Published in final edited form as:
J Epidemiol Community Health. 2018 June ; 72(6): 484–490. doi:10.1136/jech-2017-210258.

A secular change in the association between urbanization and abdominal adiposity in China (1993 – 2011)

Yosuke Inoue[1], **Annie Green Howard**[1,2], **Amanda L. Thompson**[1,3,4], and **Penny Gordon-Larsen**[1,4]

[1]Carolina Population Center, The University of North Carolina at Chapel Hill, NC, USA

[2]Department of Biostatistics, Gillings School of Global Public Health, The University of North Carolina at Chapel Hill, NC, USA

[3]Department of Anthropology, The University of North Carolina at Chapel Hill, NC, USA

[4]Department of Nutrition, Gillings School of Global Public Health, The University of North Carolina at Chapel Hill, NC, USA

Abstract

Background—Little attention has been paid to how the association between urbanization and abdominal adiposity changes over the course of economic development in low- and middle-income countries.

Methods—Data came from the China Health and Nutrition Survey wave 1993 to 2011 (7 waves). A mixed linear model was used to investigate the association between community-level urbanization with waist-to-height ratio (WHtR; an indicator of abdominal adiposity). We incorporated interaction terms between urbanization and study waves to understand how the association changed over time. The analyses were stratified by age (children versus adults).

Results—Adult WHtR was positively associated with urbanization in earlier waves but became inversely associated over time. More specifically, a one-standard deviation [SD] increase in the urbanization index was associated with higher WHtR by 0.002 and 0.005 in waves 1993 and 1997 while it was associated with lower WHtR by 0.001 in 2011. Among child participants, the increase in WHtR over time was predominantly observed in more urbanized communities.

Correspondence to: Yosuke Inoue, 123 W Franklin St, Carolina Population Center, The University of North Carolina at Chapel Hill, NC, 27516, USA, yosuke.yoshi.yosky@gmail.com, telephone: 9195933765.

CONTRIBUTIONSHIP

All authors contributed to conception, design, and interpretation of data, YI contributed to data analysis, PGL contributed to the acquisition of data, YI drafted the manuscript, AGH, ALT, and PGL contributed to critical revision of the manuscript. YI and PGL had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and approved the final manuscript.

COMPETING INTEREST

None declared.

Conclusion—Our study suggests a shift in adult abdominal adiposity from more urbanized communities to less urbanized communities over a time of rapid economic development in China. Children living in more urbanized communities had higher increase in abdominal obesity with urbanization over time relative to children living in less urbanized communities.

Keywords

Epidemiology of chronic non communicable diseases; URBANISATION; OBESITY; LONGITUDINAL STUDIES; SOCIO-ECONOMIC

Introduction

In contrast to other low- and middle-income countries (LMICs) where overweight/obesity increased predominantly in urban areas [1–5], China has presented a different picture, with higher obesity prevalence in rural versus urban communities [6]. In addition, Dearth-Wesley et al. [7] showed in China that during the period between 1991 and 2004 annual change in overweight prevalence was 14.2% per year among rural communities but 5.7% per year in urban communities, portending a future shift in the burden of obesity-related non-communicable diseases toward rural populations. This reversal of the association between urbanization and obesity, which was suggested to result from dietary change (i.e., transition to a high-fat and low-fiber diet) among low-income people living in rural communities [7], needs to be studied more extensively in order to better inform efforts to manage obesity and its complications.

Our study extends the previous studies on the association between urbanization and obesity in the following manner. First, instead of body mass index (BMI; a conventional indicator of obesity), we used waist-to-height ratio (WHtR), which is an indicator of abdominal adiposity that is directly comparable in youth and adults [8–10]; abdominal obesity is a major factor of metabolic syndrome (i.e., clustering of cardiovascular disease (CVD) risk factors) [11, 12] and its patterning in urban versus rural areas is not well understood. In addition, WHtR is particularly relevant to the Chinese population given the higher cardiometabolic risk at the same BMI in Asian compared to European populations [13]. Second, we focused on the time span of rapid economic development in China, which is critical as this economic growth has been accompanied by dramatic changes in lifestyles and disease profiles. Third, we used a continuous, multicomponent urbanization index that captured a range of urbanization-related changes across 12 dimensions, which enabled us to capture a more nuanced definition of urbanization than a simple rural-urban dichotomy [14].

To address these gaps, our objective was to investigate the association between the community-level urbanization and WHtR from 1993 to 2011 using longitudinal data from the China Health and Nutrition Survey (CHNS). We used a mixed linear model accounting for multiple individuals within communities and multiple measurements for individuals by including random intercepts at both the individual and community levels.

METHODS

China Health and Nutrition Survey

The CHNS is an ongoing longitudinal cohort study that collects data in 228 communities across nine provinces in China (North: Heilongjiang, Liaoning; Central: Shandong, Henan, Jiangsu; South: Hunan, Hubei, Guangxi, Guizhou) in ten survey rounds from 1989 – 2015 [15]. Using a multistage, random cluster design, a stratified probability sample was used to select study communities; after choosing two cities (urban; one large and one small city) and four counties (rural; stratified by income [one high, two middle and one low income counties] using State Statistical Office definitions [16]) in each province, communities were randomly selected from each city/county, followed by random selection of household within each community. We used questionnaires to collect demographic, socioeconomic, behavioral, and health information from each household member. Details on the survey procedures are described previously [17]. The study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill, the China-Japan Friendship Hospital, Ministry of Health, and the National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention. Subjects gave informed consent for participation.

