Does child–parent resemblance in body weight status vary by sociodemographic factors in the USA?

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ABSTRACT

Background Clustered obese parents and children are prevalent, but there is little knowledge about whether and how child–parent resemblance varies by sociodemographic groups.

Methods This paper used nationally representative data from the National Health and Nutrition Examination Survey III (NHANES: 1988–1994). We matched 4958 parents with 6765 children aged 2–16 years old for whom we had complete data on body mass index (BMI), overweight and obesity status. Correlation coefficients and κ statistics between parents' and children's BMI and body weight status were calculated for different sociodemographic groups. Multivariate linear and logistic regression models were fit to study the child–parent resemblance and socioeconomic and demographic differences in the resemblance.

Results The child–parent correlation coefficients for BMI were greater in Caucasians than in minorities and greater in groups with higher socioeconomic status. The mother–child resemblance in BMI was negatively associated with child age ($p<0.001$). The mother–daughter resemblance in overweight was significantly lower in non-Hispanic blacks (OR=0.53, 95% CI (0.36 to 0.78)) and Mexican Americans (OR=0.58, 95% CI (0.36 to 0.93)) than in Caucasians. The father–child resemblance in overweight was significantly lower in high school graduates compared with those with less-than-high-school-graduate fathers (OR=0.53, 95% CI (0.37 to 0.77) for father–son dyads and OR=0.69, 95% CI (0.50 to 0.96) for father–daughter dyads). Similar results were found for parent–child resemblance in obesity.

Conclusions Child–parent resemblance in body weight status exists across sociodemographic groups in the USA, but it varies by demographics and socioeconomic status.

INTRODUCTION

The prevalence of overweight and obesity has reached alarming levels in the USA and many other countries worldwide.[1–3] Family factors such as socioeconomic status (SES) affect the problem.[4 5] Clustered obese parents and children are prevalent, which is likely due to their shared genes, food resources, eating behaviours and habitual physical activities.[6–9] The resemblance of children's and their parents' weight status has been the focus of long-term interest, which has assisted in developing effective obesity interventions.[10–13] Among multiple approaches to control childhood obesity, family-based interventions have proven to be effective.[14] This line of research suggests that both parents and children should be the intervention targets instead of only the child and that parental weight changes could be a significant predictor of children's weight change.[13] Understanding the factors affecting the child–parent resemblance in body weight can guide the development of even more effective interventions to kerb the obesity epidemic.

There is little knowledge about whether and how child–parent resemblance varies by sociodemographic groups based on the national data. Although the resemblance in body weight may largely reflect genetic heritage, sociodemographic factors may affect genetic expression and thus also have an impact on body mass accumulation.[15] For example, obese parents with higher SES may be able to afford more healthy food choices for their children, so the biological effects can be offset to some degree, although this is still a hypothesis to be tested. Understanding the variations in child–parent weight resemblance will help policy experts to design more effective family-based interventions that are geared towards particular sociodemographic population groups, not only towards low SES groups. For example, one of the most effective family-based interventions was a parent training programme that required parents to change their eating behaviour and physical activities as well as their children's.[13] Most of the existing studies in the literature on child–parent weight resemblance have relied on small or local population samples.[10–13] A limitation of such studies is that they may be affected by regional differences or sampling bias.[16] Moreover, these studies have not examined the association between the resemblance and sociodemographic factors.

To fill these gaps in the literature, we used a large, nationally representative data set for the USA and applied innovative measures to study child–parent weight resemblance. We were able to compare this resemblance across sociodemographic groups and formally test the significance of these variations.

METHODS

Data and study sample

We used data from the Third National Health and Nutrition Examination Survey (NHANES III), 1988–1994. NHANES was a series of cross-sectional surveys on non-institutionalised US individuals that collected detailed sociodemographic and health information from the participants. NHANES III was a nationally representative survey using multistage sampling of 20 050 adults and 13 944 children aged 2 months to 20 years. Some of these adults and children were sampled from the same households. NHANES III provided a family sequence number and linked birth certificate information to 8836 children surveyed. The key

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variables for matching parents and children were either not available in previous rounds or not publically accessible in subsequent surveys. Therefore, NHANES III created a unique opportunity for researchers to match parents with their children and study the child–parent resemblance in body weight status using nationally representative data.

Matching children and their parents' data

NHANES III used a family sequence number to identify adults and children in the same family. However, there was no variable to identify the nature of the relationship between the child and the adult. The literature suggests using sex as the key variable to identify father or mother.[17] However, using only sex as the variable may result in a one-to-many relationship between child and parents, that is, one child may have multiple 'fathers' or 'mothers' in the same household, when in fact some of the adults may be grandparents or siblings. Therefore, we improved the matching by using the age information in the natality file of NHANES, which had used the birth certificates of 8836 children surveyed in NHANES III to determine the ages of the mother and father when the child was born. Then we matched the age of the parent from the natality file plus the age of the child with the ages of adults in the same households. For example, the natality file might have suggested that the father was 30 years old when the child was born. In NHANES, the child was 10 years old, and there was a male in the same household aged 40 years, so we identified this adult as the child's father. A 1-year difference was allowed in the matching due to possible age-reporting errors.

