a]	15.36 ± 0.44[a]	17.22 ± 0.42[b]	18.03 ± 0.39	18.7 ± 0.32	19.56 ± 0.29*	19.1 ± 0.38	19.19 ± 0.36
Waist circumference (cm)	57.95 ± 0.99[a]	56.42 ± 1.03[a]	61.8 ± 0.97	64.36 ± 0.92	64.38 ± 0.75	66.09 ± 0.68	64.17 ± 0.89	64.66 ± 0.85
Triceps skinfold (mm)	6.12 ± 1.00[b]	7.38 ± 1.04[a*]	9.45 ± 0.98[b]	13.7 ± 0.93 b*	15.27 ± 0.76	21.12 ± 0.69*	18.1 ± 0.90	18.83 ± 0.85

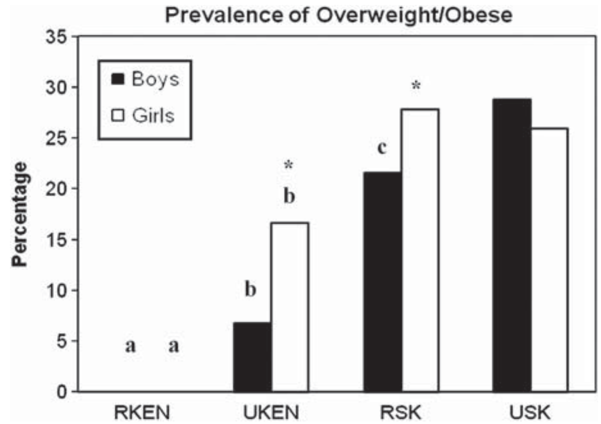

Figure 1. Prevalence of overweight/obesity. See text for definition of groups. *=significant gender difference, a = significant <than all groups, b = significant <RSK & USK, c = significant <USK.

Urban Kenyan children were found to be the least flexible group, as measured by their sit and reach values, but other than girls being more flexible than boys no apparent trends were identified (Table III).

Discussion

Main findings

Kenyan children in urban settings appear to be showing signs of the nutrition-physical activity transition, as judged by the anthropometric similarities to contemporary living Canadian children. Further support is provided by examining the difference in prevalence of overweight/obesity among UKEN (6.8% boys and 16.7% girls) compared with their RKEN counterparts and their lower aerobic fitness level. Additional data from our KIDS-CAN group, reported elsewhere (24), also indicates that urban Kenyan children partake in more sedentary behaviours, rely less on active transport practices and accrue fewer daily step counts than their rural counterparts. Collectively, these data suggest that UKEN children are being exposed to a more obesogenic lifestyle and show greater similarity to contemporary living Canadian children than rural Kenyan children.

Anthropometrics

As hypothesized, the RKEN were leaner than the UKEN as measured by BMI, waist circumference and triceps skinfold thickness. Table I and Figure 1 illustrate an upward trajectory in body composition measures from rural to urban Kenyan and then to contemporary living Canadian children supporting the premise that urbanization and thus adoption of a more 'Western' lifestyle leads to less favourable

Table II. Aerobic fitness. *= significant gender difference, a = significant >UKEN (significance defined as $p < 0.05$).

	RKEN		UKEN	
	Boys	Girls	Boys	Girls
20 metre Shuttle Run (no. laps)	59.25 ± 2.52^{a}	$48.37 \pm 2.67^{a*}$	40.96 ± 2.46	$26.3 \pm 2.28^{*}$
Maximal shuttle run speed (km/h)	11.65 ± 0.13^{a}	$11.11 \pm 0.14^{a*}$	10.66 ± 0.13	$9.87 \pm 0.12^{*}$
Estimated VO_{2max} (ml/kg/min)	52.75 ± 0.66^{a}	$50.13 \pm 0.70^{a*}$	47.85 ± 0.64	$44.04 \pm 0.59^{*}$

body composition profiles. Data related to physical activity levels and sedentary behaviours (television (TV), video games) in UKEN versus RKEN children is reported elsewhere (24), but do indicate that UKEN children participate in more sedentary behaviour than their RKEN counterparts. However, TV and video games are not unfamiliar in the RKEN environment as many of the children do report time spent watching TV or playing video games. As we have seen in contemporary living populations, the availability of such sedentary pastimes will likely replace more active ones as electricity and other similar amenities become more available to the RKEN population.

