Published in final edited form as:
*Eur J Clin Nutr*. 2015 December ; 69(12): 1306–1312. doi:10.1038/ejcn.2015.71.

# Is waist circumference per body mass index rising differentially across the US, England, China, and Mexico?

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## Abstract

**Background/Objectives—**Little is known about whether waist circumference (WC) has increased disproportionately relative to body mass index (BMI) around the world.

**Subjects/Methods—**Data came from the US National Health and Nutrition Examination Survey (1988–94 and 2007–10), Health Survey for England (1992–93 and 2008–9); the Mexican Nutrition Survey (1999) and the Mexican National Health and Nutrition Survey (NHNS 2012); and the China Health and Nutrition Survey (1993 and 2011). Country- and sex-stratified (for the US, also race/ethnicity-stratified) multivariable linear regressions were used estimate mean difference in WC over time relative to BMI at specified overweight and obesity cut-points, adjusting for age and survey year.

**Results—**While mean WC and BMI shifted upward over time in all age-sex subpopulations in all four countries, trends in in overweight prevalence were less consistent. However, WC relative to BMI increased at varying magnitudes across all countries and subpopulations except US Black men. The magnitude of increase was largest for women in the youngest age group (20–29 years), particularly for women in Mexico (+6.6 cm, $p<0.0001$) and China (+4.6 cm, $p<0.0001$) (holding BMI constant at 25 kg/m$^2$). For men, the increase was primarily evident among Chinese men (+4.8 cm, $p<0.0001$).

**Conclusions—**WC has increased disproportionately over time relative to overall body mass across the US, England, Mexico, and China, particularly among young women, with the largest increases occurring in the middle-income countries of Mexico and China. These patterns are potentially a cause for concern especially for countries undergoing rapid economic and nutritional transitions.

### Keywords

waist circumference; waist circumference-BMI ratio; US; England; China; Mexico

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**Conflict of interest:** None declared.

Supplementary information is available at EJCN's website.

## Introduction

There is extensive documentation from many countries that over time, the body mass index (BMI) distribution has shifted upward, average waist circumference (WC) has also increased, and overweight and obesity prevalence have increased[1–3]. In particular, Razak et al. documented an upward shift in the BMI distribution among women in 37 lower-middle income countries, and a disproportionate increase in BMI at the upper tail of the distribution[2]. More recently, investigators have raised the question of whether average WC for a given BMI has increased along with the upward shifts in the distributions of BMI and WC[4]. WC has increased for a given BMI in Chinese adults[5] and Mexican-origin women[6], however, no one has conducted wider comparative research and synthesized these findings on multiple countries over time.

WC is a marker of abdominal obesity, which is strongly associated with dyslipidemia, inflammation, insulin resistance, cardiovascular disease, and cancer[7–9]. Asians are known to have higher amounts of central fat at the same BMI compared to Caucasian populations, and higher attendant cardiovascular risk[10, 11]. Evidence of a similar pattern in Hispanics and Mexican-origin individuals is mixed[12–16], though some studies have shown that WC better predicts insulin resistance and diabetes than BMI in Mexican-Americans[17, 18]. The health implications of increasing WC for the same BMI within the same population have not been empirically examined. Nevertheless, in countries where this pattern is evident, given the strong association between WC and chronic disease, the potential exists for a higher morbidity and mortality burden than would be predicted by relying on BMI alone.

In the current paper, we utilized anthropometric data from population-based samples from four countries where both BMI and WC data were available for at least two time points: the US, England, China and Mexico. We were interested in examining whether trends seen in women from 37 lower and middle income countries extended to men and women in higher and middle income countries across three continents. In all four countries, the focal time period spanned a period of significant increase in obesity. We used these data to examine whether WC has increased disproportionately over time relative to overall body mass in men and women, and assessed whether this was pattern was more predominant in certain countries. We positioned these findings within the context of the few other studies that have examined similar patterns elsewhere.

## Methods

### Data

All data were from population-based studies across two time points spanning approximately two decades. All of the studies, with the exception of the Chinese study, are nationally representative. Few national studies have collected data on both BMI and WC at more than one point in time, which precluded the inclusion of a larger number of countries, particularly middle-income countries, in these analyses. Our sample included males and females aged 20–49 years, excluding pregnant women, with measured data available on weight, height and WC at both times points. This age range was selected for comparability across studies since the first time point for the Mexican survey only collected data on women of childbearing age.

## United States

The National Health and Nutrition Examination Surveys (NHANES III: 1988–94 and the combined NHANES 2007–8 and 2009–10): The NHANES program of the National Center for Health Statistics, Centers for Disease Control and Prevention, includes a series of cross-sectional nationally representative health examination surveys beginning in 1960. Each cross-sectional survey provides a national estimate for the US population at the time of the survey, enabling examination of trends over time in the US population. In each survey, a nationally representative sample of the US civilian non-institutionalized population was selected using a complex, stratified, multistage probability cluster sampling design. NHANES III was conducted between 1988 and 1994. Beginning in 1999, NHANES became a continuous survey without a break between cycles. The procedures followed to select the sample and conduct the interview and examination were similar to those for previous surveys. This report is based on data for individuals from NHANES III and the two consecutive 2-year cycles of the continuous NHANES (2007–10)[19].

## England

The Health Survey for England (HSE), 1992–93 and 2008–9: includes independent cross-sectional nationally representative, multi-stage stratified random samples at both time periods[20]. The surveys were conducted annually by Office for Population Censuses and Surveys and the National Centre for Social Research. The HSE covers all of England and consists of individuals aged 16 years and older residing at private residential addresses. These analyses are based on data from the 1992 and 1993 annual surveys, and the 2008 and 2009 surveys.