As waist circumference was collected since wave 1993, we confined our analyses to the 7 waves during the period between 1993 and 2011 (i.e., the latest wave from which data has been released) (Figure 1). While we collected information from individuals aged 2 and older, we determined in preliminary analyses that the meaning of WHtR was different among children at the age of 7 or younger as their WHtR was dependent on height (See Supplementary Figure 1), therefore we dropped children when they were 7 years or younger from the analysis (8,416 observations). When they were aged 60 years old and above, individuals were excluded to avoid age-related body composition changes with aging (i.e., height shrinkage and sarcopenia [18]) (18,748 observations). We then excluded participants who resided in three megacities (i.e., Beijing, Shanghai and Chongqing; n = 3,262) since they newly joined the survey in 2011 and we did not have longitudinal measures on these individuals. We further excluded participants who did not have anthropometric data (waist circumference and height measures) (37,093 observations) and whose data were deemed outliers (n = 1,429; described below). In the end, we had analytic sample of 16,738 adults living in 238 communities with 46,665 observations and 5,653 children living in 237 communities with 9,423 observations.

Dependent variables

Waist circumference (measured twice at the midway between the lowest rib and the iliac crest using a tape measure) and height (measured in triplicate using stadiometer) were used to calculate WHtR (waist cm/height cm). Outliers were identified by the following procedure: first, we used a bivariate method, which calculates Mahalanobis distance to identify outliers, in relation to WHtR and height (‘hadimvo’ script in Stata [19]) (20 observations). We then excluded those with WHtR and height which exceeded a threshold of +/−4SD at given combination of age (in years) and sex (92 observations). Finally, we calculated intra-individual difference in height and identified the outliers (i.e., an increase by 10cm after the age of 25 and a decrease by 10 cm at any age range) (1,429 observations).

Explanatory variables

We used a 12-component urbanization index, which was previously validated to capture the degree of urbanization in the study communities (reliability across study waves [Cronbach's Alpha]: 0.85 – 0.89; validity: 0.75 – 0.78) [14]. We included the following 12 components in the development of the urbanization index; population density; types of economic activity; traditional market; modern markets; transportation and infrastructure; sanitation; communications; housing; education; diversity; health infrastructure; and social services (Supplementary Table 1 for more detailed descriptions) [14]. The score, which theoretical ranges from 0 to 120, was available in each community and in each study wave; it was standardized to a mean of 0 and a standard deviation (SD) of 1. We used study years as a categorical variable (1993 to 2011).

Covariates included: age (in years), sex (male and female), education (graduated from primary school or less; graduated from junior high school; graduated from high school; and attained further education), and annual household income per capita inflated to 2011 value (categorized into tertiles). Educational status among younger participants (i.e., 25 years or younger) was replaced with that of the household member who attained highest educational status.

Statistical analysis

We calculated means and standard deviations for continuous measures and percentages for categorical measures at each wave. We used a mixed model to investigate the association between the community-level urbanization index and WHtR (continuous) while accounting for multiple individuals within a community and multiple measurements for an individual by including random intercepts at both the individual and community levels. We incorporated the interaction term between the urbanization index and study years to understand how the associations between urbanization and abdominal adiposity changed across study years. We stratified the analyses by children and adults (i.e., 7 – 17.99 years/18 – 59.99 years), accounting for possible differences in determinants and distribution of abdominal adiposity between these groups [20]. Models were adjusted for age, sex, education and household income. If information was missing for any of the covariates, we created a "missing" category and included it in the analysis to keep statistical power.

To interpret our model-based finings, we then calculated predicted values for WHtR at given combination of urbanization index (i.e., from −2 SD to 2 SD at an interval of 1 SD) and study years while holding the covariates at their mean values [21]. We also tested wave-to-wave differences in the direction of interaction terms to identify when the association between urbanization and WHtR changed.

To test the robustness of the study findings, we conducted a set of sensitivity analyses that investigated the association while confining our study participants to individuals who participated multiple times. Six analyses (from twice or more to all seven waves) and two analyses (from twice or more to three or more waves) were conducted for adult participants and child participants, respectively. All statistical analyses were conducted using Stata 14.0 (College Station, TX). The level of statistical significance was set to $p < 0.05$ for main effects and $p < 0.10$ for interaction (two-tailed).

RESULTS

Descriptive statistics for the study participants are shown in Table 1. Mean WHtR increased over time among adults, which is also illustrated in Figure 2. In contrast, WHtR fluctuated over time among children.

