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Socio-demographic disparities in distribution shifts over time in various adiposity measures among American children and adolescents: What changes in prevalence rates could not reveal

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Abstract

Background—While obesity prevalence in the U.S. has been increasing, adiposity shifts may vary across socio-demographic groups, and various adiposity measures may reveal different patterns.

Methods—To study changes over time in adiposity measures, distributional shifts in body mass index (BMI, kg/m^2), BMI-percentile, waist circumference (WC) and triceps skinfold thickness (TST), and compare between-group differences, National Health and Nutrition Examination Surveys (NHANES) III 1988-94 and 1999-04 data were analyzed. Annual shift in adiposity measures across percentiles were shown as Tukey's mean-difference plots, with percentile-specific mean differences being divided by 10.5 years. Overall and quintile-specific adjusted shifts were estimated from multivariate ordinary least square (OLS) regression models.

Results—Mean 10.5-year increases in adiposity were statistically significant, higher in older groups, more pronounced in some sex-ethnic groups (e.g. black girls) and at upper percentiles (more obese groups) for most measures and sex-age-ethnic groups. Adjusted increase in mean BMI was 0.60 in girls and 0.64 in boys; BMI percentile, 3.01 and 3.15 units; WC, 2.42 and 2.85 cm; and TST, 0.81 and 1.18 mm. Ethnic, age and sex disparities in mean BMI became wider over time. Several significant ethnic differences in adjusted adiposity shifts within the lowest (Q_1) and uppermost (Q_5) quintiles of adiposity measure distributions were noted.

Conclusions—The increase in adiposity among American children was unequally distributed across groups and varied across the spectrum of various adiposity measures. Overweight groups gained more adiposity over time, especially WC. Solely examining prevalence shifts masks pattern complexity.

Keywords

Adiposity; obesity; body mass index; waist circumference; skinfold thickness; child; adolescent; United States

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Introduction

Obesity has become a public health crisis in the United States as currently over two-thirds of American adults and one-third of American children and adolescents are overweight or obese. (1-2) National data show considerable socio-demographic disparities in the prevalence and trends (1, 3-4). In particular, whereas the overall national average prevalence of overweight was similar among boys and girls in the age group 6-19, larger gender gaps based on recent National Health and Nutrition Examination Surveys (NHANES 1999–2000 through 2003–2004) were observed among non-Hispanic Blacks and Mexican-American children and adolescents compared with non-Hispanic Whites (4).

Obesity increases the risks for many other chronic conditions (3), and health consequences of obesity may be greater in minority populations(5). While the most widely used adiposity measure is the body mass index (BMI), studies suggest that waist circumference (WC), reflecting central adiposity, may be a better predictor for future health risks (6-7). The World Health Organization (WHO) also recommends using triceps skinfold thickness (TST) for body fat distribution assessment among children (8-11). Thus, it is of interest to examine adiposity gains using these various measures. Recently we have found marked differences in the shift patterns by the type and levels of adiposity measures, across socio-demographic groups among US adults over the past two decades, with largest overall shifts in BMI and WC observed in young US adults and NH black women, and women's shifts in WC being mostly concentrated in the uppermost percentiles, as opposed to men's BMI and WC and women's BMI shifts over time (12).

Most previous epidemiological studies chose to examine and report obesity prevalence rates. Studying population-level changes in adiposity distributions (i.e., treating adiposity as a continuous variable and examining changes over its entire range) could provide more information regarding the changes over time, and indicate whether the already obese group is gaining more adiposity over time, when compared to the sole examination of overall obesity prevalence. Additionally, this may aid in understanding the roles played by both individual-level (e.g., genetics and behaviors) and socio-environmental factors (e.g., changes in food environment and social norms) across socio-demographic groups.

The present study is one of very few studies to examine population distribution shifts in adiposity among US children and adolescents (13-14), and the first to examine several different adiposity measures (i.e., BMI, BMI percentiles, WC and TST) simultaneously while comparing the related time-, age-, sex-, and ethnic differences in the shifts over the past decade. We hypothesized that some US child/adolescent groups (e.g., minority, male and older children) might have gained more adiposity than the other groups, and that adiposity gains may vary by various adiposity measures (e.g., gained more WC than BMI). WC reflects abdominal adiposity and BMI, overall adiposity.

Data and Methods

Databases and Measurements

The NHANES database includes a series of cross-sectional surveys initiated in the 1960s that provided nationally representative information on the nutrition and health status of the U.S. civilian population. NHANES III (1988-94) and those collected between 1999 and 2004 were used. Our analyses were limited to participants aged 2-19 years, 10,542 in NHANES III and 11,660 in NHANES 1999-04. Appendices A and B and other publications including ours provided details about the data sets we used (12, 15-21).

Outcome variables

Our three key adiposity measures are BMI [=weight (kg)/height (m)^2], waist circumference (WC, cm), and triceps skinfold thickness (TST, mm). We also calculated BMI percentile for each subject based on the 2000 CDC Growth Charts (22). BMI percentile may be appealing as it is adjusted for age and sex, but the same amount of change in percentile can mean very different changes in actual BMI values. For instance, some children and adolescents ranking on the 100th percentile of age and sex-adjusted BMI may have zero change in that percentile while their BMI may have increased markedly over time. Existing growth references do not allow us to calculate WC and TST percentiles

Covariates

The socio-demographic variables included in our analysis were age (preschool age children 2-5, school age children 6-11, adolescents 12-19), sex and race/ethnicity, which was categorized as Non-Hispanic (NH) whites, non-Hispanic blacks, Mexican-American (MA), and “other” groups, including multi-racial and other Hispanics.

Statistical Analysis

To study the shift over time between NHANES III (1988-94) and NHANES 1999-2004, we conducted a set of analysis, some were stratified by wave (e.g., estimate means) while for some we pooled the data (e.g., test statistical significance of the shifts). All our analyses and graphical plots took into account complex sample design effect by including appropriate sampling weights using STATA version 9.0 (23). Statistical significance was set at p-value of <0.05, but we also marked those differences with p<0.01.

1. Estimation of wave-specific means and testing between-group differences in adjusted mean shifts of adiposity measures—First wave-specific means with SE of outcomes were computed. Next, between-group differences were tested using ANOVA test. “Adjusted mean shifts” reflecting the adjusted changes in the average adiposity measures between the two NHANES survey periods were estimated using pooled NHANES data, in which period was included as a variable (period=0 for NHANES III and period=1 for NHANES 1999-2004). Then, a set of ordinary least square (OLS) multivariate regression models were fitted with the outcome variable being the adiposity measure and the main predictor being period/time. Main effects of age groups, ethnic groups and sex were added along with 2-way, 3-way and 4-way interaction terms with the variable period as needed in order to estimate group-specific shifts. This approach is equivalent to conducting stratified OLS regression analysis with main predictor being the period variable. For instance, to examine overall sex difference in the shift over time, the 2-way interaction term, period×sex, was added in the model. Linear combinations of interaction terms were then computed with their 95% CI to estimate adjusted mean shifts within each sex, age, ethnic group, sex-age, sex-ethnicity, and sex-age-ethnic group, depending on the OLS model being ran.

2. Testing differences by adiposity levels (from low to high) in adjusted mean shifts over time of adiposity measures, and the related differences by sex, age and ethnicity—We tested whether the shifts over time across low- to high- levels of adiposity were statistically significant. In particular, quintile groups of adiposity measures were created separately for NHANES III and NHANES 1999-2004. Adjusted mean shifts and differences across sex-age-ethnic groups were estimated using a saturated model with all 2-way, 3-way and 4-way interaction terms with period within each quintile of the distribution. Only the results for the lowest and uppermost quintiles (Q1—‘thin’ group and Q5—‘obese’ group) were presented.

3. Mean-difference plots of estimated annual distributional shifts across levels (percentiles) of adiposity distribution—Overlayed distributions of adiposity measures (BMI, BMI percentile, WC and TST) for NHANES III and 1999-04 were represented using kernel densities, a non-parametric smoothing technique that allows to examine distributions and visually assess their change in shape and shifts over time (24). Changes in percentile values of the distribution of these adiposity measures in 1988-94 and 1999-04 were analyzed graphically using a variation of Tukey's mean-difference plot (m-d) curves (13). The x-axis represents the population distribution percentile (to divide the US population into 100 groups, from very thin to very obese) of an adiposity measure; and the y-axis, for yearly average shift in that measure. To compute the yearly shift, mean differences between the two NHANES waves for each wave-specific percentile were divided by 10.5 years (time interval between the two waves). These percentile-specific annual shifts were termed "annual distributional shifts."

Results

Adjusted mean shifts over time in various adiposity measures by sex, age, and ethnicity

Mean values of BMI, BMI percentiles, WC and TST by sex, age and race/ethnicity and adjusted distribution shifts in means over the 10-year period are presented in Table 1. Over this period, mean BMI increased by 0.64 kg/m^2 among boys and 0.60 kg/m^2 among girls; mean BMI percentiles increased by 3.15 units among boys and 3.01 units among girls; average WC increased substantially, by 2.42 cm among boys and 2.85 cm among girls; and TST increased by 1.18 mm among boys and 0.81 mm among girls ($p<0.05$). Contrasting 6-11 and 12-19 years age categories against the 2-5 years age group, BMI, WC and TST but not BMI percentiles indicated a significantly higher mean adjusted shift at older ages ($p<0.05$).