## China

The China Health and Nutrition Survey (CHNS, 1993 and 2011): The CHNS, which began data collection in 1989, was conducted in 9 diverse provinces and 218 communities selected on the basis of substantial variation in geography, economic development, and health indicators. Using a multistage, random cluster design, a stratified probability sample was used to select counties and cities stratified by income and urbanicity using State Statistical Office definitions[21]. Communities and households were then randomly selected from these strata initially mirroring national age-sex-education profiles.[22, 23] The CHNS household and individuals were followed over time. By 2011, the CHNS provinces constituted 47% of China’s population (according to 2010 census). Survey procedures have been described elsewhere[24]. WC data was not collected in the 1989 and 1991 surveys, thus the baseline year for these analyses is 1993.

## Mexico

The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012) are nationally representative, cross-sectional, multi-stage, stratified surveys aimed at characterizing the health and nutritional status of the

Mexican population[25, 26]. The MNS 1999 was conducted between October 1998 and March 1999, however, it only collected information of preschoolers (1–4y-old), school age children (5–11y-old) and women of childbearing age (12–49y-old)[26]. The NHNS 2012 was conducted between October 2011 and May 2012 and surveyed both men and women across a larger age distribution.[25]

## Anthropometric data

In all four country surveys, trained personnel used a standardized protocol to collect anthropometric measurements. Height was measured without shoes to the nearest 0.2 cm using either a fixed or portable stadiometer, weight was measured without shoes in light clothing to the nearest 0.1 kg on a beam balance or digital SECA scale, and WC (in cm) was measured with a tape measure at the mid-point between the lower edge of the rib cage and the iliac crest. For descriptive purposes, we classified BMI into categories of overweight and obesity. We used the WHO BMI threshold of 25 kg/m$^2$ for all countries for the overweight cutpoint for comparative purposes. For obesity, we use the WHO BMI threshold of 30 kg/m$^2$ for the US, England, and Mexico. Given the higher cardio-metabolic risk among Asians at lower BMI[11], we used the Chinese reference of 28 kg/m$^2$ for the obesity threshold in China[27].

**Analysis—**In all four countries, analyses were conducted separately for men and women, except in Mexico, where only data for women were available for both time points. For the US, results were further stratified by race/ethnicity (non-Hispanic whites, non-Hispanic Black, and Mexican-American). Descriptive analyses included appropriate sampling weights to produce national population estimates for the Mexican, English, and US samples, and accounted for unequal probabilities of selection, non-response, and non-coverage. Sampling weights were not available for China. All analyses were conducted using Stata software, version 12.1 (Stata Corp, College Station, Texas). The SVY module was used in all descriptive and linear regression analyses to account for the complex sampling design of the England, US, and Mexican studies. For the CHNS, all analyses accounted for clustering by community and household.

First, we conducted descriptive analyses of changes in BMI and WC between the baseline year and the subsequent end year. Next, we used linear regression to estimate mean difference in WC over time relative to BMI, adjusting for age (categorized as 20–29 years, 30–39 years, and 40–49 years) and survey year. The relationship between WC and BMI was curvilinear, thus we included a BMI-squared term in all models. We also investigated whether change in WC over time, adjusted for BMI, varied by age or by BMI level. To do this, we tested interactions between age and survey year and between BMI and survey year. To facilitate interpretation, predicted mean WC was computed for BMI values of 25, 30, and 35 kg/m$^2$ across the two survey years for the US, Mexico, and England; in China, predicted values were computed at a BMI of 25 and 28 kg/m$^2$. We used the Bonferroni correction to adjust for multiple comparisons across the six groups of women and five groups of men from the four countries examined.

Because of the non-linearity between BMI and WC, we conducted additional sensitivity analyses. First, we estimated the constants in the scaling relationship between WC and weight, and between WC and height, at the baseline survey year. We then combined these estimated constants with the observed body weights from the later years to investigate whether the WC observed in the later period exceeded what would be predicted based on that scaling relationship.

## Results

We had large samples of adults from each of the four studies (Table 1). The unadjusted results for each country showed that mean WC has increased over time in all age-sex subpopulations, as has obesity prevalence. In contrast, overweight prevalence did not markedly increase for many country-sex subpopulations, with the exception of US non-Hispanic white women, Mexican-American men, English women, and Chinese men and women.

We present in Tables 2 and 3 shifts in the distribution of BMI and WC at different cutoff points between the two times periods for all four samples of women and men. This provides a clear sense of the shifting distribution toward higher BMI levels at all points in the distribution. The results are presented as annualized percentage point shifts to provide comparability in all the samples for which different lengths of time exist.

Table 4 presents the predicted mean WC at specified BMI values for each survey year, obtained from adjusted linear regression analyses. Interactions between age and survey year and BMI and survey year were statistically significant for some groups, but for comparability, they were retained in all models. Thus, predicted mean WC, derived from the models with interactions, was also computed for each of the three age categories in all countries. In general, there were statistically significant increases in WC for given BMI over time across most subpopulations of women and men, except for US Black men. Among women, in all countries except for England, the magnitude of increase was largest for the youngest age group (20–29 years) relative to women in the older age group (40–49 years). Among men, similar differences by age cohorts were found only among Mexican-Americans, and to a lesser extent, among US whites. WC also increased to a greater extent at higher BMI values, but this was a pattern that was primarily observed among women, and not men, in the US (all race/ethnic groups), Mexico, and England. In China, the opposite pattern was found - WC increased to a greater extent among both women and men at lower BMI values.