Table 2 shows the results of a mixed liner regression model investigating the associations between urbanization and WHtR in adults. The directions of the associations between urbanization and WHtR in later periods differed from that of wave 1993, as suggested by positive urbanization-by-study wave interactions in waves 1997 ($p = 0.001$) and 2000 ($p = 0.008$) and inverse urbanization-by-study wave interactions in waves 2009 ($p = 0.001$) and 2011 ($p < 0.001$). We also found statistically significant differences in the interaction between waves 1993 and 1997 ($p < 0.001$), waves 2000 and 2004 ($p < 0.001$) and waves 2006 and 2009 ($p = 0.039$) (Supplementary Table 2).

To facilitate interpretation of our model-based findings, we predicted WHtR values using model coefficients at specified combinations of urbanization index values and study wave (Figure 3 and Supplementary Table 3). We found that a one-SD increase in the urbanization index was associated with an increased WHtR by 0.002, 0.005 and 0.004 (waist cm/height cm) in 1993, 1997 and 2000, respectively, while urbanization was associated with a decrease in WHtR by 0.001 and 0.001 waist cm/height cm in 2009 and 2011, respectively. During the period between 1993 to 2011, predicted WHtR of individuals living in less urbanized communities (one SD below the mean) changed from 0.475 to 0.509 and those of more urbanized community (one SD above the mean) changed from 0.478 to 0.475.

In children, the urbanization index was inversely associated with WHtR in earlier waves while it reversed in later waves. More specifically, one-SD increase in the urbanization index was associated with a lower WHtR by 0.005 in 1993 while it was associated with a slightly higher WHtR (i.e., 0.002) in 2011 (Figure 3, right panel). Children from less urbanized areas (one SD below the mean), WHtR changed from 0.429 in 1993 to 0.435 in 2011. In more urbanized communities (one SD below the mean), WHtR changed from 0.417 in 1993 and 0.438 in 2011.

When we confined the analytical sample by specified numbers of survey visits that participants contributed data to the models, we found that our central findings for the association between urbanization and WHtR over time did not substantially differ by the number of survey visits by respondents (Supplementary Figures 2 (adults) and 3 (children)). More specifically, in adults, the initial increase in abdominal adiposity was observed in more urbanized communities, followed by the increase in abdominal adiposity in less urbanized communities which eventually caught up with the level of more urbanized communities. In children, the increase in abdominal adiposity during the period was observed more in urban environments than in rural environments.

DISCUSSION

Summary of findings

Using data from the China Health and Nutrition Survey waves 1993 to 2011, we showed that the direction of the associations between urbanization and abdominal adiposity changed during this period. More specifically, in adults, a higher urbanization index was linked with a higher abdominal adiposity in earlier waves while it was associated with a lower abdominal adiposity in the more recent waves. In children, abdominal adiposity increased predominantly in more urbanized communities over time.

Adult participants

Mean WHtR increased from 0.469 in 1993 to 0.513 in 2011. Given that the established cut-point of 0.5 has been proposed as an international indicator of abdominal obesity [22, 23] which has been also used in China [9], our findings suggest that a substantial portion of the population has a WHtR in the range of abdominal obesity. The change we observed (i.e., an increase of 0.044) is concerning given that previous research in China [24] showed that an increase in WHtR by 0.05 – 0.06 was associated with statistically significant higher odds in the range of 1.74 to 2.57 of several cardiometabolic diseases. Furthermore, when we look at changes in WHtR over time (as we showed in Figure 3), we see that abdominal adiposity increased predominantly in more urbanized communities between 1993 and 2004, whereas WHtR increased in rural communities between 2006 and 2011, essentially showing that abdominal obesity in rural communities caught up to match and then increase beyond the average WHtR in more urbanized communities.

The pattern of association we observed in the current study (i.e., reversal of the association between urbanization and abdominal adiposity over time) may have resulted from the comparatively greater decline in physical activity in less (versus more) urbanized communities which was reported in previous literature. Specifically, Attard et al. [25] examined temporal changes in physical activity using the CHNS data during the period between 1991 and 2009 and showed that physical activity decline was larger among individuals living in less urbanized communities compared to those in more urbanized communities. The Attard paper showed that physical activity declined from 500 to 300 MET-hours/week in communities within the lowest tertile of the urbanization index, while PA declined from 200 and 125 MET-hours/week in communities in the highest urbanization tertile, potentially due to the decline in occupational labor [26].

The growing trend in abdominal obesity in adults living in less urbanized communities might relate to changes in diet with urbanization. For example, Zhai et al. [27] found an increase in consumption of animal-source foods and away-from-home foods as well as an increase in less healthy cooking methods, such as frying and cooking with oil. Zhai et al also found that the daily consumption of edible oil among adults was higher in more urbanized communities than in less urbanized communities in 1991 (26.8 vs. 21.1 grams) but became equivalent in 2011 (29.7 vs. 29.8 grams). In addition, during the same period, the proportion of energy contributed by food-away-from-home increased from 2.9 to 16.4% in less urbanized communities while it increased from 14.4 to 20.5% in more urbanized communities.

Our findings suggest that increased abdominal obesity is a growing concern for public health officers and researchers since more than 40% of the Chinese population lives in the rural areas [28]. The cardiometabolic consequences of this increase would be exacerbated if access to the medical and social system and health-related knowledge remain poor in those rural areas over time [29, 30]. To avoid a widening of the urban-rural health disparity in China, policy and intervention efforts are needed to reverse the observed trends in abdominal adiposity.