Racial/ethnic and sex disparities in mean BMI had become wider over time particularly when comparing NH black to NH white girls whose mean BMI adjusted shifts were 1.34 and 0.42 kg/m^2, respectively. This significant difference in adjusted shifts between NH black and NH white among girls was also shown for all the other 3 measures. No significant ethnic differences in adiposity shifts were noted among boys, though significant positive adjusted shifts in mean BMI percentiles were noted only in NH whites and NH blacks ($p<0.05$), unlike other measures where a positive and significant adjusted shift was noted in all ethnic groups ($p<0.01$).

Figure 1 shows overall (boys and girls) BMI, BMI percentile, WC and TST distribution curves and their shift patterns between 1988-94 and 1999-04. Though apparently different, their shift patterns had several common features. First, they had increased variability in the distribution (variance increased by 35%; 27%; 11%; 3% for BMI, WC, TST and BMI-percentiles, respectively). Second, the skewness statistic was reduced consistently for all four measures by 11%-68%. Moreover, BMI, WC and TST distributions have become more platykurtic with a drop in kurtosis by 21%-22%, though kurtosis statistic increased by 3% for BMI percentile over this period of time.

Adjusted mean shift over time in various adiposity measures by sex, age and ethnicity and within the lowest and uppermost quintiles (Q_1 and Q_5)---Had the more obese group gained more adiposity over time?

These analyses allowed us to test whether the differences in the shifts over time between the groups with low and high adiposity measures (Q_1 and Q_5) were statistically significant. Table 2 estimates adjusted mean shifts in each adiposity measure after sub-setting the data into sex-age-ethnic-specific quintiles. In general, more positive (i.e. change>0) and

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significant (i.e. $p<0.05$) adjusted mean shifts were observed within Q_5 than Q_1 (15/25 within Q_5 *vs.* 3/25 within Q_1 for BMI, 18/25 *vs.* 1/25 for BMI percentiles, 17/25 *vs.* 10/25 for WC), though the reverse was true for TST (9/25 vs. 13/25). These differences were accentuated when used $p<0.01$ (e.g. 13/25 vs. 1/25 for BMI). Within each age-sex category and within each of the two quintiles considered, a few significant ethnic differences in adjusted mean shifts were noted.

Among boys aged 2-5 years, NH blacks had significantly lower adjusted mean shifts than NH whites in the cases of BMI (Q_5), BMI percentiles (Q_1 and Q_5), WC (Q_5) and TST (Q_5) ($p<0.05$). “Other ethnicities” however had significantly higher adjusted mean shifts than NH whites in Q_5 of BMI percentiles and TST. The patterns among 2-5 years old girls were less consistent.

Among boys aged 6-11 years, no significant differences in shift patterns were observed within Q_1. However, in Q_5, Mexican-Americans had a significantly larger adjusted mean shift than NH whites in terms of BMI and WC. NH blacks had significantly lower adjusted mean shifts in BMI percentiles than NH whites. The other ethnic groups shifted to a significantly greater extent in Q_5 of BMI percentiles and TST compared to NH whites in the same age group. Among girls aged 6-11 years, NH blacks experienced significantly larger shifts in BMI percentiles than NH whites within Q_1 but not Q_5. Mexican-Americans had significantly higher shifts in BMI (Q_5) and TST (Q_1) compared to NH whites.

Among adolescents (12-19 years), ethnic differences in shift patterns were slightly different within each quintile. For boys, a decline in mean BMI was noted in Q_1 and was significantly higher in absolute value among NH whites compared to NH blacks. For BMI percentiles, a similar decline was observed in Q_1 which was only significant among Mexican-Americans and was significantly different from that observed in NH whites. In contrast, in Q_5, BMI percentile shifted upwards in all ethnic groups though the shift was significantly smaller among Mexican-Americans compared to NH whites. This pattern was also observed among adolescent girls. Moreover, among adolescent girls and within Q_1, BMI shifted upward and was significantly greater among NH blacks compared to NH Whites.

Mean-difference plots of estimated annual distributional shifts across levels (percentiles) of adiposity distribution

Figures 2 through 4 show a set of Tukey's mean-difference plot for the average yearly changes in means of BMI, WC and TST within each population distribution percentile, by sex, age group and ethnicity. These Figures further illustrated some of the patterns observed in Table 2 and examined, in a descriptive manner, yearly shifts within each percentile. In Figure 2, BMI percentiles were also presented.

Overall, many of the larger distributional shifts appeared to occur at the upper tail of the distribution (those with high adiposity measures), with the exception of BMI percentiles in which shifts were most pronounced in the middle of the distribution. Several other distinctive patterns were also observed when examining each percentile in a descriptive manner. As shown in Figure 2, in children aged 6-11, appreciable estimated yearly increases in BMI were noted in the upper tail (beyond the 90^{th} percentile) only among boys. For WC and TST and among boys, yearly increases were more notable above the median. Among girls, a similar pattern was noted, though yearly increases tended to decline beyond the 85^{th} percentile. In adolescents, sex differences were also noted. In boys, estimated yearly shifts in three out of the four adiposity measures (the exception was BMI percentiles) were directly and pseudo-linearly associated with percentile rank, though the association was reversed beyond the 90^{th} percentile. Among girls, whereas BMI and TST shifts started out at a null to low level (<0.1), WC increased at a relatively high level (>0.2) even at the lowest percentile ranks. While BMI and WC's yearly shifts increased in a linear fashion, TST shifts seemed constant across the whole distribution, with an inverted U-shaped trend (range between -0.05 and 0.17).

In adolescents (Figure 3), BMI annual distributional shifts increased steadily across percentiles for all race/ethnicity groups with the exception of MA girls in whom shift was negative and stable in lower percentiles and increased to positive values beyond the 80^{th} percentile. Unlike girls from other ethnic groups, MA girls' annual distributional shifts increased minimally in WC below the 10^{th} percentile (<0.1 cm.), and then were larger (>0.2 cm) beyond the 60^{th} percentile. MA girls had the largest increases in TST among all ethnic groups for most of the distribution. NH white and black boys saw a linear increase in TST shifts.

Most of the distributional shift patterns by ethnicity and sex among US children aged 6-11 years (Figure 4) were similar to those in adolescents, while there were some notable differences. Distributional shift acceleration in BMI at upper percentiles was noted among all ethnic groups and for both sexes, except for NH white girls, whereby a decreasing trend in positive annual distributional shifts was noted in the upper tail of the distribution. In addition, unlike other ethnic groups, NH white boys and girls have witnessed WC annual distributional shifts that were above 0.2 cm between the 50^{th} and 60^{th} percentiles. NH black girls had very small annual distributional shifts (<0.1) in all three adiposity measures compared to the other groups, until the 80^{th} percentile.

Discussion

This comprehensive analysis of the nationally representative survey data shows that the shifts (increase) in adiposity in US children and adolescents were unequally distributed across socio-demographic groups and across the spectrum of BMI, WC and TST measures, with notable shift patterns (both adjusted mean shifts and annual distributional shifts) since the later 1980s. First, overall, all four measures' distributions appeared to shift to a larger extent in the upper tail (at higher percentiles) than in the lower tail, with the heavier American children and adolescents gaining more adiposity during 1988-84 and 1999-04 based on the NHANES nationally representative data. Adjusting for all other socio-demographic variables (i.e. age group and ethnicity), mean BMI increased for each gender by 0.60-0.64 kg/m^2; mean BMI percentile increased by 3.01-3.15 units, average WC increased substantially by 2.42-2.85 cm; and TST by 0.81-1.18 mm.

Second, although the three different adiposity measures consistently showed that US children at corresponding higher percentiles gained more adiposity, they revealed some differences in the annual distributional shifts. Compared to those at lower percentiles, those at high percentiles gained more WC than BMI, i.e., steeper slopes. This was consistent across sex and ethnic groups, but was more dramatic in adolescents than the 6-11 years old. This suggests that US young people may be at greater obesity related risks than what was revealed by increases in BMI as WC is a better predictor of future health risks such as for type 2 diabetes and heart disease in adults (6-7). In addition, considering that WC (only need a tape to measure) is easier and cheaper to be assessed than BMI, WC may be a more useful measure to be collected in clinical settings and in population-based studies although previously BMI has been widely recommended and used. Note that although some research suggests WC/height may have a better predictive value of cardiovascular disease and its risk factors among children, (25-27) we used WC to allow for comparisons with other studies with children as well as those with adults (12, 28).