The final sample for analysis had 4958 parents matched with 6765 children aged 2–16 years old, including 2121 fathers and 2837 mothers, 3388 sons and 3377 daughters. The child–parent pairs had 1789 father–son, 1816 father–daughter, 2524 mother–son and 2519 mother–daughter couples. Note that the number of mother–child dyads is greater than the number of father–child dyads, since the sampling of NHANES III reflected the family structure in the USA, in which more children lived in single mother families than in single father families.[18]

Key study variables

Definition of body weight status for children and their parents

NHANES III used standard protocols and direct physical examination in a mobile examination centre to collect each individual's body weight and height. Body mass index (BMI) was defined as weight (kg)/height^2 (m^2). Adults' body weight status was defined as overweight if BMI ≥25 and obese if BMI ≥30. For children, there are two sets of BMI references for the classification of overweight and obesity: one by the International Obesity Task Force (IOTF) and the other by the US Centers for Disease Control and Prevention (CDC). The IOTF reference was developed based on data collected in Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the USA, and is widely used for international studies on childhood obesity.[19] The 2000 US CDC reference was based on nationally representative data from the National Health Examination Survey (NHES) and the National Health and Nutrition Examination Survey (NHANES).[20] In this paper, children's body weight status was categorised based on the age–sex-specific BMI percentile in the 2000 US CDC Growth Chart: overweight (including obesity), if BMI ≥85th centile; obese, if BMI ≥95th centile. The parental overweight or obesity status was defined as having at least one of the parents overweight or obese.

Child–parent weight resemblance

We created two resemblance measures to summarise the difference between parental and children's body weight status. Since BMI is a continuous variable, we first created a so-called dissimilarity score, which was the absolute difference between the decile ranks of the children's age–sex-specific BMI percentile and their parents' BMI. The dissimilarity score was greater if there was more disparity between parents' and children's BMI decile ranks. Higher dissimilarity values indicate greater variability between parents' and children's body weight status. Second, for overweight/obese status, we created a 'concordance score', which was 1 if the child's overweight/obese status (overweight/obese or not) was the same as their parents'. Otherwise, it was 0.

Sociodemographic characteristics

Demographic characteristics included the child's age, gender and parental race/ethnicity. Since there is no clear definition of obesity for children younger than 2 years old and the NHANES III youth file only included children up to 16 years old,[20] our analytical sample included children aged from 2 to 16. Based on the WHO's definition of adolescence, we categorised the children into two age groups, 2–10 and ≥10.[21]

Since 1997, the US Office of Management and Budget (OMB) has required all federal agencies to report data at least in five races (white, black or African-American, American Indian or Alaska Native, Asian and Native Hawaiian or other Pacific Islander) and two ethnic groups (Hispanic or not).[22] NHANES created four mutually exclusive racial/ethnic groups (non-Hispanic white, non-Hispanic black, Mexican American and other) for the basis of the sampling and weighting. The official NHANES III guideline recommends using these four racial/ethnic groups in analyses.[23] The 'other race/ethnicity' group accounted for 8% of the NHANES III sample and included a diverse population, such as Aleut, Eskimo, American Indian, Asian or Pacific Islander, and other multiracial/ethnic groups. Owing to the small sample size and heterogeneous nature of the 'other race/ethnicity' group, it is a common practice to exclude this group from analysis, including in the US CDC's report.[24] Our analytical sample included only 193 children in the 'other race/ethnicity' group, so we did not conduct any stratified analyses for this group.

SES included parental education and family income measured using poverty income ratios (PIRs). PIR is the ratio of household income and the poverty threshold published by the Census Bureau for a certain family size in a given calendar year. Specifically, we used the PIR tertiles to indicate SES groups: 0–129% were considered poor, 130–299% were near-poor and 300%+ were not-poor. Parent's education in years was taken as the highest level of education completed among the parents and was divided into three categories: less than high school, high school graduates, and some college or graduate-level education.[16]

Statistical analysis

Correlation coefficients and κ statistics

The agreement between parent and child BMI as well as body weight status were examined through correlation coefficients and κ statistics. If the child had two parents, the maximum parental BMI was used to calculate the parent–child correlation coefficients. Note that parents and children need to be in the same overweight category to show an agreement on overweight. For example, if the child was obese but the parent was overweight, that was not considered as concordance. To test the difference in correlation coefficients of BMI, we applied Fisher's r-to-z transformation.

Regression analysis

First, we conducted logistic regression analysis with the child's overweight/obesity status as the outcome and a binary indicator for having at least one overweight/obese parent. We stratified the analyses across socioeconomic groups and compared the ORs to examine whether the risk of having an overweight/obese child among overweight/obese parent differs across SES.

Then, using dissimilarity score and concordance score as the outcomes, we fit multivariate linear regression models for continuous outcomes and logistic regression models for categorical outcomes. All models were stratified by four pairs of child–parent relationships: father–son, father–daughter, mother–son and mother–daughter. ORs and 95% CIs were reported for logistic regression models. All regression models included socio-demographic variables such as child's age, race/ethnicity, PIR, parent's education, metropolitan status and parent's smoking habits. The estimation took into account the complex survey design in the NHANES III, to provide nationally representative estimates. SAS V.9.3 was used in the analysis.[25]

RESULTS

Characteristics of child–parent pairs

Table 1 presents the descriptive statistics of the child–parent dyads. The average age of parents was about 35 years, and the

Table 1 Characteristics of matched US parents and their children in NHANES III (1988–1994)