In a study of 38 low- and middle-income countries during the period between 1991 and 2004, Neuman et al. [31] found that rural-urban difference in BMI was driven by differences in SES in low- and middle-income countries. In the current paper, we found that the association between urbanization and abdominal adiposity changed across study period after adjusting for education and household income, thus reflecting other sources of urbanization-related changes that were associated with abdominal obesity beyond income and education.

Child participants

In contrast with adults, the average WHtR of child participants in our study did not exceed the abdominal obesity cut-offs for children aged 7–17 years in China (i.e., 0.47 for boys and 0.45 for girls)[10], abdominal obesity was comparatively lower in children than adults. However, rapid increases in mean WHtR for children living in more urbanized communities call attention to the potential for future cardiometabolic risk. Our current findings are in line with previous research that reported urbanization is positively associated with an increase in childhood obesity in China [32, 33]. Future study should focus on how this increase in the child obesity in more urbanized communities will be linked with the urbanization-obesity association in the future when they grow up.

In our study, the associations between urbanization and WHtR were inverse in the earlier study waves. These inverse associations may be due to the taller heights of children living in more urbanized communities compared to children in less urbanized communities (data not shown), and not because of lower waist circumference in urban children compared to their rural counterparts. Zong et al. [34] reported based on the Chinese National Survey on Students Constitution and Health that obesity prevalence in urban areas was higher than in rural areas during the period between 1985 to 2010. In less urbanized communities, waist circumference increased in proportion to height while in more urbanized communities, waist circumference increased at a higher pace than height so that WHtR of urban children outpaced that of rural children.

Limitations

There are several limitations to our study. First, there are several variables that would have explained the secular change in the association between urbanization and WHtR, e.g., energy balance. While we have information on estimated energy consumption and physical activity level based on a 3-day dietary recall and a physical activity questionnaire [27, 35], they cannot be used to measure energy balance. Second, there were participants who did not attend every survey wave while this is inevitable given the nature of long-term population-based studies. To check the robustness of our study findings we confined our analytic samples to participants who attended multiple times and confirmed that our results did not change. We also confirmed that there were no clear differences in the pattern of the variables between those who stayed longer in the survey and those who dropped earlier.

CONCLUSION

Our longitudinal study in China during the period between 1993 and 2011 suggests that the association between urbanization and central obesity was positive in earlier waves while it reversed in the more recent waves in adults. In children, the increase in central obesity was predominantly observed in more urbanized communities. Future studies should focus on whether abdominal obesity will continue to increase in more remote areas of China where medical and social systems remain less available.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank the National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention, the Carolina Population Center, the University of North Carolina at Chapel Hill and all the people involved in the China Health and Nutrition Survey. Y.I. was financially supported by the Nippon Foundation International Fellowship Program (http://http://intl-fellow.jp/en/).

FUNDING

This work was supported by the National Institute of Diabetes and Digestive and Kidney Diseases (R01-DK104371), the National Heart, Lung, and Blood Institute (R01-HL108427) and uses data from China Health and Nutrition Survey (CHNS), funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R01-HD30880), although no direct support was received from grant for this analysis. We thank the National Institute of Nutrition and Health, China Center for Disease Control and Prevention, the NIH (DK056350 and R01-HD38700) and the Fogarty NIH grant 5 D43 TW009077 for financial support for the CHNS data collection and analysis files from 1989 to 2011 and future surveys. We also are thankful to general support from the Carolina Population Center (P2C HD050924), the University of North Carolina at Chapel Hill. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

1. Allender S, Foster C, Hutchinson L, et al. Quantification of Urbanization in Relation to Chronic Diseases in Developing Countries: A Systematic Review. J Urban Health. 2008; 85:938–51. [PubMed: 18931915]
2. Monteiro CA, Conde WL, Lu B, et al. Obesity and inequities in health in the developing world. Int J Obesity. 2004; 28:1181–6.
3. Patel SA, Narayan KM, Cunningham SA. Unhealthy weight among children and adults in India: urbanicity and the crossover in underweight and overweight. Ann Epidemiol. 2015; 25:336–41. e2. [PubMed: 25795227]
4. Mohan I, Gupta R, Misra A, et al. Disparities in Prevalence of Cardiometablic Risk Factors in Rural, Urban-Poor, and Urban-Middle Class Women in India. PLoS One. 2016; 11:e0149437. [PubMed: 26881429]
5. 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; 35:232–49. [PubMed: 18428015]