Third, ethnic disparities in mean BMI have become wider particularly when comparing black girls to their white counterparts for all ages combined. Moreover, in all four measures, adjusted mean shifts varied significantly across sex, age and race/ethnicity groups. For instance, adjusted mean shifts in means of BMI, WC and TST were largest among adolescents. Among girls but not boys and for all ages combined (2-19 years), NH blacks had significantly larger adjusted mean shifts in all adiposity measures than NH whites. However, when examining ethnic differences in adjusted mean shifts in adiposity within each sex-age group across lowest (Q_1) and uppermost (Q_5) quintiles of distribution, we found other interesting patterns. For instance, among those aged 6-11 years, NH black girls experienced significantly larger adjusted mean shifts in BMI percentiles than NH whites within Q_1 but not Q_5. Among boys aged 6-11 and within Q_5, Mexican-Americans had a significantly larger adjusted mean shift than NH whites in BMI and WC; NH blacks had significantly lower adjusted mean shifts in BMI percentiles than NH whites. Among adolescent boys and girls and in Q_5, BMI percentile shifted upwards in all ethnic groups though was significantly lower among Mexican-Americans compared to NH whites. Previous studies using the same data but examining overweight prevalence in older children and adolescents (6-19 years) by sex and race/ethnicity have indicated that there were larger gender gaps among non-Hispanic Blacks and Mexican-American children and adolescents compared with non-Hispanic Whites (4).

The findings of larger increases in adiposity in adolescents than children, particularly among girls (BMI, WC and TST), suggests that environmental changes in the US may have greater impact on the age group with the greatest degree of autonomy in deciding their health behavior and choices(29). Lifestyles such as higher intakes of energy dense foods and sedentary behaviors may in part explain the age disparities. Differences between age groups may be caused by cohort effects over time rather than by age effects, though this cannot be tested in cross-sectional data. Our previous study on adults showed greater shifts in younger adults compared to older adults (12). These findings suggest that both US adolescents and young adults are the most susceptible age groups to the obesogenic environment.

Moreover, we found a decrease in BMI and TST among NH white children aged 6-11 (especially girls) at high values of the percentile distribution (e.g.,>85th percentile) —their average adiposity at higher percentile ranks in NHANES 1999-04 became lower than that in 1988-94, different from most other groups. This may be due to the increased awareness and related actions taken by their care providers to promote weight loss (30), though further research is needed to test this hypothesis. Moreover, our findings and those by others may also suggest that WC is a better adiposity measure than many of the other ones to help monitor the shifts in adiposity and the related biological and environmental causes considering its many strengths (6, 31).

Two previous studies examined BMI distributional shifts among the youth in the US and Germany, but showed different patterns (13-14). One tested the distributional shifts in BMI among US adults and children using earlier NHANES waves, suggested an increased positive skewness at the upper end of the BMI distribution among younger children and to some extent among adolescents. This finding indicated that the heaviest US group became markedly heavier in NHANES III (1988-94)(13). A recent study conducted among school-age children in East Germany suggested that weight gain was a characteristic of the entire population rather than the highest risk group which reflects the underestimation of the looming public health crisis when presenting only prevalence of overweight or obesity (14).

We suspect that the adjusted mean and annual distributional shift patterns we observed may be attributed to the later phase of the obesity epidemic in the United States compared to other populations under an earlier stage. The U.S. has a powerful obesogenic environment.

Those population groups that are more susceptible (e.g., because of genetic, psychosocial, or behavioral factors) to this environment are likely to gain more weight than other groups – thus, those with high adiposity measures tended to gain more adiposity over time. Meanwhile, obesity-related social support and medical treatment efforts for the extremely obese are stronger in the U.S. than elsewhere (32-33), which could help explain some reductions in the magnitude of both mean and annual distribution shifts in some groups with very high adiposity levels. In some other countries at earlier phases, the patterns may be different, such that the increases in adiposity measures may be more evenly distributed across the distributions or more in the modestly overweight group (34).

Some of the patterns we observed in US children and adolescents differed from those we recently observed in US adults. For example, the annual distributional shifts in women's WC were stable between the 25^{th} and 75^{th} percentiles, but gained pace at higher WC, while women's BMI and men's BMI and WC shifts increased linearly (12). These annual distributional shift patterns observed among adults were comparable with those observed among adolescents but less so among children.

To examine the differences in the magnitude and location of adiposity annual distributional shifts may aid in understanding the roles played by individual-level (e.g., genetics and behaviors) and socio-environmental factors (e.g., changes in food environment, opportunities for physical activity, social norms) across socio-demographic groups. For example, equal shifts across the whole distribution may hint at predominance of environmental changes that are independent of genetic makeup or individual-level behavior changes. In contrast, localized shifts in the upper tail may suggest gene-environment interactions (13, 35), where greater shifts are observed among those susceptible individuals, assuming that the related broad environmental shifts are similar in these individuals' living environments.

Eliminating racial/ethnic and socio-economic disparities in health status including obesity is a national priority as outlined in the US Healthy People 2010. (36) However, the determinants of obesity disparities across ethnic groups in the US are poorly understood although genetic susceptibility has been suggested as an important contributor (5, 37-38). The variation in shift pattern in various adiposity measures across age-, sex- and ethnic groups may provide hints about the causes of the US obesity epidemic. Whereas genetic drifts are unlikely to occur within a period as short as 10 years, changes related to the built and food environments among others, are more probable roots to this problem (39-44). It is possible, however, that the between-group differences in adiposity gain are the result of the interactions between genetic and environmental factors, such that different groups may respond differently to similar overall environmental factors and changes. Gene-environment interaction has been suggested as a model with good fit to human adiposity (5, 37-38). For example, our findings may suggest that for all adiposity measures, subjects who are genetically susceptible and belong to the upper percentiles of the distribution may be more affected by (or respond more to) environmental changes that promote obesity.

Some of our findings point to complex sex-age-ethnicity interactions whereby environmental changes may have had similar effects in some cases and divergent effects in others on overall adiposity (BMI) and body fat distribution (e.g., WC, abdominal fat). For instance, MA girls aged 6-11 (Table 2) had significantly higher adjusted mean shifts in WC compared to NH whites in the uppermost quintile of the distribution but not in the lowest quintile. This pattern was also noted among boys aged 6-11 when contrasting “other ethnicities” with NH whites for the BMI percentiles and TST measures. This pattern may indicate gene-environment interaction whereby the more susceptible group may be influenced to a greater extent by environmental changes. Some of the environmental differences between race/ethnicity and SES groups include access to fitness facilities and different types of food stores and restaurants and different relative food prices may have affected their energy-balance related behaviors, and thus their body weight (44-51).

The present study has a number of strengths, including being based on nationally representative data, and providing national estimates. Second, it is the first study to examine shifts in BMI, WC and TST simultaneously and compare those shifts across sociodemographic groups. A limitation of this study is that analyses of average shifts over time in adiposity are based on two 10-year apart national cross-sectional surveys. It is possible, though unlikely, that minor differences in sampling design and measurements might affect the observed changes. Moreover, some of our statistical tests (e.g., those test changes over time) may be over-conservative, while some may argue smaller p-values should be used for multiple comparisons. In addition, we were unable to examine “other ethnicities”, given the limited sample size especially when broken down by age and sex groups. Finally, these NHANES cross-sectional data cannot allow for testing causal relationships. Although we examined the between group increase/shifts over time in the selected adiposity measures, we could not track the real changes over time in individuals' measures. Nevertheless, as addressed above, our findings provide a number of important insights.

In conclusion, while overall, means of BMI, BMI percentile, WC and TST have increased significantly over time and are expected to do so for most socio-demographic groups in the years to come, patterns of shifts in distribution differed between these four measures and across age, sex and ethnic groups. Overweight US children and adolescents had gained more adiposity, especially central adiposity reflected by waist circumference since the late 1980s. Solely examining changes over time in the prevalence of overweight and obesity assessed based on BMI and related cut points could not capture the complex patterns. More vigorous effort should be made to understand the underlying causes of the differential shift patterns we observed across socio-demographic groups and in various adiposity measures. Such knowledge will help guide future population-based interventions including those focusing on the total population and those targeting at the more vulnerable or genetically susceptible groups.

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Appendices

APPENDIX A: NHANES data set and study samples

NHANES III (1988 to 1994)

NHANES III is a survey that was carried out between 1988 and 1994 using a multistage, stratified sampling design. The survey over-sampled older adults (60 years or more) and minority groups (African Americans and Mexican Americans). Sampled individuals were first interviewed at home and then invited to a mobile examination center (MEC) to undergo body measurements, clinical evaluations and laboratory testing. Anthropometric measurements were performed on all study participants using standardized methods and equipments. BMI was computed based on measured weight and height. Weight was measured on a Toledo self-zoning weight scale while participants wore light clothing provided by MEC. Height was measured with a stadiometer to the nearest millimeter. As for

WC, it was measured in a standard manner using a steel measuring tape to the nearest 0.1 cm. positioning it at a high point of the iliac crest at minimal respiration. The body measurements protocol specified that skinfolds would be measured at four different anatomic body sites (triceps (TST), biceps, subscapular and suprailiac). Independent measures were taken at each body site by two technicians, resulting in a minimum of two skinfold observation for each site. If data were available for the third and fourth measurements and the difference between those measurements was within the specified tolerance limit, then the summary value was the mean of the third and fourth measurements. In all other cases, the summary value was the mean of all available skinfold measurements at that site (15, 19).