Strength and flexibility

Given the typical lifestyle related activities (traveling to collect water, manual harvesting chores, shuttling cattle etc.) associated with rural living in Kenya, we had anticipated that these children would have been stronger than their urban counterparts. Paradoxically we found that grip strength was actually lower in the rural Kenyan population, even when adjusted for body size, compared with that measured in the urban children and the contemporary and traditionally living Canadian populations.

Aerobic fitness

While this is not the first report of Kenyan boys having high measured VO_2max levels (25), the observation that aerobic fitness was significantly greater in RKEN (boys and girls) compared with UKEN, as demonstrated by the number of shuttle laps completed, estimated VO_2max, and maximal speed attained, is new. This study was not designed to address why this phenomenon takes place but we would hypothesize that the greater aerobic fitness is likely due to preservation of a more traditional and active lifestyle and less reliance on automobile transport and avoidance of a sedentary lifestyle. In comparison to worldwide data RKEN children score higher on average than any other country where data are available while UKEN children appear average (see Table IV). It is important to note that the exercise values obtained in rural Kenyan children likely underestimate aerobic fitness. Exercise testing was conducted at approximately 8 000 feet of altitude. Moreover, the children studied in this investigation were all natives to high altitude and we are unable to ascertain with any certainty what their sea-level aerobic fitness would be, or what is the effect of life-long acclimatization.

Data from the 2003 Kenya Demographic and Health Survey, carried out by the Central Bureau of Statistics in partnership with the Ministry of Health and the National Council for Population and Development (26), indicates that approximately 90% of children between 6 and 15 years of age attend school. Attendance is not different between rural and urban schools or between boys and girls. However, the dress code differs significantly between boys and girls, with girls wearing dresses or skirts in both urban and rural environments. This difference in dress code may impede regular participation in physical activity outside of scheduled physical education lessons and thus may contribute to the differences in body composition and fitness variables between girls and boys; however, would not account for the differences between rural and urban environments as the uniforms worn by girls were similar in both locales. Traditionally there have been gender differences in the encouragement or acceptability of physical activity but considerable progress has been made regarding gender equity in Kenyan schools and we would not expect female students to receive less support for engaging in physical activity. It must be mentioned that strong socio-cultural beliefs do exist in many developing countries that perceive obesity, or "roundness", as something to be revered and a sign of wealth and prestige. Kenya, like many other African nations, is experiencing these challenges and such beliefs may exacerbate the fight against the physical activity transition and commensurate rise in childhood obesity.

Methodological limitations

This study is not without limitations. We relied on a relatively small, convenience sample, as was described in the methods section. While we cannot interpret this as representative of the country as a whole, there is no reason to believe that the urban and rural schools (both private and public) tested would be

Table III. Static strength and flexibility. *= significant gender difference, a = sign. <RKEN, RSK & USK, b = significant <RSK (significance defined as $p < 0.05$).

	RKEN		UKEN		RSK		USK	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Strength								
Handgrip (kg/kg body weight)	0.99 ± 0.04[a]	0.93 ± 0.04[a]	1.13 ± 0.04	0.92 ± 0.04[a*]	1.24 ± 0.03	1.14 ± 0.03*	1.12 ± 0.04	0.99 ± 0.03[a*]
Flexibility								
Sit-and-reach (cm)	25.71 ± 0.95	31.04 ± 0.99 [b*]	24.86 ± 0.93	25.85 ± 0.88[a]	26.66 ± 0.72	32.22 ± 0.65*	26.92 ± 0.86	31.35 ± 0.81*

Table IV. Twenty metre shuttle run performance indices for various countries adapted from Olds et al. (37). Performance index = mean age- and sex-specific maximal speed z-scores, n = sample size. A z-score of 0 indicates that the maximal speed equals the mean. A positive z-score indicates that the maximal speed is greater than the mean and a negative z-score indicates that the maximal speed is less than the mean.