	All (mean/%±SD)	Males (mean/%±SD)	Females (mean/%±SD)
Parental characteristics			
Number of parents	4958	2121	2837
Age of parents (years)	34.9±0.2	37.0±0.2	32.8±0.2
Parents' race/ethnicity (%)			
Non-Hispanic white (N=1385)*	71.5±1.5	76.0±1.6	67.0±1.7
Non-Hispanic black (N=1599)	13.1±0.8	8.9±0.6	17.1±1.1
Mexican American (N=1781)	7.5±0.7	7.5±0.7	7.4±0.6
Other (N=193)	8.0±1.1	7.6±1.2	8.4±1.3
Education of parents (school years)	12.6±0.1	12.8±0.1	12.3±0.1
Less than HS (N=2255)	21.7±1.4	21.1±1.7	22.4±1.7
Non-Hispanic white (N=218)	14.1±1.4	14.4±1.7	13.8±2
Non-Hispanic black (N=642)	26.8±1.6	25.9±1.7	27.8±1.9
Hispanic (N=1298)	56.2±3	57.5±3.6	54.9±3.1
High school graduate (N=3498)	67.8±1.6	67.7±1.9	68±2.2
Non-Hispanic white (N = 1008)	72.0±2.1	70.9±2.7	73.2±2.6
Non-Hispanic black (N = 1479)	69.8±1.6	70.8±1.7	68.7±2.1
Hispanic (N=874)	41.7±3.3	41.1±3.9	42.3±3.4
College (N=306)	10.5±1.2	11.2±1.5	9.6±1.3
Non-Hispanic white (N = 174)	13.9±1.8	14.7±2.4	12.9±2
Non-Hispanic black (N = 70)	3.4±0.7	3.3±0.7	3.5±0.9
Hispanic (N=39)	2.1±1.1	1.4±0.6	2.8±1.6
PIR (%)			
Poor (PIR 0–129) (N=1895)	22.8±1.5	16.0±1.5	29.6±1.6
Non-Hispanic white (N=215)	14.3±1.7	10.2±1.7	18.9±1.8
Non-Hispanic black (N=693)	43.7±2.5	28.1±2.5	51.8±2.5
Hispanic (N=909)	57.4±2.4	53.2±2.4	61.5±2.9
Near-poor (PIR 130–299) (N=1738)	42.2±1.7	43.2±2.2	41.1±1.6
Non-Hispanic white (N=609)	43.2±2.3	42.7±2.7	43.7±2.3
Non-Hispanic black (N=548)	39.4±2	46.2±2.4	35.9±2.1
Hispanic (N=519)	32.4±1.8	34.6±1.8	30.2±2.3
Not poor (PIR ≥300) (N=909)	35.0±1.6	40.8±2.0	29.3±1.5
Non-Hispanic white (N=509)	42.5±2	47.1±2.3	37.4±2.1
Non-Hispanic black (N=226)	16.9±1.5	25.7±2.1	12.4±1.4
Hispanic (N=149)	10.2±1.3	12.2±1.6	8.2±1.2
Parental BMI (kg/m^2)	26.5±0.2	27.0±0.2	26.1±0.3
Parental overweight (%)†,‡	63.8±1.5	60.7±1.9	49.3±1.8
Parental obesity (%)	29.0±1.3	21.2±1.2	24.9±1.9
Children's characteristics			
Number of children	6765	3388	3377
Age of children (years)	9.9±0.1	9.9±0.1	9.8±0.2
Children's BMI (kg/m^2)	19.1±0.1	19.0±0.2	19.1±0.2
Children's overweight (%)	27.3±1.3	27.2±1.6	27.5±1.8
Children's obesity (%)	12.0±1.0	12.6±1.2	11.3±1.3

*N is the raw number of observations without sampling weight adjustment.
†Parental obesity or overweight is taken as having at least one obese or overweight parent.
‡Overweight is defined as BMI ≥25 for adults and the 85th centile for children.
BMI, body mass index; PIR, poverty income ratio.

average age of children was 10 years. The majority of the parents were non-Hispanic white (71.5%). The mean schooling of the parents was 12.6 years. There were 22.8% of parents living under 130% of the poverty line. Note that the prevalence of poverty status among mothers was greater than that among fathers (29.6% vs 16%).

Average BMI was 26.5 for parents and 19.1 for children. About 29% of children had at least one parent who was obese. The prevalence of obese parents is based on either parent's obesity status; the obesity prevalence in fathers and mothers as distinct groups was smaller (21.2% in fathers and 24.9% in mothers vs 29% having at least one obese parent). The prevalence of overweight (BMI ≥25) was greater in fathers than in mothers (60.7% vs 49.3%), but mothers had a greater prevalence of obesity than fathers (24.9% vs 21.2%). The prevalence of obesity among children was 12%, but slightly more boys than girls were obese (12.6% vs 11.3%).

Child–parent resemblance in body weight status

Table 2 presents the correlation coefficient (r) for BMI and κ for the body weight statuses between parents and children. Concordance between parents' and children's BMI was consistently significant. The father–son dyad's BMI correlation coefficient was the greatest among the four types of child–parent pairs (r=0.34), while the father–daughter dyad's BMI correlation coefficient was the weakest (r=0.25). There was a significant difference between correlation coefficients of BMI across dyads (p =0.035).

BMI correlation coefficients varied significantly across race/ethnicity. All other correlation coefficients were significantly different across race/ethnicity (p<0.05), except for BMI correlation coefficients between Mexican Americans and Caucasians in mother–son dyads (p>0.1) and Mexican Americans and African-Americans in mother–daughter dyads (p=0.06). Black fathers–children (sons or daughters) had the weakest concordance compared with white and Mexican American groups. The correlation coefficient of black father–daughter BMI was the only insignificant coefficient among all of the race–ethnic groups. White and Mexican American mother–son dyads had stronger BMI concordance than their black peers (r=0.33, 0.33, 0.28 for Caucasians, Mexican Americans and African-American, respectively, with p<0.05), but white mothers–daughters had the strongest BMI concordance among the three race/ethnic groups. In general, white children–parents had a larger correlation coefficient of BMI than minorities. Younger daughters and older sons had greater BMI correlations with their parents. Father–daughter BMI correlation decreased with family income level; contrarily, mother–child BMI correlation increased with family income level. College-educated parents had the weakest BMI correlation with their children, but high-school-graduate parents had the strongest BMI correlation among all three educational groups (eg, r=0.01, 0.35 and 0.13 for mother–daughter dyads with education statuses of college, high school graduate and less than high school graduate, respectively). The child–parent concordance in obesity and overweight were similar to that of BMI in terms of gender, race/ethnicity and SES.