6. Zhang YW, Wang JH, Zhi XL, et al. An epidemiological investigation on overweight and obesity in adults from Tianjin city. Zhonghua liuxingbingxue zazhi. 2009; 30:1147–51. [PubMed: 20193584]
7. Dearth-Wesley T, Wang H, Popkin B. Under-and overnutrition dynamics in Chinese children and adults (1991–2004). Eur J Clin Nutr. 2008; 62:1302–7. [PubMed: 17637598]
8. Li WC, Chen IC, Chang YC, et al. Waist-to-height ratio, waist circumference, and body mass index as indices of cardiometabolic risk among 36,642 Taiwanese adults. Eur J Nutr. 2013; 52:57–65. [PubMed: 22160169]
9. Shao J, Yu L, Shen X, et al. Waist-to-height ratio, an optimal predictor for obesity and metabolic syndrome in Chinese adults. J Nutr Health Aging. 2010; 14:782–5. [PubMed: 21085910]
10. Zhou D, Yang M, Yuan ZP, et al. Waist-to-Height Ratio: a simple, effective and practical screening tool for childhood obesity and metabolic syndrome. Prev Med. 2014; 67:35–40. [PubMed: 24967955]
11. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. J Clin Endocrinol Metab. 2008; 93:S9–30. [PubMed: 18987276]
12. Gu DF, Reynolds K, Wu XG, et al. Prevalence of the metabolic syndrome and overweight among adults in China. Lancet. 2005; 365:1398–405. [PubMed: 15836888]
13. Gordon-Larsen P, Adair LS, Meigs JB, et al. Discordant risk: overweight and cardiometabolic risk in Chinese adults. Obesity (Silver Spring, Md). 2013; 21:E166–74.
14. Jones-Smith JC, Popkin BM. Understanding community context and adult health changes in China: Development of an urbanicity scale. Soc Sci Med. 2010; 71:1436–46. [PubMed: 20810197]
15. Popkin BM, Du S, Zhai F, et al. Cohort Profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. Int J Epidemiol. 2010; 39:1435–40. [PubMed: 19887509]
16. National Bureau of Statistics of China. China Statistical Yearbook. Beijing: China Statistics Press; 2007.
17. Popkin, BM. The implications of the nutrition transition for obesity in the developing world. In: Crawford, D.Ball, K., Brug, J., editors. Obesity Epidemiology: From Aetiology to Public Health. Oxford: Oxford University Press; 2010. p. 136-42.
18. Zamboni M, Mazzali G, Zoico E, et al. Health consequences of obesity in the elderly: a review of four unresolved questions. Int J Obesity. 2005; 29:1011.
19. Hadi AS. A modification of a method for the detection of outliers in multivariate samples. Journal of the Royal Statistical Society. Series B (Methodological). 1994:393–6.
20. Thompson AL, Houck KM, Adair L, et al. Multilevel examination of the association of urbanization with inflammation in Chinese adults. Health Place. 2014; 28:177–86. [PubMed: 24908386]
21. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. Stata J. 2012; 12:308–31.
22. Ashwell M, Gunn P, Gibson S. Waist−to−height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta−analysis. Obes Rev. 2012; 13:275–86. [PubMed: 22106927]
23. Schneider HJ, Friedrich N, Klotsche J, et al. The predictive value of different measures of obesity for incident cardiovascular events and mortality. J Clin Endocrinol Metab. 2010; 95:1777–85. [PubMed: 20130075]
24. Zeng Q, He Y, Dong S, Zhao X, Chen Z, Song Z, Chang G, Yang F, Wang Y. Optimal cut-off values of BMI, waist circumference and waist: height ratio for defining obesity in Chinese adults. Brit J Nutr. 2014; 112(10):1735–1744. [PubMed: 25300318]
25. Attard SM, Howard AG, Herring AH, et al. Differential associations of urbanicity and income with physical activity in adults in urbanizing China: findings from the population-based China Health and Nutrition Survey 1991–2009. Int J Behav Nutr Phys Act. 2015; 12:152. [PubMed: 26653097]
26. Yao C, Huang L, Lü X, et al. Temporal and spatial change of cultivated land use intensity in China based on emergy theory. Transactions of the Chinese Society of Agricultural Engineering. 2014; 30:1–12.
27. Zhai FY, Du SF, Wang ZH, et al. Dynamics of the Chinese diet and the role of urbanicity, 1991–2011. Obes Rev. 2014; 15(Suppl 1):16–26. [PubMed: 24341755]

28. World Bank. World Bank Open Data [Internet]. World Bank; 2018. https://data.worldbank.org/ [accessed Jan 26, 2018]
29. Tang SL, Meng QY, Chen L, et al. Health System Reform in China 1 Tackling the challenges to health equity in China. Lancet. 2008; 372:1493–501. [PubMed: 18930531]
30. Liu YL, Rao KQ, Wu J, et al. Health System Reform in China 7 China's health system performance. Lancet. 2008; 372:1914–23. [PubMed: 18930536]
31. Neuman M, Kawachi I, Gortmaker S, et al. Urban-rural differences in BMI in low-and middle-income countries: the role of socioeconomic status. Am J Clin Nutr. 2013 ajcn. 045997.
32. Zhang YX, Zhao JS, Chu ZH, et al. Prevalence and regional disparities in abdominal obesity among children and adolescents in Shandong, China, surveyed in 2010. Ann Nutr Metab. 2014; 64:137–43. [PubMed: 25074718]
33. Xu F, Li J, Liang Y, et al. Residential density and adolescent overweight in a rapidly urbanising region of Mainland China. J Epidemiol Community Health. 2010; 64:1017–21. [PubMed: 19858540]
34. Zong XN, Li H. Physical growth of children and adolescents in China over the past 35 years. Bull World Health Organ. 2014; 92:555–64. [PubMed: 25177070]
35. Ng SW, Howard AG, Wang HJ, et al. The physical activity transition among adults in China: 1991–2011. Obes Rev. 2014; 15:27–36.