NHANES (1999 to 2004)

Since 1999, NHANES has been a continuous annual survey. The data were recently made available for the first 6 years of the period 1999-2004. Three bi-annual waves of NHANES (1999-00, 2001-02 and 2003-04) were combined to enhance statistical power and obtain a more accurate picture of the current situation. The sample selection and data collection were performed similarly to those in NHANES III (25-27).

APPENDIX B

Table

Sample sizes for NHANES III and 1999-4 by age group, sex and race/ethnicity[1]

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness; NH, Non-Hispanic; Mex Am, Mexican American.

	NHANES III			NHANES 1999-04		
	Boys	**Girls**	**Both**	**Boys**	**Girls**	**Both**
BMI samples						
2 to 19	5,176	5,366	10,542	5,826	5,834	11,660
2 to 5	1,748	1,766	3,514	950	927	1,877
6 to 11	1,833	1,833	3,666	1,568	1,598	3,166
12 to 19	1,595	1,767	3,362	3,308	3,309	6,617
NH white	1,384	1,478	2,862	1,569	1,582	3,151
NH black	1,759	1,766	3,525	1,919	1,872	3,791
Mex Am	1,781	1,871	3,652	1,933	1,955	3,888
Other	252	251	503	405	425	830
WC samples						
2 to 19	5,028	5,221	10,249	5,751	5,735	11,486
2 to 5	1,653	1,684	3,337	909	892	1,801
6 to 11	1,811	1,814	3,625	1,556	1,568	3,124
12 to 19	1,564	1,723	3,287	3,286	3,275	6,561
NH white	1,334	1,423	2,757	1,552	1,582	3,134
NH black	1,720	1,714	3,434	1,886	1,872	3,758
Mex Am	1,730	1,840	3,570	1,909	1,955	3,864
Other	244	244	488	404	425	829
TST samples						

	NHANES III			NHANES 1999-04		
	Boys	Girls	Both	Boys	Girls	Both
2 to 19	5,010	5,202	10,212	5,751	5,670	11,421
2 to 5	1,624	1,670	3,294	966	940	1,906
6 to 11	1,814	1,814	3,628	1,555	1,566	3,121
12 to 19	1,562	1,718	3,280	3,230	3,164	6,394
NH white	1,332	1,478	2,810	1,562	1,582	3,144
NH black	1,697	1,766	3,463	1,871	1,872	3,743
Mex Am	1,739	1,871	3,610	1,913	1,955	3,868
Other	242	251	493	405	425	830

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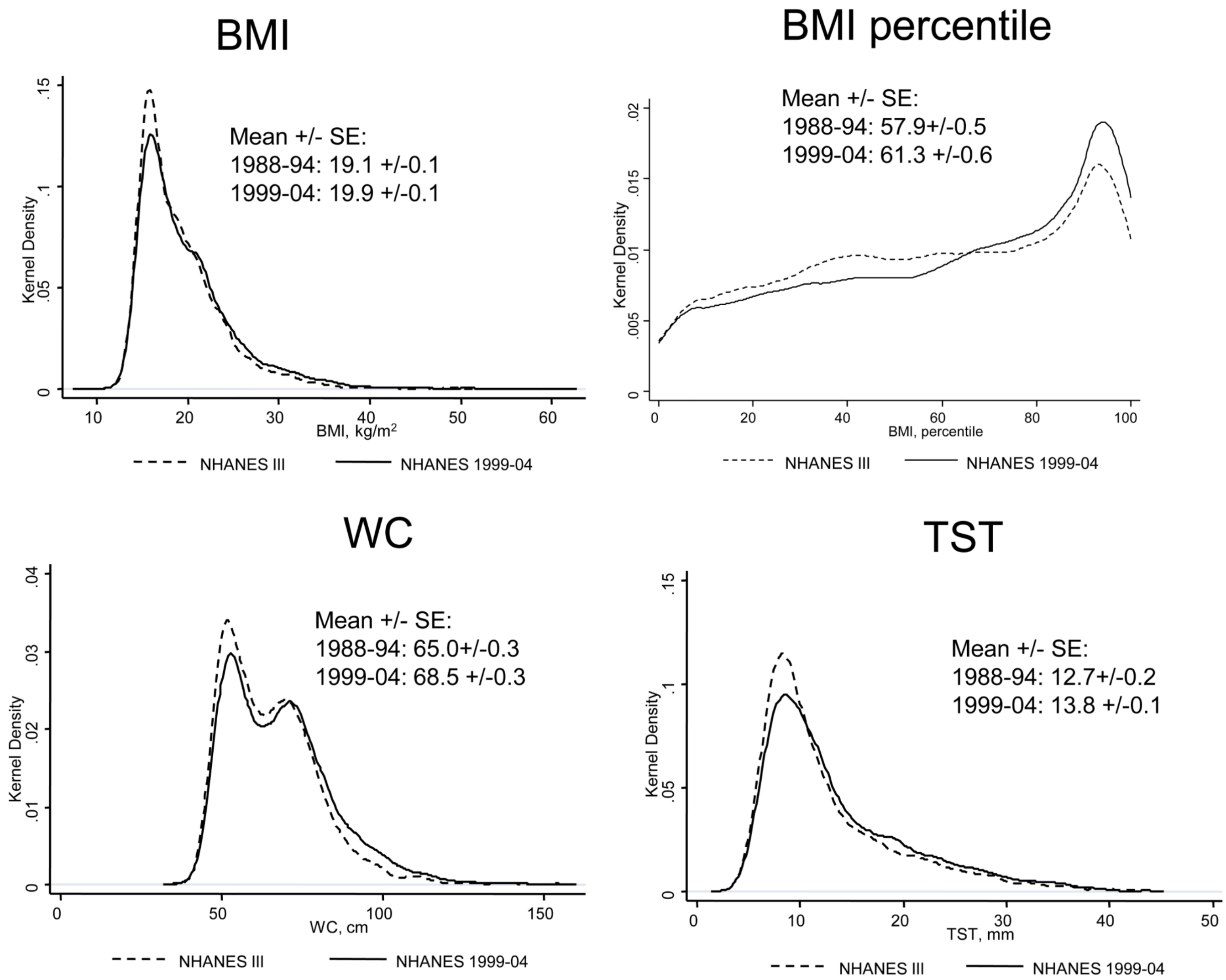


FIGURE 1.

Shifts in distributions of adiposity measures[1] between NHANES III (1988-94) and NHANES 1999-04 among US children and adolescents

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness.

[2] Sample sizes for adiposity measures by period and socio-demographic group presented: BMI (NHANES III: n=10,542; NHANES 1999-04: n=11,660); WC (NHANES III: n=10,249), NHANES 1999-04: N=11,486; TST (NHANES III: n=10,212; NHANES 1999-04: n=11,421)