Risk of having an overweight/obese child among overweight/obese parents across sociodemographics

The different ORs in table 3 indicate the varying risks across racial/ethnic or socioeconomic groups of having an overweight/obese child with an overweight/obese parent. In almost all sociodemographic groups, having an overweight/obese parent was a significant risk factor for a child to be overweight/obese. Only a few insignificant ORs were found among non-Hispanic black parents, parents with less than a high school education, or parents with college education. The ORs of black overweight/obese parents were smaller than white or Hispanic parents (eg, the OR of a black obese parent having an overweight child was 1.55 vs 2.19 among Hispanic parents and 2.94 among white

Table 2 Sex–age-specific Pearson correlation coefficients of BMI and κ statistics of body weight status between US parents and children in NHANES III (1988–1994)

	Correlation coefficient of BMI (r)					κ of Overweight*							κ of obesity†		
Group	P–C	F–S	F–D	M–S	M–D	P–C	F–S	F–D	M–S	M–D	P–C	F–S	F–D	M–S	M–D
All	0.27	0.34	0.25	0.31	0.30	0.11	0.15	0.07	0.15	0.17	0.14	0.15	0.11	0.17	0.19
Child age															
Child age (≥2 & ≤10)	0.30	0.31	0.26	0.31	0.34	0.10	0.14	0.08	0.17	0.15	0.15	0.17	0.17	0.19	0.22
Child age >10	0.27	0.33	0.24	0.33	0.27	0.11	0.15	0.06	0.13	0.19	0.12	0.14	0.07	0.16	0.14
Parental race/ethnicity															
Non-Hispanic white	0.30	0.36	0.29	0.33	0.32	0.13	0.16	0.05	0.17	0.24	0.14	0.14	0.11	0.24	0.24
Non-Hispanic black	0.22	0.16	0.09§	0.28	0.27	0.08	0.05	−0.02	0.11	0.09	0.12	0.20	0.06	0.11	0.15
Mexican American	0.22	0.31	0.21	0.33	0.23	0.09	0.08	0.05	0.11	0.11	0.15	0.17	0.17	0.17	0.20
PIR															
Poor (PIR 0–130)	0.24	0.34	0.29	0.25	0.25	0.10	0.14	0.16	0.10	0.15	0.14	0.24	0.20	0.08	0.17
Near-poor (PIR 130–300)	0.25	0.33	0.24	0.28	0.26	0.11	0.13	0.07	0.11	0.12	0.10	0.12	0.12	0.16	0.10
Not poor (PIR ≥300)	0.40	0.34	0.21	0.47	0.55	0.13	0.17	0.05	0.25	0.30	0.16	0.16	0.04	0.36	0.40
Parent education															
College	0.15	0.33	0.06§	0.16§	0.01§	0.11	0.14	0.08	0.28	0.05	0.09	0.10	0.08	0.20	0.20
High school graduate	0.31	0.34	0.25	0.35	0.35	0.12	0.14	0.08	0.18	0.21	0.13	0.08	−0.03	−0.02	0.04
Less than high school	0.14	0.32	0.25	0.17	0.13	0.09	0.17	0.09	0.04	0.08	0.15	0.27	0.16	0.11	0.15

*Overweight (including obesity): BMI ≥25 for adults or BMI ≥85th centile for children.
†Obesity: BMI ≥30 for adults or BMI ≥95th centile for children.
§Not significant at 0.05 level.
F–D, father–daughter; F–S, father–son; M–D, mother–daughter; M–S, mother–son; P–C, parent–child.
BMI, body mass index; PIR, poverty income ratio.

Table 3 ORs of overweight/obese child with at least one overweight/obese parent in the USA stratified by sociodemographics*

Outcome	Child was overweight (≥85th centile)		Child was obese (≥95th centile)	
Risk factor	At least one parent is overweight (BMI ≥25) OR (95% CI)	At least one parent is obese (BMI ≥30) OR (95% CI)	At least one parent is overweight (BMI ≥25) OR (95% CI)	At least one parent is obese (BMI ≥30) OR (95% CI)
Group: all children	2.05 (1.45 to 2.9)	2.49 (1.8 to 3.43)	2.02 (1.25 to 3.25)	2.62 (1.88 to 3.67)
Groups by parental race/ethnicity				
Non-Hispanic white	2.47 (1.50 to 4.08)	2.94 (1.80 to 4.81)	2.40 (1.28 to 4.51)	3.23 (1.94 to 5.34)
Non-Hispanic black	1.37 (0.99 to 1.92)	1.55 (1.13 to 2.14)	1.58 (1.04 to 2.39)	2.08 (1.52 to 2.84)
Mexican American	1.99 (1.32 to 3.00)	2.19 (1.68 to 2.88)	2.89 (1.76 to 4.73)	3.14 (2.48 to 3.98)
Groups by PIR				
Poor (PIR <130)	1.93 (1.22 to 3.06)	2.55 (1.67 to 3.90)	1.64 (0.91 to 2.98)	2.56 (1.62 to 4.07)
Near-poor (PIR 130–300)	1.90 (1.11 to 3.25)	1.74 (1.09 to 2.82)	1.71 (0.85 to 3.44)	2.07 (1.39 to 3.08)
Not poor (PIR ≥300)	3.07 (1.70 to 5.52)	4.61 (2.50 to 8.51)	5.39 (1.41 to 20.57)	5.43 (2.32 to 12.74)
Groups by parent education				
Less than HS	1.38 (0.76 to 2.51)	2.06 (1.33 to 3.17)	1.79 (0.93 to 3.46)	2.70 (1.70 to 4.26)
High school graduate	2.32 (1.48 to 3.63)	2.61 (1.74 to 3.92)	2.31 (1.21 to 4.39)	2.72 (1.69 to 4.38)
College	2.39 (0.59 to 9.63)	2.65 (0.63 to 10.99)	0.62 (0.10 to 3.90)	1.74 (0.15 to 19.87)

*Models were stratified by child's age, parental race/ethnicity, poverty status, parent's education level, urban residency and parent's smoking behaviour.
BMI, body mass index; PIR, poverty income ratio.

parents). The ORs of non-poor parents were greater than the parents in lower income groups, which indicated that overweight/obese parents with higher incomes were more likely to have children with a similar body weight status. However, the parents with college education did not have a significant OR for having an overweight/obese child.

