Original Article

Difference in diet quality trends between children and adults in the United States: A serial cross-sectional study from 1999 to 2018

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Background and Objectives: Previous studies had shown that trends in diet quality between children and adults may vary but lack quantitative comparisons. We aimed to compare diet quality and its trends between US children and adults in this research. **Methods and Study Design:** Children aged 2 to 18 and adults aged 19 to 59 years old in the US were enrolled the serial cross-sectional analysis of National Health and Nutrition Examination Survey (NHANES) cycles from 1999 to 2018. Diet quality was assessed using the Healthy Eating Index-2015 (HEI-2015), and trends were analyzed by joinpoint regression model. **Results:** This study included 31988 children and 34317 adults. From 1999 to 2018, there was a trend-change among 5 children's components trends (including total fruits in 2011-2012, whole fruits in 2005-2006, greens and beans in 2013-2014, dairy in 2013-2014, and total protein foods in 2013-2014, p for joinpoint <0.05 for each) and overall trend in 2013-2014, whereas no significant trend-change in adults' trend. The trends of overall HEI-2015 between children (average annual percent change 0.3%; 95% CI: -0.1% to 0.8%) and adults (0.3%; 95%CI: 0.0% to 0.6%) showed no significant difference in parallelism (p for parallelism=0.60), but a significant difference in coincidence (intercept -7.7±3.7 among children; -2.3±2.5 among adults; p for coincidence <0.05). **Conclusions:** Children had a different trend with more trend-changes in diet quality compared with adults, and the diet quality of children was worse than that of adults during 1999-2018 in the US.

Key Words: diet quality, children, adults, trend, nutrition

INTRODUCTION

Poor diet has become the second-leading cause of death and disability-adjusted life-year loss around the world and third-leading cause in the US.[1-3] Poor diet quality has an adverse effect on both children's and adults' health, leading to increased risk of noncommunicable diseases such as obesity,[4] osteoporosis,[5] cardiovascular disease,[1,6] diabetes,[7] and mortality.[8] It is a vital issue to identify the timing and extent of changes in diet quality trends. Studies accessing and comparing trend of diet quality between children and adults over time in countries with high rates of chronic diseases, including the US, are of great public health significance and reveals subsequent prevention strategies through discovering the current major dietary problems and determining the differences in the effects of interventions between children and adults.[2,6,9-17]

From 1999, trends among children and adults have shown some difference,[15,16] although a slight improvement of diet quality was observed in both children and adults. In order to improve suboptimal diet quality, it is necessary to know the change of trends and compare the diet quality between children and adults. However, no quantitative research on the change of trends or comparison between children and adults' trends has been reported yet. Joinpoint regression model[18,19] was a quantitative tool developed in 2000 to compare two segmented line regression functions. The model provides evidence for whether the function has change points, whether the two functions are coincident and whether the two functions are parallel with different intercepts to compare current trends and possible risk factors leading to suboptimal diet quality between children and adults.

Therefore, in the present study, we used joinpoint regression analysis to examine the change points, parallelism, and coincidence[19,20] of diet quality trends for children aged 2 to 18 and adults aged 19 to 59 in the US with data surveyed in all 10 cycles (from 1999-2000 to 2017-2018) from the National Health and Nutrition Examination Survey (NHANES). We hypothesized that diet qual-

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ity and its trends vary between US children and adults while there are some similarities.

METHODS

Study design and population

NHANES is a nationwide program designed to collect information on the health and nutrition status of Americans, which is conducted by the National Center for Health Statistics (NCHS) in the US. As a nationally representative cross-sectional study, the NHANES program began in the 1960s and became a continuous survey from 1999-2000, combining two years' data in one cycle. By the time of the beginning of this study, the latest database was updated to 2017-2018. The study design and protocol reported before are available online.[21]

In this study, children aged 2 to 18 and adults aged 19 to 59 who participated in NHANES from 1999-2000 to 2017-2018 (ten cycles) were included. Diet recalls without a valid value were excluded for correct analysis according to the guideline. To better represent all population in the US and fit the complex study design, missing dietary data, and poststratification, a set of sampling weights was generated and used in all analyses.[22] In accordance with the ethical standards, all personal identities were hidden, and informed consent had been signed by all participants of different races, ages, and genders. The ethical approval is not required in this study.