Figures 1A and 1B more clearly illustrate the distinct sex differences in the patterns we report. Predicted mean WC at a BMI of 25 kg/$m^2$ (from model results in table 4) were plotted for women and men aged 20–29 years across all four countries. Among young women in all countries, a BMI of 25 kg/$m^2$ was associated with a statistically significant higher mean WC over time, with the largest increases found in Mexican women (+6.6 cm, $p<0.0001$) (Table 4 and Figure 1A), even though the time interval under study was shortest in Mexico compared to the other three countries. The second largest increase was found among Chinese women (+4.6 cm, $p<0.0001$). Nevertheless, Mexican-American and US white women continued to have the highest mean WC at a BMI of 25 kg/m$^2$ (86–87 cm). For young men, a higher mean WC for the same BMI was notably evident only for Chinese (+4.8 cm, p<0.0001), and to a lesser extent, for Mexican-American (+1.4 cm, p=0.002) and US white (+0.7, p=0.029) men (Table 4 and Figure 1B). In contrast, young US Black men, and young men from England, had a more stable WC for the same BMI over time. In the older cohort (Supplemental Figure 1A, B) (aged 40–49 years), differences between women and men were less pronounced than they were for younger cohorts, particularly for the US.

Results from sensitivity analyses were broadly consistent with all of our findings with one exception. Although our original models indicated WC adjusted for BMI was significantly higher over time among Chinese men, results from the sensitivity analyses implied this was not the case. Therefore, our findings among Chinese men may be sensitive to the method of estimation used (data not shown).

## Discussion

Using four population-based surveys from the US, England, China, and Mexico, we observed substantial increases in mean WC and obesity prevalence over time in all age-sex subpopulations, but a less consistent pattern in overweight prevalence. However, WC relative to BMI showed an increasing trend across most countries and subpopulations, albeit with variation in statistical significance. The exception to this pattern was in US Black men, who had a more stable WC over time. WC relative to BMI also increased to the greatest extent among women aged 20–29 years, though the magnitude of increase was largest for Mexican women followed by Chinese women. For men, the increase was most evident for Chinese men, though results were sensitive to the method of estimation.

In studies in other high-income countries, Jannsen et al. found a similar trend in Canada[28]. Children and adults had a higher WC and greater skinfold thickness in 2007–2009 than similarly aged Canadians with the same BMI thirty years ago. Moreover, consistent with the patterns we report, the magnitude was larger for women (4.9 cm) than men (1.1 cm)[28]. There is also published evidence among U.S. adults overall (without breakdown by race/ethnicity) that WC has increased more quickly than BMI, and that WC was higher between 2003–2004 and 1988–1994 across various categories of BMI[29]. In general, these patterns fit within a literature that shows an upward shift in WC and BMI across high-, middle-, and low-income countries[2, 4]. However, this small body of evidence also points to another emerging global concern - a shift to increasing abdominal adiposity – indicated by higher WC – for a given BMI. While our analyses and results from other existing studies[5, 6, 28] indicate this pattern is occurring across several countries, our synthesis also suggests that the gravity of the problem is particularly pronounced in the rapidly developing countries of Mexico and China.

The reasons for this shift in body composition over time are unknown and we can only speculate as to the potential causes. Energy-dense diets and diets with a high glycemic index have been previously linked to a greater accumulation of abdominal fat for the same BMI[30, 31]. Less physical activity and greater sedentary behavior, which can lead to decreases in lean body mass, have also been shown to contribute to excess central fat[31, 32]. Over the past few decades, major shifts in the food systems have been observed, increasing the population's access to a large and cheap supply of energy-dense foods[33]. This process, along with declines in occupational and transportation-related activity which have also been observed on a global scale[34] may account for the secular change in the BMI-WC association over time. The pace of these changes in lower and middle-income countries has also been noted to be much faster than what had been experienced by more developed countries[34, 35]. This may explain why individuals in Mexico and China had the largest increases in WC for the same BMI relative to the US and England. However, the few countries for which both BMI and WC data were available for more than one time point may not necessarily represent the experience of other high- and middle-income countries. Thus, until other countries systematically collect WC and BMI over time, it is not possible to determine whether the trend in higher WC per BMI is also occurring especially across other LMICs.

It is also unknown whether this pattern of higher WC for a given BMI level has cardio-metabolic implications. WC is a non-specific indicator of abdominal obesity, and does not distinguish between subcutaneous and visceral fat, the latter of which is more closely associated with CVD[36, 37]. Nevertheless, an extensive literature has associated abdominal obesity with blood lipid disorders, inflammation, insulin resistance, Type 2 diabetes, and an increased risk of developing CVD[7, 8]. If higher central fat for the same BMI does indeed have implications for health, then the emerging plateau in obesity prevalence seen in some populations may not necessarily result in similar plateaus in health outcomes. As a result, BMI cutpoints may need to drift downwards over time to maintain a constant BMI-health outcome relationship. Future research will need to consider whether the patterns we report will have health consequences for the countries and subpopulations affected.

There are some limitations to our study. First, the national surveys included in this study span different time periods; however in all cases we found statistically significance increases in WC relative to BMI, even among Mexican women who were studied over the shortest time period. Second, we lacked data on Mexican men which would be important to help us understand whether the trends we observed for Chinese men were similar to those in other LMIC's. Third, few countries collected WC data at more than one time point, which precluded a more extensive evaluation across countries with different levels of economic development. WC measurement will need to be incorporated in more national surveys over time to better assess the extent of the problem in other countries. Finally, we also did not have data on other measures of body composition over time and across all countries, such as CT scans or dual-energy X-ray absorptiometry (DXA), which would provide more detailed body composition data than WC.