Relationship between child–parent resemblance in body weight status and sociodemographic factors

Table 4 presents the association between sociodemographic factors and the BMI dissimilarity score. A positive coefficient means the factors were contributing to the dissimilarity, and a negative coefficient means the factors were contributing more similarity as compared with the reference group. Child age was positively associated with dissimilarity scores, especially among mothers and children (coefficient =0.16, 95% CI 0.08 to 0.24). Compared with white father–child dyads, black fathers and children had a significantly greater dissimilarity regarding BMI, especially among fathers and daughters (p=0.01). Parents' higher education was associated with lower child–parent BMI dissimilarity, except for father–daughter pairs. The dissimilarity between fathers and daughters was greater in college-educated fathers than in less-than-high-school-educated fathers (coefficient =0.74, 95% CI 0.01 to 1.47). Family poverty level was not significantly associated with child–parent dissimilarity.

Table 5 presents the association between sociodemographic factors and the concordance of overweight and obesity status. If the OR is <1, the factor was negatively associated with being obese, overweight or not overweight for parents and children. If the OR is >1, the factor was positively associated with having the same body weight status. Compared with non-Hispanic white fathers, Mexican American fathers and children were less likely to be concordant on overweight (OR=0.57, 95% CI 0.35 to 0.92 for father–son dyads and OR=0.68, 95% CI 0.47 to 0.97 for father–daughter dyads). Black mothers and children also had an OR significantly less than 1 (OR=0.66, 95% CI 0.44 to 0.97 for mother–son dyads and OR=0.53, 95% CI 0.36 to 0.78 for mother–daughter dyads).

Higher income fathers were less likely to be as overweight as their children compared with low-income fathers (all ORs were <1, but p value >0.05). Conversely, higher income mothers–children were more likely to resemble each other in overweight than were low-income dyads, but this result was also without statistical significance. Higher educated fathers were less likely to be in the same category of overweight with their children than less-than-high-school-educated dyads. All ORs for fathers–children in the high school graduate and college educational groups were less than 1. The most significant disparity was observed among fathers and sons. Compared with less-educated fathers, father having more education were significantly less likely to resemble their children's overweight status (OR=0.53, 95% CI 0.37 to 0.77 for high-school-educated fathers and their sons; OR=0.69, 95% CI 0.50 to 0.96 for college-educated fathers and their daughters.)

Minority parents and their children were less likely to be obese simultaneously (OR <1), except for black fathers and sons. The most significant dissimilarity in obesity was among minority mothers and their children (all four ORs >1 and p value <0.05). Compared with poor fathers and children, higher income fathers were less likely to be similar in obesity with their children, especially among near-poor fathers (OR=0.54, p value=0.02). However, higher income mothers and children were more likely to be obese together, although

Table 4 The relationship between sociodemographics and US parent's–child's BMI dissimilarity score*,†

Group	Father–son			Father–daughter			Mother–son			Mother–daughter		
	Coefficient	SE	95% CI	Coefficient	SE	95% CI	Coefficient	SE	95% CI	Coefficients	SE	95% CI
Child age	0.03	0.03	(−0.03 to 0.09)	0.02	0.03	(−0.04 to 0.08)	0.16	0.04	(0.08 to 0.24)	0.11	0.04	(0.03 to 0.19)
Parental race/ethnicity												
Non-Hispanic white (ref.)												
Non-Hispanic black	0.51	0.27	(−0.02 to 1.04)	0.70	0.25	(0.21 to 1.19)	0.21	0.41	(−0.59 to 1.01)	−0.26	0.29	(−0.83 to 0.31)
Mexican American	0.04	0.22	(−0.39 to 0.47)	0.30	0.29	(−0.27 to 0.87)	−0.04	0.43	(−0.88 to 0.80)	−0.02	0.33	(−0.67 to 0.63)
PIR												
Poor (PIR 0–130) (ref.)												
Near-poor (PIR 130–300)	−0.09	0.22	(−0.52 to 0.34)	−0.25	0.35	(−0.94 to 0.44)	0.33	0.37	(−0.4 to 1.06)	0.12	0.33	(−0.53 to 0.77)
Not poor (PIR ≥ 300)	0.39	0.30	(−0.20 to 0.98)	−0.39	0.44	(−1.25 to 0.47)	0.45	0.50	(−0.53 to 1.43)	0.10	0.41	(−0.70 to 0.9)
Parental education												
Less than high school (ref.)												
High school graduate	−0.40	0.30	(−0.99 to 0.19)	0.40	0.25	(−0.09 to 0.89)	−0.73	0.29	(−1.3 to −0.16)	−0.18	0.42	(−1.01 to 0.64)
College	−0.25	0.41	(−1.05 to 0.55)	0.74	0.37	(0.01 to 1.47)	−1.11	0.89	(−2.85 to 0.63)	−0.21	0.67	(−1.52 to 1.10)

*Dissimilarity Score=Parent BMI decile−Child BMI decile.
†Model: each dyads' dissimilarity score = child's age+parental race/ethnicity+poverty status+parent's education level + urban residency+parent's smoking behaviour.
BMI, body mass index; PIR, poverty income ratio.

with a p value >0.05. No significant disparity in concordance in obesity was observed across parental education levels.