Country	n	Performance index
Rural Kenya	81	0.918
Urban Kenya	98	−0.113
Cote d'Ivoire (Africa)	3 881	0.292
Benin (Africa)	5 280	0.117
Senegal (Africa)	3 023	0.033
Djibouti (Africa)	1 784	0.016
South Africa (Africa)	1 230	0.040
Canada (North America)	13 474	0.245
USA (North America)	1 878	−0.620
France (Europe)	11 301	0.266
UK (Europe)	6 333	−0.046
Australia	82 129	−0.201
Japan (Asia)	95 763	0.216
Singapore (Asia)	104	−0.867

significantly different from those in other regions in Kenya. While every attempt was made to ensure that measurements were made in an accurate and reliable fashion, the assessments were made in a field setting without the tight control of a laboratory setting. Few schools in Kenya have a gymnasium, thus the aerobic fitness testing was performed outdoors in the schoolyard on the flattest surface available. Given the measures were made outdoors we were unable to control temperature or humidity; however, these environmental conditions were not drastically different between locations and were customary in these regions.

Perspectives

Life in many developing nations is undergoing rapid change, and although technologies, such as computers, the internet, satellite TV, and cell phones, took decades to permeate North American society, all of these 'electronic age' items are becoming available very quickly in Kenya. Our findings, as well as those from other groups, indicate that urban environments appear particularly threatened (7,27). In fact, data from other African nations have also illustrated a significant rise in childhood obesity, particularly in urban centres (16,28) and these in addition to trends from the adult population (16,29–31) imply that the environmental and societal conditions exist for developing nations, such as Kenya, which has a virtually identical population as Canada, to experience a public health dilemma unlike those generally seen in developed nations. They will be forced to cope with the double burden of a greater infectious disease load (i.e., HIV/AIDS: 1 million in Kenya (32) versus

65 000 in Canada (33), and malaria affecting 20 million Kenyans annually (34) vs. <400 Canadians annually (35)), in addition to chronic disease (obesity, diabetes, heart disease, among others). Given the frequently publicized fledgling public health care systems and commonly reported shortage of medical specialists in developing countries (36), prevention strategies are of paramount importance to reduce the predicted detrimental impact of a chronic disease epidemic.