Assessment of nutrients and food groups

The nutritional assessment component of NHANES was consisted of one or two 24-hour dietary recall interviews for each participant. At first, one 24-hour dietary recall was conducted by trained dietary interviewers of Mobile Examination Center (MEC). In order to obtain more representative data to simulate the usual dietary intake, a second dietary interview scheduled 3 to 10 days later had been added to the survey since 2003. All foods consumed by each person in the last 24 hours were recorded in different codes. Instead of the former 4-step "multiple-pass method", the 5-step "automated multiple-pass method[23] had been applied since 2002. Besides, a standard set of measuring guides was provided for participants to estimate the volume and dimensions of the food items consumed.[24]

For 12 to 18 years old adolescents and all adults, dietary interview was completed by themselves. Children aged 6 to 11 were interviewed in proxy-assisted ways. Children under five and other children who cannot self-report were interviewed by proxy respondents. To convert dietary data in NHANES to food groups used in analysis, Food Patterns Equivalents Database (FPED) was applied to obtain 37 USDA Food Patterns components for each participant. Different equivalents were used to measure the Food Patterns. Fruit, vegetables, and dairy were measured as cup equivalents. Grains and protein foods were measured as ounce equivalents. Added sugars were measured as teaspoon equivalents. Solid fats and oils were measured as gram equivalents. Alcoholic drinks were measured as the number. During the first three cycles from 1999 to 2004, MyPyramid Equivalents Database (MPED), a former version of FPED, was applied to assess food groups. There are also some differences between MPED and FPED, particularly fruit juices were combined in individual fruit subgroups in MPED but became a new variable in FPED.

Outcomes, diet quality assessment tools

The main outcomes were the trend, trend change, parallelism, and coincidence of the Healthy Eating Index (HEI) -2015 scores, which was calculated by joinpoint regression model. As a diet quality assessment tool, the HEI was an effective tool developed to show personal diet consistency with the Dietary Guidelines for Americans for whom aged 2 years and older.[25]

The HEI originated in 1995. The HEI-2015 was the latest version of the HEI to assess how conformable between usual intake and recommendations of the 2015-2020 Dietary Guidelines for Americans.[26,27] The HEI-2015 was made up of thirteen dietary components, including total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats (Table S1). Scores for all components were added up to reflect overall diet quality. The total HEI-2015 score ranged from 0 to 100, and a higher score indicated a better diet quality in each component.

Statistical analysis

To fit the complex sampling design, sampling weights were used in all analyses. The distribution of usual dietary intakes for children and adults was obtained by the Multivariate Markov Chain Monte Carlo (MCMC) method, which was recommended by the National Cancer Institute (NCI).[28] The MCMC method was the latest and most advanced NCI method used to model a population-based usual dietary intake of foods and nutrients from 24-hour recalls in the NHANES, to better estimate usual intakes of a particular population and assess the effects of demographic covariates on usual consumption.[29] Additionally, the Balanced Repeated Replication (BRR) Weights were calculated to provide an unbiased estimate of standard errors arising from complex sample designs according to the effects of stratification, clustering, and probabilities of selection. Sampling stratum and primary sampling units (PSUs) in the NHANES were considered as the main stratification. Meanwhile, gender, age, and race were treated as covariates in the formula. Missing data were considered during the generation of weights and preparation of dataset.

Trends on scores of HEI-2015 were estimated by joinpoint regression model. Developed in 2000, the joinpoint regression model was used to describe the continuous changes of dependent variables and fit the regression function with unknown joinpoints.[19] According to Surveillance Research Program, the existence of one joinpoint is assumed as alternate hypothesis, while null hypothesis means there is no joinpoint.

In this study, a logarithmic model was chosen to better compare the changes in trends between children and adults. Annual percent change (APC) and average annual percent change (AAPC) were calculated to evaluate the trend of HEI-2015 scores in children and adults.[30,31] If the APC >0, it means that the score is increasing annually, otherwise it is decreasing. When there were a joinpoint, the whole trend would be divided into two parts by the joinpoint, the first period and the second period, whose APC were different. If there is no joinpoint, then APC = AAPC, indicating that the overall trend is increasing or decreasing monotonously. Coincidence and parallelism were tested using pairwise comparison option in software to determine whether the trend of diet quality scores between children and adults with time were identical or had a parallel change with different intercepts.18 Similar trends were confirmed when there was no significant difference in parallelism between the two trends.