In general, the child–parent concordance in body weight status was weaker in older and minority children, but stronger with higher SES. The resemblance of parent–child body weight status varied across sociodemographic factors and parent–child genders.

DISCUSSION

To the best of our knowledge, this is the first study using nationally representative data and innovative methods that has examined how sociodemographic factors are associated with child–parent resemblance in body weight status in the USA. Our results provide important insights into the factors that might affect the resemblance, which helps illuminate the adult and childhood obesity epidemic in the USA. Our study is guided by health behaviour theories to help unlock the epidemic's black box through a health production perspective from the microlevel linked with empirical and large-scale population data. In the underlying model, parents purchase foods on the market and combine them with time and other factors in a health production function to produce 'commodities'—the health outcomes of the household members in a given social, demographic and economic context.

Child age, race/ethnicity and SES were associated with the strength of parent–child resemblance in body weight status. Based on the theories of developmental genetics, the genes influencing metabolism can be expressed in different scales across ages.[15] However, there has been some debate as to the life stage at which parental heritage is the most influential on childhood body weight status.[11] Stunkard *et al*[26] suggest that at a very early stage of life, young children's or infants' adiposity may become independent of genetics' influence. Our results suggest that children in puberty might be less susceptible to the biological heritage from their parents, after controlling other sociodemographic factors, but it is also possible that this reflects the independence of teenagers from their parents' influences on diet or physical activity.[27] As children grow older, the influence of body image and peers' lifestyle may outweigh parental influence on diet or physical activity, and thus the teenager's greater autonomy and stronger peer influence may jointly reduce the parent–child resemblance in body weight status.[28] Furthermore, the school food environment could also direct children's growth trajectory away from their parents'. Data for this study were collected in 1988–1994, when school lunches were infamous for their association with children's higher risk of obesity.[29 30] In addition, snacks/beverages sold around school or sports venues could also affect children's dietary behaviours and weight status independent from the parents' influence.[31 32]

Our study found a weaker resemblance in minorities than in non-Hispanic whites. These findings are consistent with previous studies, including ours, which suggest that minorities, especially non-Hispanic blacks, have a weaker correlation in terms of dietary intake, such as fat, fibre, soft drinks and overall Health Eating Index (HEI) scores.[33] The higher prevalence of obesity in minorities fully justifies the pursuit of programmes designed to implement more effective interventions in minority households or communities.[34] Lower resemblance in minority parent–children dyads reflects the difference in parenting styles and food habits across race/ethnicity[35] and also generational differences in health-related behaviours and outcomes, as it is likely that more minority parents are immigrants than white parents. This pattern may also reflect minority children's greater dependence on meals/foods obtained in school than is the case

Table 5 ORs of US parent's–child's overweight and obesity concordance status from logistic regression models*,†

Group	Father–son		Father–daughter		Mother–son		Mother–daughter	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Outcome: overweight								
Child's age	1.0	(0.95 to 1.05)	0.99	(0.96 to 1.03)	0.99	(0.96 to 1.03)	0.97	(0.94 to 1.01)
Parental race								
Non-Hispanic white (Ref.)								
Non-Hispanic black	0.66	(0.43 to 1.01)	0.78	(0.53 to 1.13)	0.66	(0.44 to 0.97)	0.53	(0.36 to 0.78)
Mexican American	0.57	(0.35 to 0.92)	0.68	(0.47 to 0.97)	0.74	(0.46 to 1.2)	0.58	(0.36 to 0.93)
PIR								
Poor (PIR 0–130) (Ref.)								
Near-poor (PIR 130–300)	0.73	(0.5 to 1.06)	0.71	(0.46 to 1.08)	1.09	(0.76 to 1.55)	0.93	(0.61 to 1.40)
Not poor (PIR ≥300)	0.81	(0.47 to 1.38)	0.68	(0.44 to 1.04)	1.46	(0.87 to 2.46)	1.65	(0.89 to 3.07)
Parental education								
Less than high school (Ref.)								
High school graduate	0.53	(0.37 to 0.77)	0.69	(0.50 to 0.96)	1.10	(0.67 to 1.81)	1.25	(0.77 to 2.02)
College	0.49	(0.23 to 1.05)	0.61	(0.26 to 1.46)	1.85	(0.6 to 5.70)	0.86	(0.34 to 2.22)
Outcome: obesity								
Child's age	0.96	(0.89 to 1.03)	0.95	(0.89 to 1.01)	0.98	(0.94 to 1.02)	0.97	(0.93 to 1.02)
Parental race								
Non-Hispanic white (Ref.)								
Non-Hispanic black	1.10	(0.60 to 2.01)	0.64	(0.39 to 1.03)	0.59	(0.36 to 0.97)	0.54	(0.31 to 0.93)
Mexican American	0.97	(0.57 to 1.66)	0.85	(0.44 to 1.64)	0.51	(0.3 to 0.86)	0.58	(0.33 to 0.99)
PIR								
Poor (PIR 0–130) (Ref.)								
Near poor (PIR 130–300)	0.60	(0.31 to 1.15)	0.54	(0.31 to 0.92)	1.40	(0.86 to 2.29)	1.07	(0.74 to 1.54)
Not poor (PIR ≥300)	1.19	(0.57 to 2.47)	0.66	(0.31 to 1.38)	1.93	(0.91 to 4.11)	2.13	(0.97 to 4.69)
Parents' education								
Less than HS (Ref.)								
High school graduate	1.13	(0.68 to 1.89)	1.23	(0.70 to 2.16)	0.72	(0.46 to 1.12)	0.78	(0.46 to 1.33)
College	2.62	(0.81 to 8.54)	5.16	(0.85 to 31.39)	0.82	(0.26 to 2.58)	1.08	(0.40 to 2.96)

*Concordance=1 if parent's and child's body weight status is the same, 0 if it is different.
†Each column reflects one logistic regression for one outcome: that is, logit (each dyads' concordance)=child's age+parental race/ethnicity+poverty status+parent's education level +urban residency+parent's smoking behaviour.
PIR, poverty income ratio.

for non-Hispanic whites. Therefore, the design of family-based interventions may need to account for these racial/ethnic differences and include the influences of environmental factors beyond home.