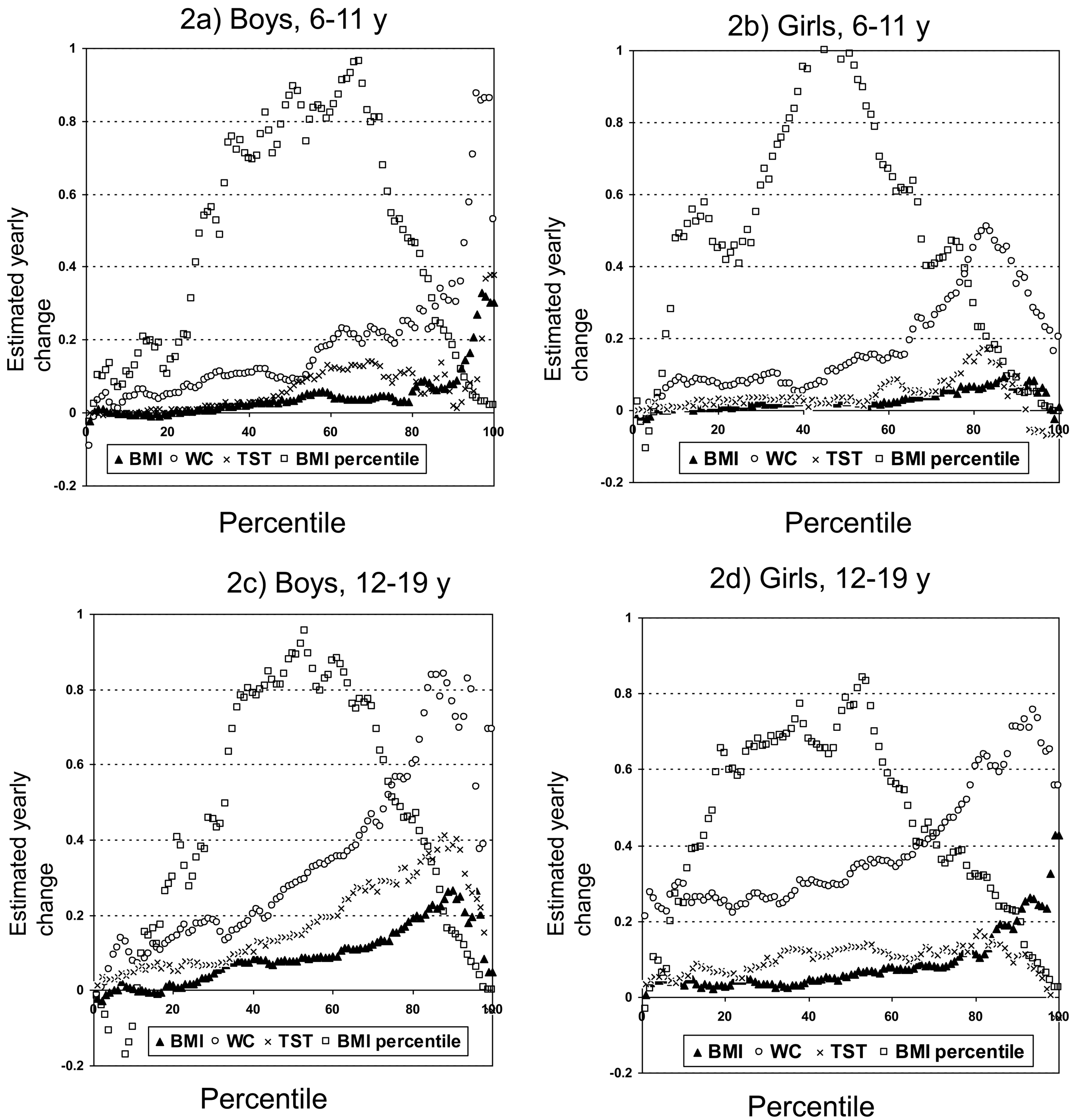


FIGURE 2.

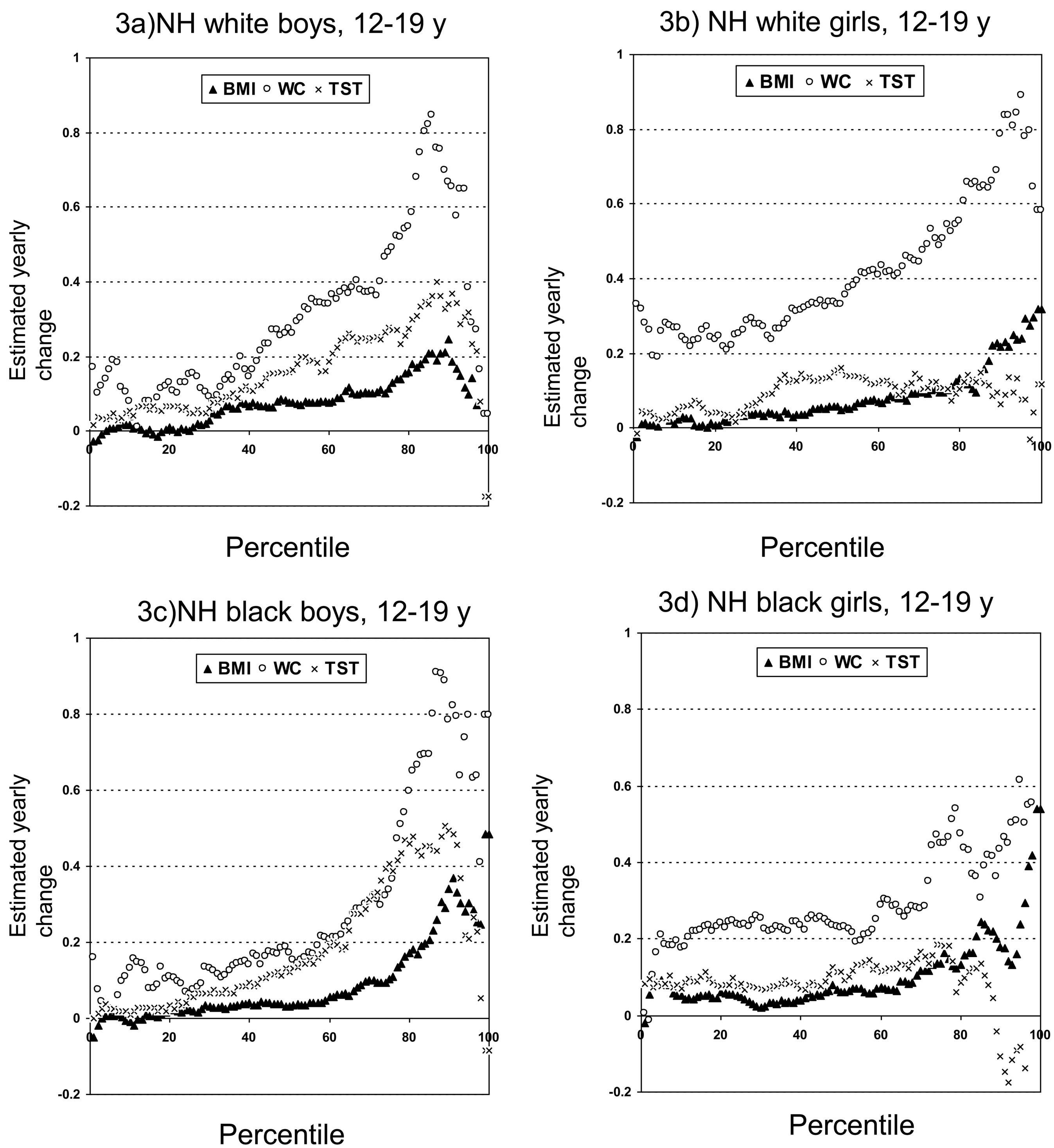
Annual distributional shift in BMI (kg/m2), WC (cm) and TST (mm) in US boys and girls: Ordinary Least Square (OLS) estimate of average yearly shift within percentile groups [1]

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness.

[2] Sample sizes for adiposity measures by period and socio-demographic group presented: BMI [6-11, boys: n=1,833 (III), n=1,556 (1999-04); 6-11, girls: n=1,833 (III), n=1,598 (1999-04)]; [12-19, boys: n=1,595 (III), n=3,308 (1999-04); 12-19, girls: n=1,767 (III), n=3,309 (1999-04)]

WC [6-11, boys: n=1,811 (III), n=1,556 (1999-04); 6-11, girls: n=1,814 (III), n=1,568 (1999-04)]; [12-19, boys: n=1,564 (III), n=3,286 (1999-04); 12-19, girls: n=1,723 (III), n=3,275 (1999-04)]

TST [6-11, boys: n=1,814 (III), n=1,555 (1999-04); 6-11, girls: n=1,814 (III), n=1,566 (1999-04)]; [12-19, boys: n=1,562 (III), n=3,230 (1999-04); 12-19, girls: n=1,718 (III), n=3,164(1999-04)]


3a)NH white boys, 12-19 y
BMI WC TST
Estimated yearly change
Percentile
3b) NH white girls, 12-19 y
BMI WC TST
Estimated yearly change
Percentile
3c)NH black boys, 12-19 y
BMI WC TST
Estimated yearly change
Percentile
3d) NH black girls, 12-19 y
BMI WC TST
Estimated yearly change
Percentile