Normal distribution numerical variables were expressed as mean (95% confidence interval) or mean± SD, and categorical variables were represented as number (proportion). The absolute differences of mean scores between 1999-2000 and 2017-2018 were estimated in Student t-test. The trends from 1999-2000 to 2017-2018 were tested in joinpoint regression model. All analyses were performed using SAS version 9.4 (SAS Institute Inc) and Joinpoint Regression Program 4.8.0.1. A 2-tailed $p<0.05$ was considered as significance.

RESULTS

Participant characteristics

During ten cycles from 1999-2000 to 2017-2018, there were 66305 participants, including 31988 children (weighted mean age 9.9±0.14 years; n=15891, women 49.7%) aged 2 to 18 and 34317 adults (weighted mean age 37.7±0.77 years; n=17943, women 52.3%) aged 19 to 59 enrolled in the study. Children (n=4762) and adults (n=3705) without a valid diet recall were excluded.

From 1999 to 2018, the proportion of female increased from 48.6% to 48.8% in children, but decreased from 51.2% to 51.0% in adults. The proportion of little kids (2 to 6 years old) decreased from 30.1% to 28.3%, while adolescents (13 to 18 years old) increased from 34.1% to 36.5% in children. The proportion of adults aged 19 to 29 years old) decreased from 27.1% to 26.5%, while adults aged 50-59 years old increased from 18.0% to 26.7% in adults. As for races/ethnicities, family income, and education, slight difference was also estimated among both children and adults (Table 1).

Trends of diet quality from 1999 to 2018

Between 1999-2000 and 2017-2018, overall HEI-2015 of children increased with a total score from 48.73 (95% CI: 47.01 to 50.45) to 51.59 (95% CI: 51.37 to 51.81) (difference 2.86; 95% CI:2.84 to 2.88; $p<0.001$). There were seven component scores increased and six component scores decreased significantly. For adults, overall HEI-2015 increased with a total score from 53.1 (95% CI: 50.61 to 55.60) to 53.18 (95% CI: 51.10 to 55.26) (difference 0.08; 95% CI: 0.01 to 0.15; $p<0.01$). There were six component scores increased and seven component scores decreased significantly (Table 2, Figure 1, Figure 2).

From 1999-2000 to 2017-2018, one joinpoint was found in children's total score of diet quality (in 2013-2014, p for joinpoint <0.05) significantly, while no joinpoint was found in adults' (p for joinpoint=0.76). It means that the monotonicity of children's diet quality had changed during ten cycles while adults' diet quality was increasing monotonically. There were 5 joinpoints found within children's trend including total fruits (in 2011-2012, p for joinpoint <0.01), whole fruits (in 2005-2006, p for joinpoint <0.05), greens and beans (in 2013-2014, p for joinpoint <0.05), dairy (in 2013-2014, p for joinpoint <0.01), and total protein foods (in 2013-2014, p for joinpoint <0.05), whereas no joinpoint within adults' trend in 13 component scores, meaning that the monotonicity of children's trend had changed in 5 components scores while