Although the κ statistics were all significant across SES, only a selected number of child–parent groups had a significant disparity in weight status resemblance across SES. One notable pattern is the non-linear relationship between child–parent resemblance in BMI and education levels. For example, the largest correlation coefficient of mothers–daughters was among high school graduates, with a very weak correlation among college educated mothers (r=0.35 and 0.01, respectively). Similar patterns can be found in fathers–daughters as well (r=0.25, 0.06 for high school and college, respectively). We hypothesised that the resemblance can be related to parenting style, which varies with educational levels. For example, literature suggests that more highly educated mothers in the USA spend more time in working.[36] Longer working time means less time for parents and children to spend together on various activities, which increases the chance of heterogeneity in terms of weight status. These results were also consistent with our previous study on the child–parent resemblance in dietary intakes.[16]

Our study suggests that sociodemographic factors, such as race/ethnicity or education, could be associated with child–parent resemblance in body weight status. The results supported a strong biological determinant of childhood obesity, so more basic science researchers should join the task force in the war against obesity.[37] However, further research is needed to understand the complicated mechanisms involved in how these sociodemographic factors may influence parents' and children's food consumption, physical activity, parenting style and family time allocation, all of which could shed light on the growing obesity epidemic in the USA. Since obesity is becoming a global epidemic among adults and children,[38] it is worth exploring the possibility of promoting healthy behaviours at home for parents and children across countries. To reduce childhood obesity, parents need to serve as good role models in terms of dietary and exercise habits. In this sense, resemblance in healthy weight should be encouraged, while the resemblance in overweight or obesity should be reversed. Although due to the racial/ethnic disparity in the USA these results may not be validly applied to other countries, researchers in other countries can nevertheless gain insights as to sociodemographic factors that may affect child–parent resemblance in weight status in their own national arenas.

This study has several major strengths. First, it is based on nationally representative data. Second, we created the dissimilarity score and the concordance status as direct measurements of resemblance in body weight status. Third, the weight and height data collected by NHANES was directly measured rather than

based on self-reports, thus allowing a more accurate picture of the nation's obesity status.

This study also had a few limitations. First, NHANES is cross-sectional data, so we can only examine associations instead of causation between the resemblance and sociodemographic factors. In addition, the data are relatively old. One may suspect that the patterns of resemblance might have changed over time. However, one of our studies used a different nationally representative sample from the USA, the recent Medical Expenditure Panel Study, and it indicated that the child–parent resemblance in body weight status using correlations was similar to the data from this study.[39] We note that only self-reported weight and height information was collected in that study. Third, our analyses did not include some minority groups with small sample sizes in NHANES III, such as Asians and Native Americans, and the study has limited external validity for these racial/ethnic groups. Fourth, the data is for the US population in the 1980s–1990s and may be not generalisable to other countries or times. Nevertheless, the data here may be instructive to researchers working in other geographic or national settings and can be usefully compared with current or future populations in the USA. Finally, we only controlled for individual and household factors. Other environmental factors at the community or neighbourhood levels can affect weight status among children and adults, which could confound the degree of child–parent resemblance in weight status.

In conclusion, we observed a modest child–parent resemblance in weight status in the USA, but the strength of the resemblance varied across groups, such as child age, gender and race/ethnicity. Minority children had a lower resemblance to their parents' weight. The relationship between child–parent resemblance in BMI and parental education was not linear.

What is already known on this subject

Children resemble their parents' body weight status due to genetics, resemblance in diet and resemblance in habitual physical activities.

What does this study adds

- Child–parent resemblance varies by race/ethnicity and parental education levels.
- Weaker child–parent resemblance was found in minorities, older children and lower socioeconomic groups.