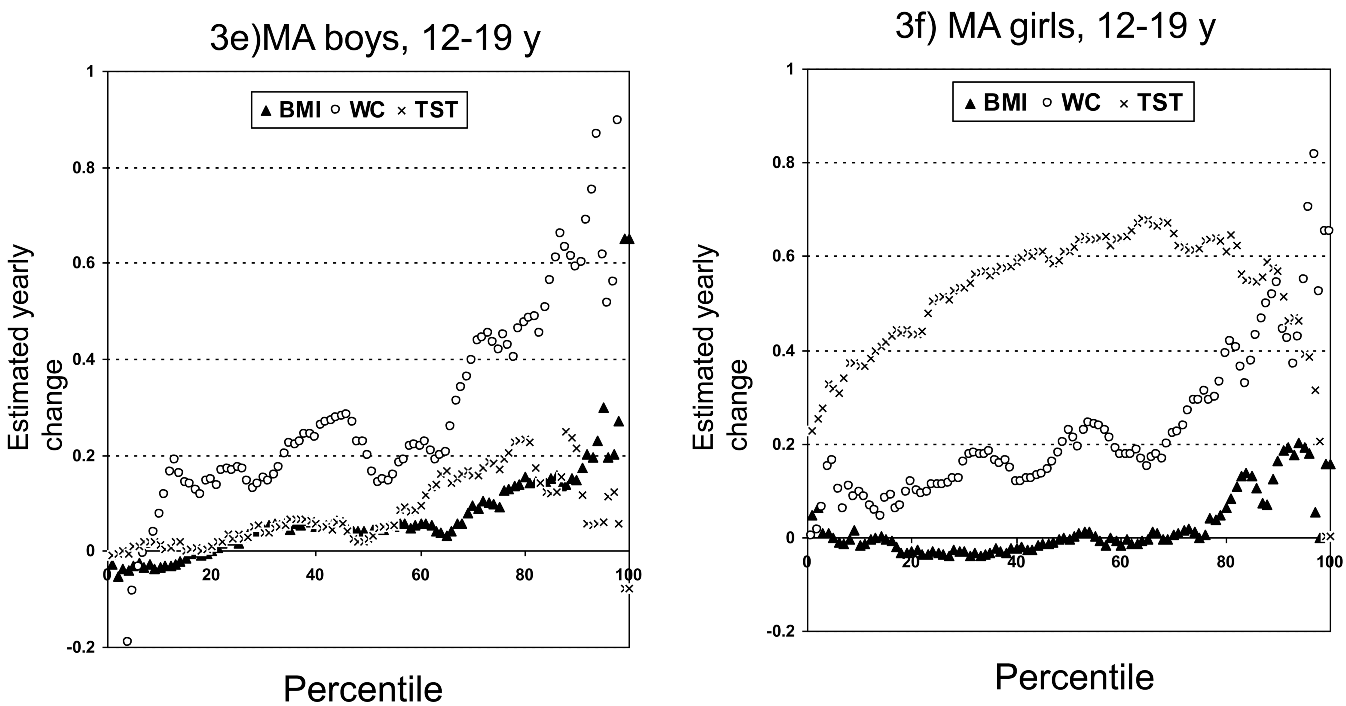
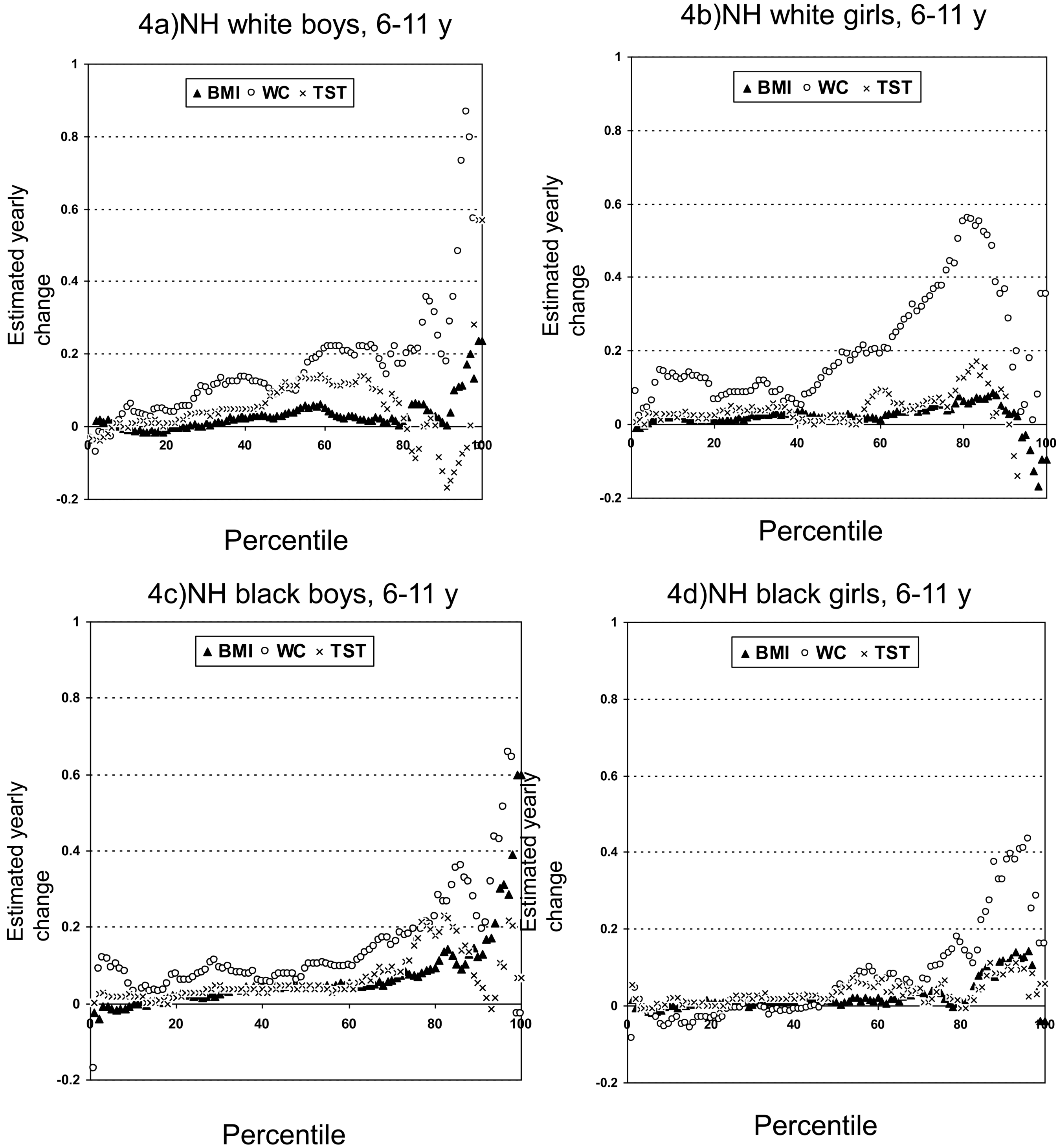
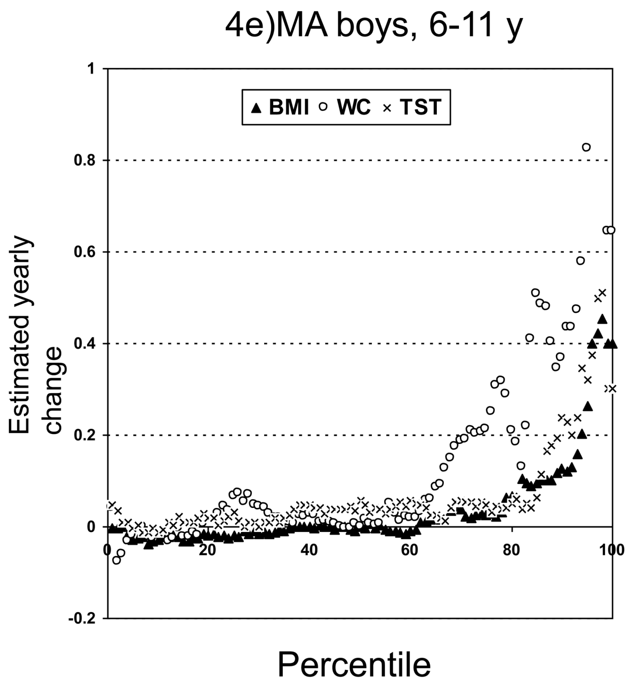


FIGURE 3.
Annual distributional shift in BMI (kg/m2), WC (cm.) and TST (mm.) among adolescents (12-19 years) by sex and ethnicity: Ordinary Least Square (OLS) estimate of average yearly shift within percentile groups [1]

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness; NH, Non-Hispanic; Mex Am, Mexican American.

[2] Sample sizes for adiposity measures by period and socio-demographic group presented:
BMI [**NH White**: 12-19, boys: n=328 (III), n=799 (1999-04); 12-19, girls: n=405 (III), n=796 (1999-04)]; [**NH black**: 12-19, boys: n=479 (III), n=1,015 (1999-04); 12-19, girls: n=536 (III), n=958 (1999-04)]; [**MA**: 12-19, boys: n=479 (III), n=1,067 (1999-04); 12-19, girls: n=479 (III), n=1,080 (1999-04)]
WC [**NH White**: 12-19, boys: n=319 (III), n=795 (1999-04); 12-19, girls: n=399(III), n=783 (1999-04)]; [**NH black**: 12-19, boys: n=469 (III), n=1,003 (1999-04); 12-19, girls: n=520 (III), n=957 (1999-04)]; [**MA**: 12-19, boys: n=470 (III), n=1,067(1999-04); 12-19, girls: n=468 (III), n=1,065 (1999-04)]
TST [**NH White**: 12-19, boys: n=319 (III), n=786 (1999-04); 12-19, girls: n=400 (III), n=769(1999-04)]; [**NH black**: 12-19, boys: n=461 (III), n=979 (1999-04); 12-19, girls: n=515 (III), n=904 (1999-04)]; [**MA**: 12-19, boys: n=473 (III), n=1,049 (1999-04); 12-19, girls: n=467 (III), n=1,031 (1999-04)]


4a)NH white boys, 6-11 y
4b)NH white girls, 6-11 y
4c)NH black boys, 6-11 y
4d)NH black girls, 6-11 y
BMI
WC
TST
Estimated yearly change
Percentile
1
0.8
0.6
0.4
0.2
0
-0.2
0
20
40
60
80
100



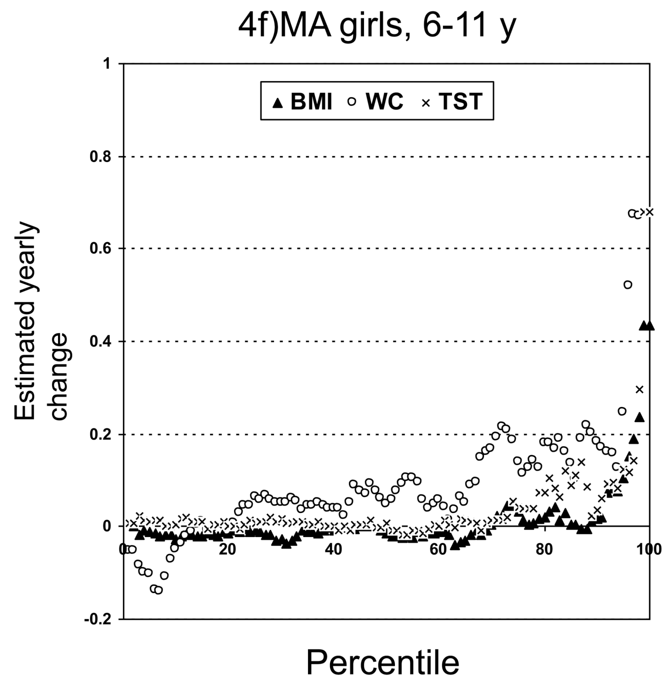


FIGURE 4.