In conclusion, WC has increased disproportionately over time relative to overall body mass in the US, England, China, and Mexico. Given the strong association between abdominal obesity and cardiovascular disease-related morbidity and mortality, there is a potential cause for concern across the globe. Additional research and data collection are needed to understand how prevalent these set of changes are across both LMIC's and higher income countries. Future research will also be needed to understand both the causes and health consequences of these trends.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

This work was supported by NIH: NICHD (R01-HD30880) and NHLBI (R01-HL108427). NIH had no role in the design and conduct of the study, collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript. We thank our colleagues at the National Institute of Public Health, Cuernevaca Mexico, particularly Juan Rivera, for providing access to the Mexican data. We also thank our collaborators at the Chinese National Institute of Nutrition and Food Safety for collaboration in collection of the China Health and Nutrition Survey. We also wish to thank Ms Frances Dancy for administrative support and Mr. Tom Swasey for graphics support in this effort.

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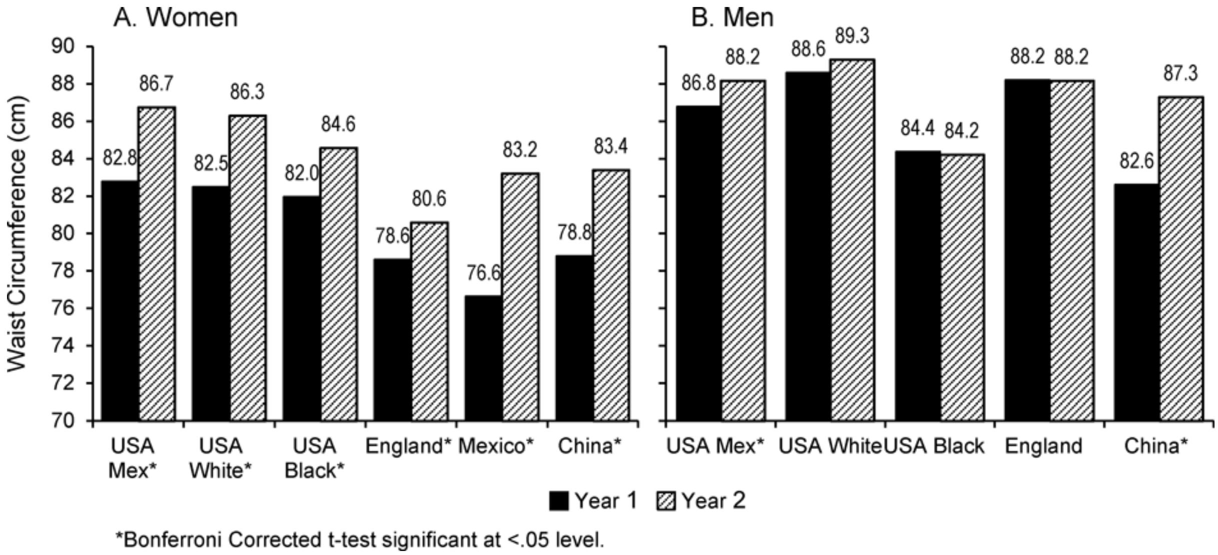


**Figure 1.**

Predicted mean WC (cm) for BMI=25 kg/m$^2$ in Year 2 compared to Year 1 for women and men aged 20–29 years in the US (by race/ethnicity), England, Mexico, and China. A) Women; B) Men. Data are derived from: *China:* The China Health and Nutrition Survey (CHNS, 1993 and 2011)[24]; *England:* The Health Survey for England (HSE), 1992–93 and 2008–9[20]; *United States:* The National Health and Nutrition Examination Survey (NHANES III:1988–94 and the combined NHANES 2007–8 plus 2009–10)[19]; *Mexico:* The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012)[25, 26]. Panels A and B show results from country- and sex-stratified (in the US, also race/ethnicity-stratified) multivariable linear regression models that include: age (categorized: 20–29, 30–39 40–49 years), BMI, BMI-squared, survey year, age*survey year, BMI*survey year, BMI-squared*survey year. For brevity, only results for age group 20–29 years shown in figure.

## Table 1

Descriptive statistics of women and men aged 20–49 years from the US National Health and Nutrition Examination Surveys (NHANES III: 1988–1994 and 2007–2010), the Health Survey for England (HSE 1992–1993 and 2008–2009), the Mexican Nutrition Survey (MSN 1999) and the Mexican National Health and Nutrition Survey (NHNS 2012), and the China Health and Nutrition Survey (CHNS 1993 and 2011) *

| **US NHANES** | **1988–94** | | **2007–10** | |
|---|---|---|---|---|
| **Non-Hispanic Whites** | | | | |
| **Sample size by age group** | **Women** | **Men** | **Women** | **Men** |
| Age 20–29 | 443 | 387 | 348 | 337 |
| Age 30–39 | 559 | 440 | 414 | 424 |
| Age 40–49 | 452 | 417 | 462 | 408 |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 25.3 | 26.3 | 27.5 | 28.1 |
| Overweight % (BMI≥25<30) | 19.8 | 38.9 | 26.2 | 36.8 |
| Obese % (BMI≥30) | 19.8 | 16.6 | 28.7 | 31.9 |
| Mean Waist Circumference (cm) | 84.3 | 93.7 | 92.0 | 98.9 |
| **Non-Hispanic Blacks** | | | | |
| **Sample size by age group** | | | | |
| Age 20–29 | 548 | 478 | 177 | 176 |
| Age 30–39 | 595 | 469 | 172 | 159 |
| Age 40–49 | 418 | 339 | 190 | 167 |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 28.3 | 26.4 | 31.8 | 28.6 |
| Overweight % (BMI≥25<30) | 28.4 | 34.9 | 25.0 | 28.7 |
| Obese % (BMI≥30) | 33.5 | 20.3 | 51.7 | 36.1 |
| Mean Waist Circumference (cm) | 90.5 | 90.1 | 99.1 | 95.3 |
| **Mexican-Americans** | | | | |
| **Sample size by age group** | | | | |
| Age 20–29 | 554 | 652 | 180 | 206 |
| Age 30–39 | 474 | 453 | 192 | 164 |
| Age 40–49 | 348 | 367 | 186 | 193 |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 27.8 | 26.6 | 29.3 | 29.0 |
| Overweight % (BMI≥25<30) | 31.5 | 42.7 | 31.8 | 45.0 |
| Obese % (BMI≥30) | 32.0 | 18.5 | 40.7 | 34.7 |
| Mean Waist Circumference (cm) | 89.4 | 92.0 | 95.3 | 99.0 |
| **England HSE** | **1992–93** | | **2008–09** | |
| **Sample size by age group** | **Women** | **Men** | **Women** | **Men** |
| Age 20–29 | 2841 | 2636 | 1090 | 858 |
| Age 30–39 | 3308 | 3059 | 1487 | 1155 |