What is already know on this subject?

- Urbanization is associated with an increase in overweight and obesity, particularly in low- and middle-income countries, but less is known about the changes in abdominal adiposity.

What this study adds

- In China, abdominal adiposity has increased more rapidly and became higher in adults living in less urbanized communities compared to individuals in more urbanized communities during the period between 1993 and 2011.
- In children, more urbanized environment was associated with an increase in abdominal adiposity.

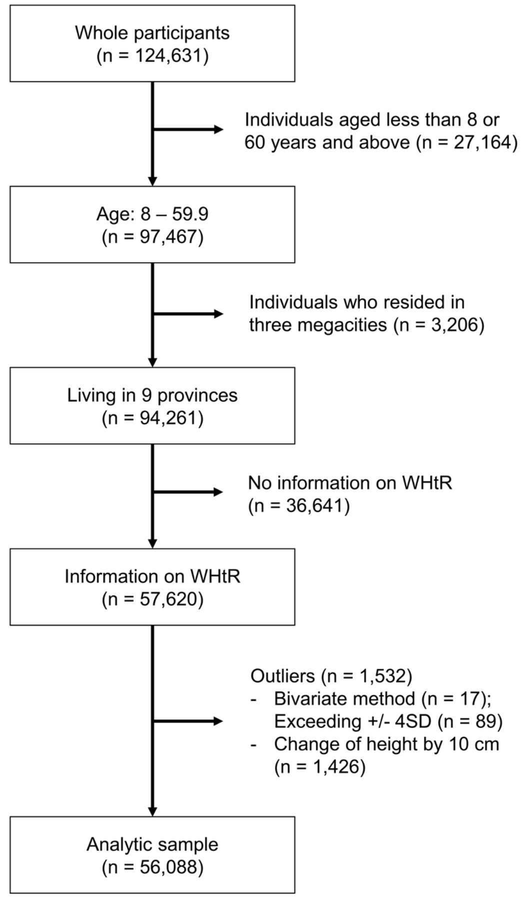

Figure 1.
Participants in the 7 waves of the China Health and Nutrition Survey in China (1993 to 2011).

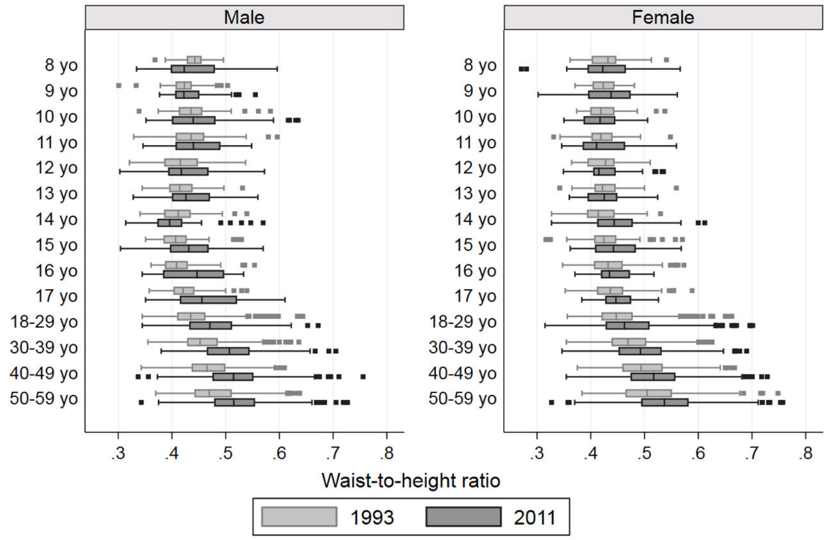

Figure 2.

Box plots of waist-to-height ratio shown by sex, age category and wave in China (1993 and 2011).

Each boxplot shows the median and 25th and 75th percentile values by given age-sex category. The upper adjacent value was defined as the largest figure less than or equal to the 75th percentile values + 1.5 × interquartile range (IQR) and the lower adjacent value was defined as the smallest figure more than or equal to the 25th percentile values −1.5 × IQR. Dots represent participants whose waist-to-height ratio did not fall between the two adjacent values.