Annual distributional shift in BMI (kg/m2), WC (cm.) and TST (mm.) among children (6-11 years) by sex and ethnicity: Ordinary Least Square (OLS) estimate of average yearly shift within percentile groups [1]

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness; NH, Non-Hispanic; Mex Am, Mexican American.

[2] Sample sizes for adiposity measures by period and socio-demographic group presented: BMI [**NH White**: 6-11, boys: n=439(III), n=421 (1999-04); 6-11, girls: n=426 (III), n=430 (1999-04)]; [**NH black**: 6-11, boys: n=572 (III), n=537 (1999-04); 6-11, girls: n=539 (III), n=552 (1999-04)]; [**MA**: 6-11, boys: n=557 (III), n=524(1999-04); 6-11, girls: n=585 (III), n=520 (1999-04)]

WC [**NH White**: 6-11, boys: n=417 (III), n=566(1999-04); 6-11, girls: n=421 (III), n=529 (1999-04)]; [**NH black**: 6-11, boys: n=533 (III), n=558 (1999-04); 6-11, girls: n=550 (III), n=576 (1999-04)]; [**MA**: 6-11, boys: n=558(III), n=520 (1999-04); 6-11, girls: n=576 (III), n=510 (1999-04)]

TST [**NH White**: 6-11, boys: n=429 (III), n=415 (1999-04); 6-11, girls: n=419 (III), n=419 (1999-04)]; [**NH black**: 6-11, boys: n=565 (III), n=529 (1999-04); 6-11, girls: n=526 (III), n=541 (1999-04)]; [**MA**: 6-11, boys: n=559 (III), n=518 (1999-04); 6-11, girls: n=579 (III), n=511 (1999-04)]

Table 1

Distribution of adiposity measures (mean±SE) and adjusted mean shifts between NHANES III and 1999-04, by sex, age, and race/ethnicity [1]

	BMI, kg/m^2 (mean±SE)			BMI, 2000 CDC percentiles (mean±SE)		
	NHANES III	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**	**NHANES III**	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**
Gender						
Boys	19.0±0.1 *	19.9±0.1 *	0.64±0.15 §	57.8±0.6 *	61.3±0.7 *	3.15±1.10 §
Girls	19.2±0.1	20.0±0.1	0.60±0.15 §	58.1±0.8	61.4±0.7	3.02±0.99 §
Both genders						
Age						
2-5	16.1±0.1 *	16.3±0.1 *	0.21±0.10 †	55.2±0.8 *	57.7±1.0 *	2.25±1.19
6-11	17.8±0.1	18.4±0.1	0.56±0.16 §;‡	58.8±1.0	62.0±1.0	2.96±1.31 †
12-19	22.1±0.2	23.0±0.1	0.90±0.23 §;‡	58.8±1.0	62.6±0.8	3.65±1.19 §
Race/ethnicity						
NH white	19.0±0.1 *	19.7±0.1 *	0.49±0.19 §	57.3±0.7 *	60.3±1.0 *	2.84±1.23 †
NH black	19.4±0.1	20.5±0.1	0.93±0.10 §;‡	58.3±0.5	62.9±0.7	4.43±0.81 §
Mex Am	19.6±0.1	20.2±0.1	0.58±0.16 §	64.1±0.7	64.9±0.8	0.69±1.03
Other	18.8±0.3	20.0±0.3	0.98±0.38 §	55.9±2.1	61.0±1.4	4.86±2.57
Boys						
Age						
2-5	16.1±0.1 *	16.5±0.1 *	0.46±0.12 §	53.6±1.1 *	58.3±1.3 *	3.00±1.61
6-11	17.2±0.2	18.3±0.1	0.56±0.16 §	59.8±1.1	62.4±1.2	3.54±1.52 †
12-19	21.9±0.2	22.8±0.1	0.82±0.26 §	58.5±1.2	61.8±1.0	2.94±1.51
Race/ethnicity						
NH white	19.0±0.2 *	19.7±0.1 *	0.56±0.21 §	58.0±0.8 *	60.8±1.2 *	3.43±1.56 †
NH black	19.0±0.1	20.0±0.1	0.52±0.14 §	56.0±0.9	60.5±0.8	2.17±1.08 †
Mex Am	19.6±0.1	20.4±0.1	0.81±0.17 §	63.5±0.8	66.1±0.9	2.03±1.15
Other	18.4±0.4	20.0±0.4	1.11±0.43 §	54.0±2.7	59.9±2.3	3.92±3.31
Girls						

	BMI, kg/m^2 (mean±SE)			BMI, 2000 CDC percentiles (mean±SE)		
	NHANES III	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**	**NHANES III**	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**
Age						
2-5	16.1±0.1*	16.2±0.1*	-0.03±0.11	56.8±1.1*	57.1±1.1*	1.52±1.33
6-11	17.9±0.2	18.4±0.2	0.45±0.23	57.7±1.4	61.5±1.2	1.79±2.16
12-19	22.3±0.2	23.2±0.2	0.98±0.24$^{§;‡}$	59.2±1.3	63.4±0.9	4.38±1.38§
Race/ethnicity						
NH white	19.0±0.2*	19.7±0.2*	0.42±0.20†	56.6±1.2*	60.0±1.0*	2.23±1.30
NH black	19.8±0.2	21.0±0.1	1.34±0.13$^{§;‡}$	60.6±0.8	65.4±0.8	6.78±0.97$^{§;‡}$
Mex Am	19.6±0.2	20.1±0.1	0.33±0.20	64.7±1.0	63.6±0.9	-0.71±1.29
Other	19.1±0.4	20.1±0.3	0.86±0.41†	57.6±2.7	62.1±1.4	5.78±2.52†
	WC, cm. (mean±SE)			TST, mm. (mean±SE)		
	NHANES III	NHANES 99-04	Adjusted mean shift:: Δ±SE	NHANES III	NHANES 99-04	Adjusted mean shift: Δ±SE
Gender						
Boys	65.4±0.3	68.7±0.3	2.42±0.38§	11.0±0.1*	12.3±0.2*	1.18±0.20§
Girls	64.6±0.5	68.2±0.4	2.85±0.41§	14.5±0.2	15.4±0.1	0.81±0.25§
Both genders						
Age						
2-5	50.8±0.1*	51.8±0.2*	0.89±0.25§	9.4±0.1*	10.1±0.1*	0.57±0.13§
6-11	61.8±0.4	64.4±0.4	2.53±0.45$^{§;‡}$	12.5±0.3	13.4±0.2	0.91±0.30§
12-19	76.3±0.5	80.0±0.4	3.66±0.57$^{§;‡}$	14.8±0.3	16.1±0.2	1.31±0.29$^{§;‡}$
Race/ethnicity						
NH white	65.3±0.5*	68.6±0.4*	2.47±0.51§	12.9±0.2*	13.9±0.2*	0.85±0.28§
NH black	64.2±0.3	67.6±0.3	2.44±0.28§	12.0±0.1	13.2±0.1	1.12±0.16§
Mex Am	66.0±0.3	69.3±0.4	2.90±0.45§	13.2±0.2	14.1±0.1	0.85±0.23§
Other	63.4±1.0	68.4±0.8	3.60±1.04§	12.0±0.5	14.1±0.3	1.82±0.52§
Boys						