| US NHANES | 1988–94 | | 2007–10 | |
|---|---|---|---|---|
| Age 40–49 | 3059 | 2801 | 1811 | 1469 |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 25.0 | 25.7 | 26.4 | 27.0 |
| Overweight % (BMI≥25<30) | 26.9 | 42.3 | 29.8 | 42.4 |
| Obese % (BMI≥30) | 13.6 | 11.7 | 22.1 | 21.6 |
| Mean Waist Circumference (cm) | 79.3 | 91.4 | 84.6 | 95.0 |
| **Mexico† MSN and NHNS** | **1999** | | **2012** | |
| **Sample size by age group** | **Women** | | **Women** | |
| Age 20–29 | 4975 | | 3788 | |
| Age 30–39 | 4478 | | 5293 | |
| Age 40–49 | 3077 | | 4673 | |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 27.0 | | 28.5 | |
| Overweight % (BMI≥25<30) | 36.5 | | 35.0 | |
| Obese %(BMI≥30) | 25.0 | | 35.8 | |
| Mean Waist Circumference (cm) | 81.1 | | 90.8 | |
| **China CHNS** | **1993** | | **2011** | |
| **Sample size by age group** | **Women** | **Men** | **Women** | **Men** |
| Age 20–29 | 853 | 834 | 569 | 503 |
| Age 30–39 | 998 | 826 | 967 | 786 |
| Age 40–49 | 825 | 769 | 1506 | 1347 |
| **Ages 20–49 years** | | | | |
| Mean BMI (kg/m$^2$) | 21.9 | 21.6 | 23.2 | 24.0 |
| Overweight % (BMI≥25<30) | 12.9 | 9.1 | 22.6 | 31.0 |
| Obese % (BMI≥30) | 0.7 | 0.4 | 4.6 | 5.2 |
| Chinese standard Obese % (BMI≥28) | 2.4 | 1.4 | 8.7 | 12.1 |
| Mean Waist Circumference (cm) | 73.9 | 76.0 | 79.3 | 86.1 |

*Weighted to be nationally representative for Mexico, the United States, and England.

†Data on men not available for Mexico

Source: *China:* The China Health and Nutrition Survey (CHNS, 1993 and 2011)[24]; *England:* The Health Survey for England (HSE), 1992–93 and 2008–9[20]; *United States:* The National Health and Nutrition Examination Survey (NHANES III-1988–94 and the combined NHANES 2007–8 plus 2009–10)[19]; *Mexico:* The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012)[25, 26].

**Table 2**

BMI Distribution in Baseline Year and Annualized Percentage Point Change in Follow-up Year among Women and Men aged 20–49 years, United States, Mexico, England, and China*

| | US Mexican Americans | | US Non-Hispanic Whites | | US Non-Hispanic Blacks | | Mexico† | | England | | China | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: |
| | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1999 | 2012 | 1992–93 | 2008–9 | 1993 | 2011 |
| BMI ($kg/m^2$), categorized | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) |
| **A. Women** | | | | | | | | | | | | |
| <18.5 | 1.8 | −0.1 | 4.3 | 0.0 | 2.6 | 0.0 | 1.8 | 0.0 | 2.2 | 0.0 | 8.3 | −0.1 |
| 18.5–22.9 | 20.1 | −0.2 | 40.2 | −0.7 | 22.3 | −0.5 | 20.9 | −0.4 | 37.2 | −0.6 | 60.3 | −0.8 |
| 23–24.9 | 14.6 | −0.2 | 15.8 | −0.1 | 13.3 | −0.3 | 16.0 | −0.3 | 20.2 | −0.1 | 17.7 | 0.1 |
| 25–27.9 | 20.6 | 0.0 | 14.3 | 0.1 | 17.8 | −0.2 | 24.1 | −0.2 | 19.7 | 0.1 | 11.1 | 0.4 |
| 28–29.9 | 11.0 | 0.0 | 5.5 | 0.2 | 10.6 | 0.0 | 12.4 | 0.1 | 7.1 | 0.1 | 1.8 | 0.2 |
| 30–34.9 | 19.7 | 0.1 | 11.3 | 0.1 | 16.2 | 0.3 | 17.6 | 0.4 | 9.3 | 0.3 | 0.7 | 0.2 |
| 35–39.9 | 7.5 | 0.3 | 5.5 | 0.2 | 10.2 | 0.2 | 5.7 | 0.2 | 3.1 | 0.2 | 0.1 | 0.0 |
| 40–44.9 | 3.3 | 0.0 | 2.1 | 0.1 | 4.0 | 0.2 | 1.4 | 0.1 | 0.9 | 0.1 | 0.0 | n/a |
| ≥45 | 1.5 | 0.0 | 1.0 | 0.1 | 3.1 | 0.3 | 0.3 | 0.1 | 0.3 | 0.0 | 0.0 | n/a |
| **B. Men** | | | | | | | | | | | | |
| <18.5 | 1.0 | 0.0 | 1.3 | 0.0 | 0.9 | 0.0 | | | 0.9 | 0.0 | 6.5 | −0.2 |
| 18.5–22.9 | 18.9 | −0.5 | 22.3 | −0.4 | 25.6 | −0.2 | | | 22.3 | −0.4 | 68.1 | −1.8 |
| 23–24.9 | 19.0 | −0.4 | 20.9 | −0.3 | 18.3 | −0.3 | | | 22.8 | −0.3 | 15.9 | 0.4 |
| 25–27.9 | 29.5 | 0.0 | 28.1 | −0.3 | 24.7 | −0.4 | | | 30.7 | −0.2 | 8.1 | 0.8 |
| 28–29.9 | 13.2 | 0.1 | 10.9 | 0.1 | 10.2 | 0.1 | | | 11.7 | 0.2 | 1.0 | 0.4 |
| 30–34.9 | 13.8 | 0.5 | 11.5 | 0.6 | 13.3 | 0.3 | | | 10.0 | 0.4 | 0.4 | 0.2 |
| 35–39.9 | 3.6 | 0.2 | 3.2 | 0.1 | 4.6 | 0.3 | | | 1.5 | 0.2 | 0.0 | n/a |
| 40–44.9 | 0.8 | 0.1 | 1.5 | 0.1 | 1.5 | 0.1 | | | 0.2 | 0.0 | 0.0 | n/a |
| ≥45 | 0.3 | 0.1 | 0.5 | 0.0 | 1.0 | 0.1 | | | 0.1 | 0.0 | 0.0 | n/a |