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REFERENCES

1 Wang Y, Lim H. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. *Int Rev Psychiatry* 2012;24:176–88.
2 Flegal KM, Carroll MD, Kit BK, *et al*. Prevalence of obesity and trends in the distribution of body mass index among U.S. adults, 1999–2010. *JAMA* 2012;307:491–7.
3 Ogden CL, Carroll MD, Kit BK, *et al*. Prevalence of obesity and trends in body mass index among U.S. children and adolescents, 1999–2010. *JAMA* 2012;307:483–90.
4 Wang Y, Zhang Q. Are American children and adolescents of low socioeconomic status at increased risk of obesity? Changes in the association between overweight and family income between 1971 and 2002. *Am J Clin Nutr* 2006;84:707–16.
5 Wang Y, Beydoun MA. The obesity epidemic in the United States—gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiol Rev* 2007;29:6–28.
6 Whitaker RC, Deeks CM, Baughcum AE, *et al*. The relationship of childhood adiposity to parent body mass index and eating behavior. *Obes Res* 2000;8:234–40.
7 Herbert A, Gerry NP, McQueen MB, *et al*. A common genetic variant is associated with adult and childhood obesity. *Science* 2006;312:279–83.
8 Wang Y, Li J, Caballero B. Resemblance in dietary intakes between urban low-income African-American adolescents and their mothers: the healthy eating and active lifestyles from school to home for kids study. *J Am Diet Assoc* 2009;109:52–63.
9 Wang Y, Beydoun MA, Li J, *et al*. Do children and their parents eat a similar diet? Resemblance in child and parental dietary intake: systematic review and meta-analysis. *J Epidemiol Community Health* 2011;65:177–89.
10 Whitaker RC, Wright JA, Pepe MS, *et al*. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 1997;337:869–73.
11 Safer DL, Agras WS, Bryson S, *et al*. Early body mass index and other anthropometric relationships between parents and children. *Int J Obes Relat Metab Disord* 2001;25:1532–6.
12 Vanderwater EA, Huang X. Parental weight status as a moderator of the relationship between television viewing and childhood overweight. *Arch Pediatr Adolesc Med* 2006;160:425–31.
13 Boutelle KN, Cafri G, Crow SJ. Parent predictors of child weight change in family based behavioral obesity treatment. *Obesity (Silver Spring)* 2012;20:1539–43.
14 Wrotniak BH, Epstein LH, Paluch RA, *et al*. Parent weight change as a predictor of child weight change in family-based behavioral obesity treatment. *Arch Pediatr Adolesc Med* 2004;158:342–7.
15 Cardon L. Genetic influences on body mass index in early childhood. In: Turner JR, Cardon LR, Hewitt JK, eds. *Behavior genetic approaches to behavioral medicine*. New York: Plenum Press, 1995;133–43.
16 Beydoun MA, Wang Y. Parent-child dietary intake resemblance in the United States: evidence from a large representative survey. *Soc Sci Med* 2009;68:2137–44.
17 Huffman PG, Kanikireddy S, Patel M. Parenthood—a contributing factor to childhood obesity. *Int J Environ Res Public Health* 2010;7:2800–10.
18 U.S. Census Bureau. Current Population Survey, Annual Social and Economic Supplements. 2013. http://www.childstats.gov/americaschildren/famsoc1.asp#1 (accessed 20 Jan 2014).
19 Wang Y, Wang JQ. A comparison of international references for the assessment of child and adolescent overweight and obesity in different populations. *Eur J Clin Nutr* 2002;56:973–82.
20 Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, *et al*. CDC growth charts: United States. *Adv Data* 2000;314:1–27.
21 World Health Organization (WHO). Health topics: adolescent health. 2013. http://www.who.int/topics/adolescent_health/en/ (accessed 20 Jan 2014).
22 US Census Bureau. Overview of race and Hispanic origin: 2010 http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf (accessed 20 Jan 2014).
23 National Center for Health Statistics. Analytic and reporting guidelines: the third national health and nutrition examination survey, NHANES III (1988–94). 1996. http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf (accessed 20 Jan 2014).
24 Fryar CD, Carroll MD, Ogden CL. Prevalence of overweight, obesity, and extreme obesity among adults: United States, Trends 1960–1962 through 2009–2010. National Center for Health Statistics E-Stats, September 2012. http://www.cdc.gov/nchs/data/hestat/obesity_adult_09_10/obesity_adult_09_10.htm (accessed 20 Jan 2014).
25 SAS Institute Inc. SAS OnlineDoc. 9.3. Cary, NC: SAS Institute Inc., 2004–2010.
26 Stunkard AJ, Berkowitz RI, Stallings VA, *et al*. Weights of parents and infants: is there a relationship? *Int J Obes Relat Metab Disord* 1999;23:159–62.
27 Backett-Milburn KC, Wills WJ, Gregory S, *et al*. Making sense of eating, weight and risk in the early teenage years: views and concerns of parents in poorer socio-economic circumstances. *Soc Sci Med* 2006;63:624–36.
28 Worthington-Roberts BS, Rodwell Williams S. *Nutrition throughout the life cycle*. McGraw-Hill, 1999.
29 Gleason P, Suitor C. Children's diets in the mid-1990s: dietary intake and its relationship with school meal participation. Mathematica Policy Research Reports 2443, Mathematica Policy Research. 2001.
30 Cole N, Fox MK. Diet Quality of American School-Age Children by School Lunch Participation Status: Data from the National Health and Nutrition Examination

Survey, 1999–2004. Mathematica Policy Research Reports 6259, Mathematica Policy Research. 2008.
31 Chen HJ, Wang Y. Influence of school beverage environment on the association of beverage consumption with physical education participation among US adolescents. *Am J Public Health* 2013;11:e63–70.
32 Thomas M, Nelson TF, Harwood E, *et al*. Exploring parent perceptions of the food environment in youth sport. *J Nutr Educ Behav* 2012;4:365–71.
33 Stanton CA, Fries EA, Danish SJ. Racial and gender differences in the diets of rural youth and their mothers. *Am J Health Behav* 2003;27:336–47.
34 Fitzgibbon ML, Stolley MR, Dyer AR, *et al*. A community-based obesity prevention program for minority children: rational and study design for Hip-Hop to Health Jr. *Prev Med* 2002;34:289–97.
35 Rhee KE, Lumeng JC, Appugliese DP, *et al*. Parenting styles and overweight status in first grade. *Pediatrics* 2006;117:2047–54.
36 Bianchi SM. Maternal employment and time with children: dramatic change or surprising continuity? *Demography* 2000;37:401–14.
37 Wardle J, Carnell S, Haworth CM, *et al*. Evidence for a strong genetic influence on childhood adiposity despite the force of the obesogenic environment. *Am J Clin Nutr* 2008;87:398–404.
38 WHO. Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/index.html (accessed 24 Jan 2014).
39 Liu Y, Chen HJ, Liang L, *et al*. Parent-child resemblance in weight status and its correlates in the United States. *PLoS One* 2013;8:e65361.