	BMI, kg/m^2 (mean±SE)			BMI, 2000 CDC percentiles (mean±SE)		
	NHANES III	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**	**NHANES III**	**NHANES 99-04**	**Adjusted mean shift: Δ±SE**
Age						
2-5	50.6±0.1 *	51.8±0.3 *	0.52±0.30	8.9±0.1 *	9.7±0.1 *	1.92±0.13 §
6-11	61.9±0.4	64.2±0.5	2.00±0.49 §,‡	11.6±0.3	12.5±0.3	1.75±0.30 §
12-19	77.3±0.6	80.5±0.4	3.78±0.62 §,‡	11.7±0.2	13.5±0.2	0.34±0.32 ‡
Race/ethnicity						
NH white	66.0±0.5 *	69.0±0.5 *	2.09±0.59 §	11.3±0.2 *	12.4±0.2 *	1.08±0.29 §
NH black	63.3±0.4	66.5±0.4	2.23±0.42 §	9.8±0.2	11.3±0.2	0.84±0.22 §
Mex Am	66.9±0.3	70.4±0.4	3.00±0.47 §	11.8±0.2	13.0±0.2	1.42±0.27 §
Other	63.0±1.2	68.5±1.1	4.06±1.31 §	9.9±0.4	12.4±0.4	1.98±0.58 §
Girls						
Age						
2-5	50.9±0.2 *	51.7±0.2 *	1.26±0.33 §	10.0±0.1 *	10.5±0.1 *	-0.76±0.21 §
6-11	61.7±0.5	64.5±0.4	1.62±0.61 §,‡	13.4±0.3	14.3±0.2	0.19±0.31
12-19	75.3±0.5	79.4±0.5	3.53±0.63 §,‡	18.1±0.3	18.9±0.2	2.33±0.31 §,‡
Race/ethnicity						
NH white	64.5±0.6 *	68.0±0.6 *	2.55±0.57 §	14.6±0.3	15.4±0.2 *	0.61±0.33
NH black	65.2±0.5	68.7±0.3	3.89±0.34 §,‡	14.3±0.2	15.3±0.2	1.42±0.21 §,‡
Mex Am	65.0±0.4	68.2±0.5	2.41±0.53 §	14.7±0.2	15.3±0.2	0.27±0.25
Other	63.7±1.2	68.2±0.9	3.61±1.13 §	14.0±0.7	15.7±0.4	1.65±0.58 §

[1] BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness; NH, Non-Hispanic; Mex Am, Mexican American.

[#] calculated based on the 2000 CDC Growth Chart.

[*] $p<0.05$ for the null hypothesis that means of BMI/WC/TST are equal between socio-demographic variable categories, ANOVA test.

[†] $p<0.05$ for null hypothesis that adjusted mean shift $\Delta=0$, Wald test.

[§] $p<0.01$ for null hypothesis that adjusted mean shift $\Delta=0$, Wald test.

[‡] $p<0.05$ for null hypothesis of no group difference in adjusted mean shift Δ for each adiposity measure, considering the top group as the referent category (i.e. Boys, 2-5 and NH Whites), Wald test.

Table 2

Adjusted Mean Shifts in adiposity measures among children and adolescents between NHANES III and 1999-04 periods: Estimates based on Multivariate OLS regression models[1]

	BMI, kg/m^2 (Δ±SE)		BMI, 2000 CDC percentiles (Δ±SE)	
	Q1	**Q5**	**Q1**	**Q5**
2 TO 5				
Boys				
NH white	0.17±0.08†	1.07±0.43§	1.69±1.19	2.19±0.54§
NH black	0.07±0.08	-0.83±0.42‡	-1.22±1.17‡	0.36±0.60‡
Mex Am	0.30±0.08§	1.48±0.39§	1.56±1.39	2.50±0.36§
Other	0.25±0.17	2.31±0.77§	1.94±2.56	3.81±0.80§;‡
Girls				
NH white	-0.10±0.06	0.40±0.32	0.84±1.03	1.88±0.62§
NH black	-0.04±0.09	-0.41±0.49	0.51±1.08	1.67±0.46§
Mex Am	-0.07±0.08	-0.74±0.45‡	-0.51±1.35	1.38±0.48§
Other	-0.19±0.19	1.15±0.89	0.74±2.71	3.49±1.08§
6 TO 11				
Boys				
NH white	0.06±0.10	0.98±0.50	0.88±1.22	0.93±0.33§
NH black	0.10±0.08	1.20±0.49§	0.62±1.07	0.06±0.29‡
Mex Am	0.00±0.12	2.50±0.33§;‡	-2.05±1.35	0.65±0.22§
Other	0.13±0.16	2.23±0.70§	1.13±2.60	2.55±0.64§;‡
Girls				
NH white	0.05±0.08	1.08±0.44§	1.02±1.07	0.90±0.30§
NH black	0.52±0.33	2.37±1.78	6.66±2.70§;‡	-0.43±0.94
Mex Am	0.49±0.25	3.51±1.52†;‡	5.16±3.05	2.36±0.86§
Other	0.58±0.33‡	2.85±2.02	1.22±5.54	2.76±1.20†
12 TO 19				
Boys				
NH white	-0.43±0.15§	1.74±0.78†	-0.01±1.21	1.41±0.32§
NH black	-0.12±0.09‡	2.79±0.65§	-1.31±0.80	1.22±0.21§
Mex Am	-0.30±0.14†	2.40±0.61§	-4.28±1.25†;‡	0.65±0.22§;‡
Other	-0.36±0.21	2.99±0.94§	0.24±3.10	3.02±0.71§
Girls				
NH white	0.03±0.15	1.38±0.76	2.35±0.94§	0.68±0.47
NH black	0.34±0.16†;‡	2.43±0.93§	1.06±1.39	0.49±0.39
Mex Am	0.16±0.18	2.04±0.84§	-1.92±1.61‡	-0.07±0.39‡

	BMI, kg/m² (Δ±SE)		**BMI, 2000 CDC percentiles (Δ±SE)**	
	Q1	**Q5**	**Q1**	**Q5**
Other	0.10±0.24	2.62±0.95[§]	2.60±3.35	2.29±0.81[§]
	WC, cm. (Δ±SE)		TST, mm. (Δ±SE)	
	Q1	Q5	Q1	Q5
2 TO 5				
Boys	-.60±0.22[§]	2.24±1.13	0.65±0.10[§]	2.94±0.60[§]
NH white	-.79±0.26[§]	-2.41±1.10[†;‡]	1.09±0.11[§;‡]	0.76±0.61[‡]
NH black	0.14±0.33	3.46±1.03[§]	0.75±0.16[§]	3.42±0.57[§]
Mex Am	0.02±0.46	6.34±2.73[†]	0.86±0.20[§]	6.33±1.22[§;‡]
Other				
Girls	0.33±0.32	2.69±0.90[§]	-0.94±0.11[§]	-0.29±0.54
NH white	0.48±0.31	0.77±1.37	-0.35±0.12[§;‡]	0.24±0.79
NH black	0.54±0.27[†]	-0.84±1.07[‡]	-1.14±0.16[§]	-1.07±0.63
Mex Am	1.13±0.60	5.89±2.59[†]	-0.89±0.25[§]	2.26±1.32
Other				
6 TO 11				
Boys	0.22±0.26	5.12±1.10[§]	0.68±0.11[§]	2.63±0.67[§]
NH white	0.29±0.26	2.72±1.34[†]	0.69±0.10[§]	1.50±0.61[§]
NH black	0.82±0.25[§]	7.98±0.96[§;‡]	0.92±0.14[§]	3.11±0.60[§]
Mex Am	0.84±0.10	9.22±2.70[§]	0.89±0.18[§]	6.02±1.45[§;‡]
Other				
Girls	1.07±0.22[§]	6.27±1.35[§]	-0.07±0.14	0.38±0.70
NH white	1.79±0.77[†]	5.83±4.35	0.03±0.34	-2.77±1.89
NH black	2.31±0.86[§]	10.67±4.12[§]	1.09±0.36[§;‡]	1.55±1.67
Mex Am	1.87±1.34	10.31±4.93[†]	0.84±0.70[‡]	5.01±3.41
Other				
12 TO 19				
Boys	0.22±0.42	8.11±1.77[§]	-0.47±0.13[§]	0.93±0.58
NH white	-0.25±0.32	7.38±1.49[§]	-0.37±0.09[§]	1.24±0.61[†]
NH black	1.16±0.40[§]	9.22±1.41[§]	-0.47±0.16[§]	0.49±0.65
Mex Am	0.84±0.52	12.22±3.27[§]	-0.26±0.26	4.32±1.53[§]
Other				
Girls	2.04±0.42[§]	4.44±1.68[§]	1.11±0.17[§]	1.71±0.63[§]
NH white	1.56±0.46[§]	3.71±1.99	1.22±0.19[§]	2.02±0.82[§]
NH black	2.98±0.53[§]	5.55±1.87[§]	1.11±0.19[§]	1.27±0.85

	BMI, kg/m^2 (Δ±SE)		BMI, 2000 CDC percentiles (Δ±SE)	
	Q1	**Q5**	**Q1**	**Q5**
Mex Am	2.65±0.47[§]	8.54±3.01[§]	1.32±0.26[§]	5.09±1.40[§]

[1]BMI, body mass index; WC, waist circumference; TST, triceps skinfold thickness; NH, Non-Hispanic; Mex Am, Mexican American.

[#]calculated based on the 2000 CDC Growth Chart.

[†]p<0.05 for null hypothesis that adjusted mean shift Δ=0, Wald test.

[§]p<0.01 for null hypothesis that adjusted mean shift Δ=0, Wald test.

[‡]p<0.05 for null hypothesis of no ethnic difference in adjusted mean shift Δ, taking NH Whites as the referent category with each sex and age category and for each adiposity measure.