*Weighted to be nationally representative for Mexico, the United States, and England.

†Data on men not available for Mexico.

Source: *China:* The China Health and Nutrition Survey (CHNS, 1993 and 2011)[24]; *England:* The Health Survey for England (HSE), 1992-93 and 2008-9[20]; *United States:* The National Health and Nutrition Examination Survey (NHANES III:1988-94 and the combined NHANES 2007-8 plus 2009-10)[19]; *Mexico:* The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012)[25, 26].

**Table 3**

Waist Circumference Distribution in Baseline Year and Annualized Percentage Point Change in Follow-up Year among Women and Men aged 20–49 years, United States, Mexico, England, and China*

| | US Mexican Americans | | US Non-Hispanic Whites | | US Non-Hispanic Blacks | | Mexico† | | England | | China | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: |
| | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1999 | 2012 | 1992–93 | 2008–9 | 1993 | 2011 |
| Waist circumference (cm), categorized | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) |
| **A. Women** | | | | | | | | | | | | |
| <65 | 1.2 | 0.0 | 2.1 | −0.1 | 1.5 | 0.0 | 5.5 | −0.4 | 3.8 | −0.1 | 10.9 | −0.4 |
| 65–69 | 5.4 | −0.2 | 11.5 | −0.4 | 5.7 | −0.2 | 10.9 | −0.6 | 13.9 | −0.4 | 20.7 | −0.6 |
| 70–74 | 10.1 | −0.3 | 16.9 | −0.4 | 11.2 | −0.3 | 15.3 | −0.7 | 22.7 | −0.5 | 26.5 | −0.4 |
| 75–79 | 11.4 | −0.1 | 16.9 | −0.3 | 10.9 | −0.3 | 18.0 | −0.5 | 20.6 | −0.2 | 19.1 | 0.0 |
| 80–89 | 26,.0 | −0.1 | 23.6 | 0.2 | 25.5 | −0.2 | 29.4 | 0.0 | 23.9 | 0.2 | 18.1 | 0.7 |
| 90–99 | 24.9 | 0.2 | 13.4 | 0.3 | 19.4 | 0.0 | 15.2 | 0.9 | 9.8 | 0.5 | 4.2 | 0.4 |
| 100–109 | 12.0 | 0.3 | 9.0 | 0.2 | 12.7 | 0.2 | 4.5 | 0.8 | 3.5 | 0.3 | 0.6 | 0.1 |
| 110–119 | 6.1 | 0.2 | 4.5 | 0.2 | 7.8 | 0.3 | 0.8 | 0.4 | 1.4 | 0.2 | 0.0 | n/a |
| 120–129 | 2.2 | 0.1 | 1.2 | 0.2 | 3.2 | 0.3 | 0.2 | 0.1 | 0.3 | 0.1 | 0.0 | n/a |
| ≥130 | 0.7 | 0.1 | 0.8 | 0.1 | 2.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | n/a |
| **B. Men** | | | | | | | | | | | | |
| <65 | 0.0 | n/a | 4.6 | n/a | 0.1 | 0.0 | | | 0.1 | 0.0 | 4.6 | −0.2 |
| 65–69 | 0.6 | 0.0 | 0.5 | 0.0 | 2.6 | 0.0 | | | 0.4 | 0.0 | 15.3 | −0.7 |
| 70–74 | 4.5 | −0.1 | 2.9 | 0.0 | 10.3 | −0.1 | | | 3.1 | 0.0 | 29.0 | −1.1 |
| 75–79 | 10.0 | −0.4 | 10.0 | −0.2 | 14.1 | −0.1 | | | 8.2 | −0.1 | 20.5 | −0.4 |
| 80–89 | 31.2 | −0.7 | 27.6 | −0.3 | 27.2 | −0.4 | | | 35.4 | −0.6 | 24.0 | 0.7 |
| 90–99 | 31.4 | 0.2 | 32.2 | −0.2 | 24.2 | 0.0 | | | 34.3 | −0.1 | 5.6 | 1.2 |
| 100–109 | 14.7 | 0.6 | 17.3 | 0.2 | 12.7 | 0.2 | | | 14.0 | 0.5 | 0.9 | 0.4 |
| 110–119 | 5.4 | 0.1 | 5.6 | 0.3 | 4.9 | 0.3 | | | 3.5 | 0.2 | 0.0 | 0.1 |
| 120–129 | 1.3 | 0.1 | 2.4 | 0.2 | 2.7 | 0.1 | | | 0.9 | 0.1 | 0.0 | 0.0 |