Acknowledgments

This study was supported by an International Opportunities Partnership grant from the Canadian Institutes of Health Research, Institute of Nutrition, Metabolism and Diabetes (OPD–83181). The authors wish to extend thanks to all of the school children who enthusiastically participated in this study. We must also acknowledge the great support and co-operation of the Head teachers, as well as the Physical Education and Games teachers from each of the data collection sites. We are grateful to both Wilfred Bungei and Philip Boit for their assistance in liaising with the rural Kenyan schools. We acknowledge Wai-May Wong for her assistance with the database design and data entry. Finally, we acknowledge the effort of the students from Kenyatta University, Department of Exercise, Recreation and Sport Science who volunteered to help with data collection at the urban sites.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Omran AR. The epidemiologic transition. A theory of the epidemiology of population change. Milbank Mem Fund Q. 1971;49(4):509–38.
2. WHO. The World Health Report 2002 - Reducing Risks, Promoting Healthy Life. Geneva: WHO; 2002.
3. Reddy KS. Cardiovascular disease in non-Western countries. N Engl J Med. 2004;350(24):2438–40.
4. Raymond SU, Leeder S, Greenberg HM. Obesity and cardiovascular disease in developing countries: a growing problem and an economic threat. Curr Opin Clin Nutr Metab Care. 2006;9(2):111–6.
5. Popkin BM. The nutrition transition: an overview of world patterns of change. Nutr Rev. 2004;62(7 Pt 2):S140–3.
6. Abubakari AR, Bhopal RS. Systematic review on the prevalence of diabetes, overweight/obesity and physical inactivity in Ghanaians and Nigerians. Public Health. 2008;122(2): 173–82.
7. Abubakari AR, Lauder W, Jones MC et al. Prevalence and time trends in diabetes and physical inactivity among adult West African populations: the epidemic has arrived. Public Health. 2009;123(9):602–14.
8. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. 2000. Report No.: 894.
9. Hossain P, Kawar B, El NM. Obesity and diabetes in the developing world—a growing challenge. N Engl J Med. 2007;356(3):213–5.
10. Africa struggles with the double burden of obesity and under nutrition. The Daily Nation 2009 Oct 10.
11. Ang'awa M. Prevent obesity in your child. The East Africa Standard Sunday Magazine. 1-3-2009.
12. Gathura G. Obesity in Kenyan schools. The Daily Nation 2009 Jun 8.
13. Njung'e C. How junk food is creating colony of overweight children. The Daily Nation 2009 Sep 15.
14. Abubakari AR, Lauder W, Agyemang C et al. Prevalence and time trends in obesity among adult West African populations: a meta-analysis. Obes Rev. 2008;9(4):297–311.
15. Bovet P, Chiolero A, Madeleine G et al. Marked increase in the prevalence of obesity in children of the Seychelles, a rapidly developing country, between 1998 and 2004. Int J Pediatr Obes. 2006;1(2):120–8.
16. Oulamara H, Nacer AA, Laure FM. Changes in the prevalence of overweight, obesity and thinness in Algerian children between 2001 and 2006. Int J Pediatr Obes. 2008;1–3.
17. Nyaruhucha CN, Achen JH, Msuya JM et al. Prevalence and awareness of obesity among people of different age groups in educational institutions in Morogoro, Tanzania. East Afr Med J. 2003;80(2):68–72.
18. Tremblay MS, Barnes JD, Copeland JL et al. Conquering childhood inactivity: is the answer in the past? Med Sci Sports Exerc. 2005;37(7):1187–94.
19. Canadian Society for Exercise Physiology. The Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA). 3rd ed. Ottawa: Canadian Society for Exercise Physiology; 2003.
20. Tomkinson GR, Olds TS. Field tests of fitness. In: Armstrong N, van Mechelen W, editors. Paediatric Exercise Science and Medicine. Oxford: Oxford University Press; 2008. p. 109–28.
21. Tomkinson GR, Olds TS. Secular changes in pediatric aerobic fitness test performance: the global picture. Med Sport Sci. 2007;50:46–66.
22. Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240–3.
23. Leger LA, Mercier D, Gadoury C et al. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci. 1988; 6(2):93–101.
24. Onywera VO, Adamo KB, Sheel AW et al. Emerging evidence of the physical activity transition in Kenya. Journal of Physical Activity and Health (submitted). 2010.
25. Saltin B, Larsen H, Terrados N et al. Aerobic exercise capacity at sea level and at altitude in Kenyan boys, junior and senior runners compared with Scandinavian runners. Scand J Med Sci Sports. 1995;5(4):209–21.
26. Central Bureau of Statistics (CBS) MoHMaOM. Kenya Demographic and Health Survey 2003. Calverton, Maryland; 2004.
27. Sobngwi E, Mbanya JC, Unwin NC et al. Exposure over the life course to an urban environment and its relation with obesity, diabetes, and hypertension in rural and urban Cameroon. Int J Epidemiol. 2004;33(4):769–76.
28. Chiolero A, Paradis G, Madeleine G et al. Discordant secular trends in elevated blood pressure and obesity in children and adolescents in a rapidly developing country. Circulation. 2009;119(4):558–65.
29. Kelly T, Yang W, Chen CS et al. Global burden of obesity in 2005 and projections to 2030. Int J Obes (Lond). 2008; 32(9):1431–7.

30. Ziraba AK, Fotso JC, Ochako R. Overweight and obesity in urban Africa: A problem of the rich or the poor? BMC Public Health. 2009;9:465.
31. Christensen DL, Eis J, Hansen AW et al. Obesity and regional fat distribution in Kenyan populations: impact of ethnicity and urbanization. Ann Hum Biol. 2008;35(2):232–49.
32. Cheluget B, Baltazar G, Orege P et al. Evidence for population level declines in adult HIV prevalence in Kenya. Sex Transm Infect. 2006;82 Suppl 1:i21–6.
33. Public Health Agency of Canada. Estimates of HIV Prevalence and Incidence in Canada; 2008.
34. Lindblade KA, Eisele TP, Gimnig JE et al. Sustainability of reductions in malaria transmission and infant mortality in western Kenya with use of insecticide-treated bednets: 4 to 6 years of follow-up. JAMA. 2004;291(21): 2571–80.
35. Berrang-Ford L, Maclean JD, Gyorkos TW et al. Climate change and malaria in Canada: a systems approach. Interdiscip Perspect Infect Dis. 2009;2009:385487.
36. Kuehn BM. Global Shortage of Health Workers, Brain Drain Stress Developing Countries. JAMA. 2007;298: 1853–5.
37. Olds T, Tomkinson G, Leger L et al. Worldwide variation in the performance of children and adolescents: an analysis of 109 studies of the 20-m shuttle run test in 37 countries J Sports Sci. 2006;24(10):1025–38.