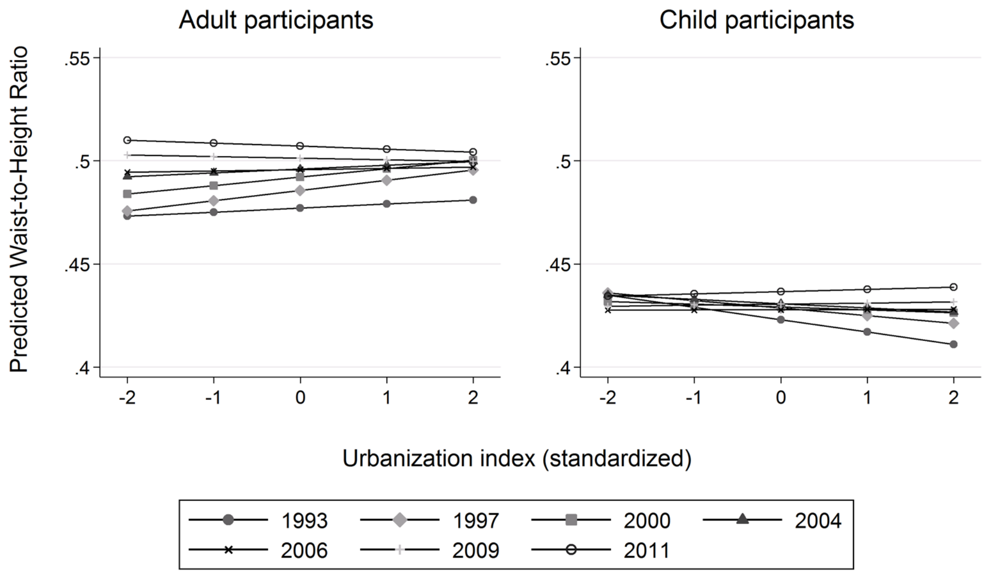

Figure 3.
Predicted waist-to-height ratios in relation to the degree of urbanization among study participants in the China Health and Nutrition Survey (1993 – 2011).
Waist-to-height ratios at given combination of urbanization index and study wave were predicted by age category (i.e., adult/child participants) while holding the covariates at their mean values.

Table 1

Basic characteristics of study participants of the China Health and Nutrition Survey (1993 – 2011), stratified by study wave and age group (adult and child participants)

Wave	1993	1997	2000	2004	2006	2009	2011
Adult participants	(n = 6416)	(n = 6644)	(n = 7357)	(n = 6826)	(n =6540)	(n = 6700)	(n = 6182)
Age, mean [SD]	37.1 [11.4]	38.1 [11.2]	39.6 [11.0]	42.0 [10.8]	42.8 [10.7]	43.2 [10.9]	44.1 [10.7]
Sex (Female), n (%)	3363 (52.4)	3395 (51.1)	3830 (52.1)	3568 (52.3)	3459 (52.9)	3534 (52.8)	3302 (53.4)
Education, n (%)							
Primary school or less	1498 (23.4)	1287 (19.4)	1049 (14.3)	839 (12.3)	976 (14.9)	892 (13.3)	719 (11.6)
Junior high school	1359 (21.2)	1475 (22.2)	1602 (21.8)	1504 (22.0)	1120 (17.1)	1150 (17.2)	1006 (16.3)
High school	2131 (33.2)	2193 (33.0)	2580 (35.1)	2489 (36.5)	2316 (35.4)	2617 (39.1)	2433 (39.4)
Attained further education	1368 (21.3)	1556 (23.4)	1977 (26.9)	1982 (29.0)	2113 (32.3)	2036 (30.4)	2016 (32.6)
Missing	60 (0.9)	133 (2.0)	149 (2.0)	12 (0.2)	15 (0.2)	5 (0.1)	8 (0.1)
Household Income, n (%) *(1)*							
Low	3686 (57.5)	2901 (43.7)	2569 (34.9)	1902 (27.9)	1625 (24.9)	970 (14.5)	714 (11.6)
Middle	2157 (33.6)	2793 (42.0)	3016 (41.0)	2347 (34.4)	2102 (32.1)	1837 (27.4)	1270 (20.5)
High	556 (8.7)	906 (13.6)	1657 (22.5)	2510 (36.8)	2707 (41.4)	3813 (56.9)	4103 (66.4)
Missing	17 (0.3)	44 (0.7)	115 (1.6)	67 (1.0)	106 (1.6)	80 (1.2)	95 (1.5)
Urbanization index, mean [SD] *(2)*	47.8 [16.3]	52.8 [18.2]	58.5 [18.3]	62.4 [20.0]	64.5 [20.1]	67.0 [19.2]	68.5 [18.6]
Waist-to-height ratio, mean [SD] *(3)*	0.469 [0.054]	0.479 [0.055]	0.489 [0.058]	0.498 [0.058]	0.499 [0.058]	0.506 [0.061]	0.513 [0.062]
Child participants	(n=1195)	(n=2057)	(n=2091)	(n=1324)	(n=1025)	(n=912)	(n=819)
Age, mean [SD]	13.6 [2.9]	12.5 [2.7]	12.9 [2.5]	13.2 [2.8]	12.8 [2.9]	12.5 [2.6]	12.4 [2.7]
Sex (Female), n (%)	586 (49)	964 (46.9)	983 (47)	627 (47.4)	495 (48.3)	405 (44.4)	403 (49.2)
Education, n (%)							
Primary school or less	29 (2.4)	43 (2.1)	10 (0.5)	12 (0.9)	26 (2.5)	20 (2.2)	27 (3.3)
Junior high school	201 (16.8)	234 (11.4)	218 (10.4)	143 (10.8)	120 (11.7)	112 (12.3)	118 (14.4)
High school	589 (49.3)	966 (47)	991 (47.4)	672 (50.8)	455 (44.4)	463 (50.8)	382 (46.6)
Attained further education	374 (31.3)	807 (39.2)	858 (41)	497 (37.5)	424 (41.4)	317 (34.8)	292 (35.7)
Missing	2 (0.2)	7 (0.3)	14 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Household income, n (%) *(1)*							
Low	766 (64.1)	1078 (52.4)	860 (41.1)	458 (34.6)	337 (32.9)	197 (21.6)	168 (20.5)