| | US Mexican Americans | | US Non-Hispanic Whites | | US Non-Hispanic Blacks | | Mexico† | | England | | China | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: | Baseline | Yearly change by: |
| | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1988–94 | 2007–10 | 1999 | 2012 | 1992–93 | 2008–9 | 1993 | 2011 |
| Waist circumference (cm), categorized | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) | (Percent) |
| ≥130 | 0.9 | 0.1 | 1.5 | 0.1 | 1.3 | 0.2 | | | 0.1 | 0.1 | 0.0 | n/a |

* Weighted to be nationally representative for Mexico, the United States, and England.

† Data on men not available for Mexico.

Source: *China:* The China Health and Nutrition Survey (CHNS, 1993 and 2011)[24]; *England:* The Health Survey for England (HSE), 1992-93 and 2008-9[20]; *United States* The National Health and Nutrition Examination Survey (NHANES III-1988-94 and the combined NHANES 2007-8 plus 2009-10)[19]; *Mexico:* The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012)[25, 26].

**Table 4**

Predicted mean waist circumference (cm) over time by age and BMI level, women and men aged 20–49 years in the United States, Mexico, England, and China

**A. USA Women**

| | Age: 20–29 years BMI level (kg/m$^2$) | | | Age: 30–39 years BMI Level (kg/m$^2$) | | | Age: 40–49 years BMI level (kg/m$^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **25** | **30** | **35** | **25** | **30** | **35** | **25** | **30** | **35** |
| **Mexican-Americans** | | | | | | | | | |
| 1988–1994 | 82.8 | 93.5 | 103.5 | 83.9 | 94.6 | 104.6 | 85.7 | 96.4 | 106.4 |
| 2007–2010 | 86.7 | 98.4 | 108.8 | 86.2 | 97.9 | 108.2 | 86.0 | 97.7 | 108.0 |
| Difference ($t_{2007-2010}-t_{1988-1994}$) | 4.0 | 4.9 | 5.3 | 2.3 | 3.3 | 3.7 | 0.3 | 1.2 | 1.6 |
| 1988–1994 vs 2007–2010 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p=0.608 | p=0.054 | p=0.041 |
| **Non-Hispanic Whites** | | | | | | | | | |
| 1998–1994 | 82.5 | 93.5 | 103.8 | 84.3 | 95.3 | 105.6 | 85.6 | 96.6 | 107.0 |
| 2007–2010 | 86.3 | 97.7 | 108.4 | 86.6 | 98.0 | 108.8 | 87.6 | 99.0 | 109.7 |
| Difference ($t_{2007-2010}-t_{1988-1994}$) | 3.8 | 4.1 | 4.6 | 2.4 | 2.7 | 3.1 | 2.0 | 2.3 | 2.7 |
| 1988–1994 vs 2007–2010 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| **Non-Hispanic Blacks** | | | | | | | | | |
| 1998–1994 | 82.0 | 93.0 | 103.4 | 84.0 | 95.0 | 105.4 | 85.7 | 96.8 | 107.2 |
| 2007–2010 | 84.6 | 96.2 | 106.8 | 84.3 | 95.9 | 106.5 | 86.6 | 98.1 | 108.8 |
| Difference ($t_{2007-2010}-t_{1988-1994}$) | 2.6 | 3.2 | 3.4 | 0.3 | 0.9 | 1.1 | 0.8 | 1.4 | 1.6 |
| 1988–1994 vs 2007–2010 | p<0.001 | p<0.001 | p<0.001 | p=0.575 | p=0.215 | p=0.156 | p=0.136 | p=0.024 | p=0.021 |
| **B. USA Men** | | | | | | | | | |
| **Mexican-Americans** | | | | | | | | | |
| 1988–1994 | 86.8 | 98.9 | 111.0 | 89.0 | 101.2 | 113.2 | 90.5 | 102.6 | 114.6 |
| 2007–2010 | 88.2 | 100.6 | 112.3 | 89.5 | 101.9 | 113.7 | 90.9 | 103.3 | 115.0 |
| Difference ($t_{2007-2010}-t_{1988-1994}$) | 1.4 | 1.6 | 1.4 | 0.5 | 0.7 | 0.5 | 0.4 | 0.7 | 0.4 |
| 1988–1994 vs 2007–2010 | p=0.002 | p=0.002 | p=0.05 | p=0.205 | p=0.084 | p=0.425 | p=0.395 | p=0.199 | p=0.61 |
| **Non-Hispanic Whites** | | | | | | | | | |
| 1998–1994 | 88.6 | 100.8 | 112.6 | 91.0 | 103.2 | 115.0 | 92.8 | 105.1 | 116.8 |

**A. USA Women**

| | Age: 20–29 years BMI level (kg/m²) | | | Age: 30–39 years BMI Level (kg/m²) | | | Age: 40–49 years BMI level (kg/m²) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **25** | **30** | **35** | **25** | **30** | **35** | **25** | **30** | **35** |
| 2007–2010 | 89.3 | 102.1 | 114.0 | 91.2 | 104.0 | 116.0 | 93.1 | 105.9 | 117.8 |
| Difference ($t_{2007–2010}$−$t_{1988–1994}$) | 0.7 | 1.3 | 1.5 | 0.2 | 0.8 | 1.0 | 0.2 | 0.8 | 1.0 |
| 1988–1994 vs 2007–2010 | p=0.029 | p=0.003 | p=0.003 | p=0.554 | p=0.095 | p=0.064 | p=0.532 | p=0.041 | p=0.039 |
| **Non-Hispanic Blacks** | | | | | | | | | |
| 1998–1994 | 84.4 | 96.9 | 108.9 | 87.1 | 99.6 | 111.7 | 89.5 | 102.0 | 114.0 |
| 2007–2010 | 84.2 | 96.4 | 108.5 | 87.2 | 99.4 | 111.5 | 88.8 | 101.0 | 113.1 |
| Difference ($t_{2007–2010}$−$t_{1988–1994}$) | −0.1 | −0.4 | −0.4 | 0.1 | −0.2 | −0.2 | −0.7 | −1.0 | −0.9 |
| 1988–1994 vs 2007–2010 | p=0.661 | p=0.299 | p=0.455 | p=0.874 | p=0.739 | p=0.79 | p=0.203 | p=0.083 | p=0.133 |
| **C. England** | | | | | | | | | |
| **Women** | | | | | | | | | |
| 1992–1993 | 78.6 | 88.5 | 97.6 | 79.7 | 89.6 | 98.7 | 80.4 | 90.3 | 99.4 |
| 2008–2009 | 80.6 | 91.0 | 100.7 | 82.0 | 92.4 | 102.2 | 82.8 | 93.2 | 103.0 |
| Difference ($t_{2008–2009}$−$t_{1992–1993}$) | 2.0 | 2.5 | 3.2 | 2.3 | 2.8 | 3.5 | 2.4 | 2.9 | 3.6 |
| 1992–1993vs 2008–2009 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| **Men** | | | | | | | | | |
| 1992–1993 | 88.2 | 99.6 | 110.4 | 90.0 | 101.3 | 112.2 | 91.4 | 102.8 | 113.6 |
| 2008–2009 | 88.2 | 99.7 | 111.3 | 90.5 | 102.0 | 113.7 | 92.0 | 103.5 | 115.1 |
| Difference ($t_{2008–2009}$−$t_{1992–1993}$) | 0.0 | 0.1 | 0.9 | 0.6 | 0.7 | 1.5 | 0.5 | 0.6 | 1.5 |
| 1992–1993vs 2008–2009 | P=0.919 | P=0.812 | P=0.076 | P=0.009 | P=0.004 | P=0.001 | P=0.01 | P=0.003 | P=0.001 |
| **D. Mexico**† | | | | | | | | | |
| **Women** | | | | | | | | | |
| 1999 | 76.6 | 85.8 | 94.4 | 77.9 | 87.0 | 95.7 | 79.0 | 88.2 | 96.8 |
| 2012 | 83.2 | 93.6 | 103.6 | 83.7 | 94.1 | 104.0 | 84.4 | 94.8 | 104.8 |
| Difference ($t_{2012}$-$t_{1999}$) | 6.6 | 7.8 | 9.1 | 5.8 | 7.0 | 8.3 | 5.4 | 6.7 | 8.0 |
| 1999 vs 2012 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| **E. China** | | | | | | | | | |
| | Age: 20–29 years | | | Age: 30–39 years | | | Age: 40–49 years | | |

**A. USA Women**

| | Age: 20–29 years BMI level (kg/m$^2$) | | | Age: 30–39 years BMI Level (kg/m$^2$) | | | Age: 40–49 years BMI level (kg/m$^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **25** | **30** | **35** | **25** | **30** | **35** | **25** | **30** | **35** |
| | BMI level (kg/m$^2$) | | | BMI level (kg/m$^2$) | | | BMI level (kg/m$^2$) | | |
| | 25 | 28 | | 25 | 28 | | 25 | 28 | |
| **Women** | | | | | | | | | |
| 1993 | 78.7 | 85.1 | | 79.6 | 86.0 | | 81.0 | 87.4 | |
| 2011 | 83.3 | 88.9 | | 82.9 | 88.5 | | 83.8 | 89.4 | |
| Difference ($t_{2011}-t_{1993}$) | 4.6 | 3.8 | | 3.2 | 2.5 | | 2.8 | 2.0 | |
| 1993 vs 2011 | p<0.001 | p<0.001 | | p<0.001 | p<0.001 | | p<0.001 | p<0.001 | |
| **Men** | | | | | | | | | |
| 1993 | 82.5 | 90.9 | | 83.4 | 91.7 | | 84.2 | 92.5 | |
| 2011 | 87.4 | 94.2 | | 88.5 | 95.2 | | 89.0 | 95.7 | |
| Difference ($t_{2011}-t_{1993}$) | 4.8 | 3.3 | | 5.0 | 3.5 | | 4.8 | 3.2 | |
| 1993 vs 2011 | p<0.001 | p<0.001 | | p<0.001 | p<0.001 | | p<0.001 | p<0.001 | |

Models stratified by country, and by sex within country. In the US, models also separately run by race/ethnicity (non-Hispanic white, non-Hispanic Black, Mexican-American). Each stratified model adjusted for: age, BMI, BMI-sq, survey year, age*survey year, BMI*survey year, BMI-sq*survey year using linear regression.

†Data on men not available for Mexico.

Source: *China:* The China Health and Nutrition Survey (CHNS, 1993 and 2011)[24]; *England:* The Health Survey for England (HSE), 1992–93 and 2008–9[20]; *United States:* The National Health and Nutrition Examination Survey (NHANES III:1988–94 and the combined NHANES 2007–8 plus 2009–10)[19]; *Mexico:* The Mexican Nutrition Survey 1999 (MSN 1999) and the Mexican National Health and Nutrition Survey 2012 (NHNS 2012)[25, 26].