Wave	1993	1997	2000	2004	2006	2009	2011
Middle	347 (29)	761 (37)	865 (41.4)	489 (36.9)	350 (34.2)	299 (32.8)	221 (27)
High	82 (6.9)	200 (9.7)	326 (15.6)	356 (26.9)	319 (31.1)	402 (44.1)	416 (50.8)
Missing	0 (0.0)	18 (0.9)	40 (1.9)	21 (1.6)	19 (1.9)	14 (1.5)	14 (1.7)
Urbanization index, mean [SD] (2)	46.5 [16.4]	50.6 [17.6]	55.8 [17.1]	59.9 [19.7]	62.4 [20.1]	64.4 [19.1]	66.6 [18.5]
Waist-to-height ratio, mean [SD] (3)	0.426 [0.041]	0.430 [0.041]	0.428 [0.042]	0.429 [0.046]	0.426 [0.047]	0.430 [0.050]	0.436 [0.055]

(1) Household income was divided by square root of the number of household members and categorized into tertiles (low, middle and higher).

(2) The urbanization index theoretically ranges from 0 to 120, with a higher value indicating more urbanized community environment.

(3) Waist-to-height ratio was calculated as waist circumference divided by standing height.

Table 2

Results of a multilevel liner regression analysis investigating the association between urbanization and center adiposity in China (1993 – 2011)

	Adult participants (46,665 obs)		Child participants (9,423 obs)	
	coef. (95%CI)	*p-value*	*coef. (95%CI)*	*p-value*
Urbanization index (1)	0.002 (0.000 to 0.004)	0.021	−0.006 (−0.009 to −0.003)	0.001
Wave (ref. wave 1993)				
1997	0.009 (0.007 to 0.010)	< 0.001	0.006 (0.002 to 0.009)	0.003
2000	0.015 (0.013 to 0.017)	< 0.001	0.006 (0.002 to 0.010)	0.001
2004	0.019 (0.017 to 0.021)	< 0.001	0.008 (0.004 to 0.012)	< 0.001
2006	0.019 (0.017 to 0.021)	< 0.001	0.005 (0.001 to 0.009)	0.028
2009	0.024 (0.022 to 0.026)	< 0.001	0.008 (0.003 to 0.012)	0.001
2011	0.030 (0.028 to 0.032)	< 0.001	0.014 (0.009 to 0.018)	< 0.001
Urbanization × Wave				
1997	0.003 (0.001 to 0.005)	0.001	0.002 (−0.001 to 0.006)	0.208
2000	0.002 (0.000 to 0.004)	0.008	0.005 (0.001 to 0.008)	0.015
2004	−0.000 (−0.002 to 0.001)	0.853	0.004 (0.000 to 0.008)	0.046
2006	−0.001 (−0.003 to 0.000)	0.099	0.006 (0.002 to 0.010)	0.003
2009	−0.003 (−0.004 to −0.001)	0.001	0.007 (0.002 to 0.011)	0.003
2011	−0.003 (−0.005 to −0.002)	< 0.001	0.007 (0.003 to 0.012)	0.002
Age	0.002 (0.002 to 0.002)	< 0.001	−0.001 (−0.001 to −0.000)	< 0.001
Sex	0.009 (0.007 to 0.011)	< 0.001	−0.005 (−0.007 to −0.003)	< 0.001
Education (ref. primary school)				
Junior high	−0.002 (−0.003 to 0.000)	0.077	0.003 (−0.004 to 0.010)	0.388
High	−0.003 (−0.005 to −0.001)	0.002	0.004 (−0.003 to 0.011)	0.267
Post-secondary	−0.008 (−0.010 to −0.005)	< 0.001	0.006 (−0.001 to 0.013)	0.076
Missing	−0.000 (−0.005 to 0.004)	0.409	0.009 (−0.010 to 0.027)	0.361
Household income (ref. Low) (2)				
Middle	−0.000 (−0.001 to 0.001)	0.639	−0.000 (−0.002 to 0.002)	0.976
High	0.001 (−0.000 to 0.002)	0.096	0.002 (−0.001 to 0.005)	0.123
Missing	0.002 (−0.002 to 0.005)	0.409	−0.008 (−0.015 to −0.000)	0.050

(1) The urbanization index was standardized to a mean of 0 and a standard deviation of 1, with a higher value indicating more urbanized community environment.

(2) Household income was divided by square root of the number of household members and categorized into tertiles (low, middle and high).