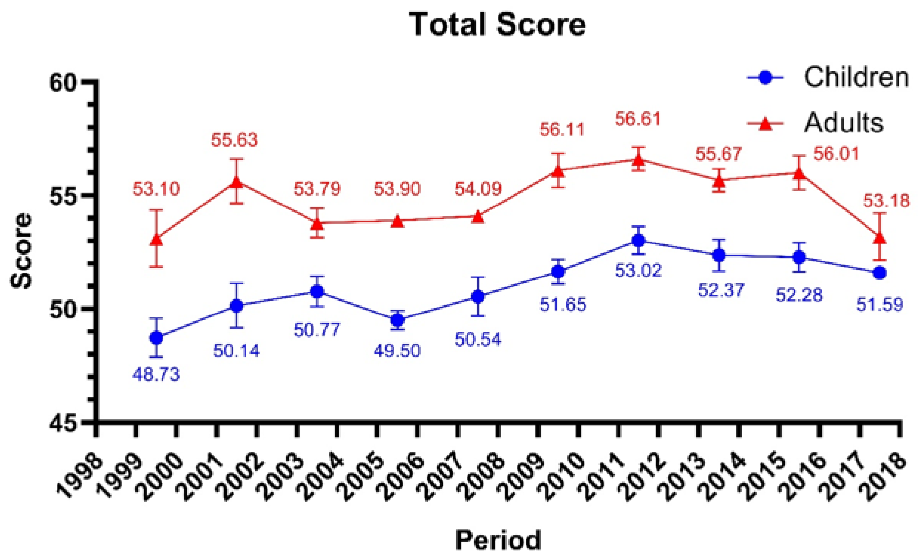

Figure 1. Trends in Estimated Overall HEI-2015 Score Among US Children Aged 2-18 and Adults Aged 19-59 by NHANES Survey Cycle From 1999-2000 to 2017-2018. Diet quality is calculated by HEI-2015 according to the 2015 Dietary Guidelines for Americans, adjusted by demographic factors using the MCMC method to estimate distributions of usual intake for foods. Total score of diet quality is based on total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars and saturated fats. Data are weighted to be nationally representative. Data points indicate estimated means; error bars indicate standard errors. Analyses of trends were based on NHANES cycles from 1999-2000 to 2017-2018 using the joinpoint regression model. $p < 0.05$ for joinpoint for total score of children in 2013-2014; $p=0.598$ for parallelism between total scores of children and adults; $p < 0.05$ for coincidence for total scores among children and adults.

Table 1. Demographic characteristics by survey cycle

Components	No. of components (Weighted%)†									
Period	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
Children										
Number	3592	4039	3554	3778	2966	3124	2987	2897	2784	2267
Female	1768 (48.6)	2039 (50.2)	1787 (48.4)	1919 (48.9)	1435 (50.0)	1501 (49.9)	1475 (49.4)	1431 (48.5)	1389 (50.0)	1147(48.8)
Age										
2-6 years old	815 (30.1)	1038 (27.7)	907 (28.0)	1085 (29.4)	1000 (29.0)	1049 (29.3)	1051 (29.7)	885 (28.1)	840 (27.8)	660 (28.3)
7-12 years old	1121 (35.8)	1258 (36.3)	1016 (34.8)	1103 (33.5)	1099 (34.2)	1117 (35.2)	1074 (35.6)	1020 (35.2)	1028 (36.2)	812 (35.2)
13-18 years old	1656 (34.1)	1743 (36.0)	1631 (37.2)	1590 (37.1)	867 (36.8)	958 (35.6)	862 (34.6)	992 (36.8)	916 (36.0)	795 (36.5)
Family PIR										
<1.30	1479 (37.2)	1592 (32.6)	1537 (33.9)	1459 (27.5)	1236 (33.2)	1364 (33.7)	1326 (37.4)	1315 (37.3)	1034 (30.9)	808 (32.1)
1.30-3.49	1045 (35.3)	1396 (38.1)	1217 (36.9)	1318 (39.4)	960 (33.3)	973 (36.3)	896 (35.6)	866 (35.5)	1017 (40.7)	804 (38.4)
≥3.50	572 (27.5)	817 (29.4)	649 (29.2)	841 (33.0)	553 (33.5)	530 (29.9)	553 (27.0)	532 (27.2)	517 (28.5)	440 (29.5)
Race/ethnicity										
Mexican American	1483 (11.2)	1181 (12.1)	1063 (12.6)	1251 (13.4)	745 (13.2)	867 (14.2)	576 (15.1)	661 (16.1)	598 (15.9)	391 (17.5)
Other Hispanic	183 (7.3)	194 (6.5)	119 (3.6)	127 (3.7)	372 (6.7)	362 (7.2)	352 (8.3)	292 (7.5)	345 (8.6)	151 (6.9)
Non-Hispanic White	787 (60.2)	1258 (61.2)	980 (62.7)	1018 (60.6)	956 (60.0)	1053 (57.6)	659 (53.3)	775 (52.6)	811 (51.1)	758 (50.5)
Non-Hispanic Black	999 (14.5)	1225 (14.2)	1229 (15.1)	1162 (14.6)	749 (14.7)	612 (13.3)	879 (14.6)	723 (13.8)	628 (14.5)	509 (12.2)
Other‡	140 (6.8)	173 (6.0)	163 (6.0)	220 (7.7)	144 (5.5)	230 (7.6)	521 (8.7)	446 (10.1)	402 (9.9)	458 (12.9)
Education										
Less than high school diploma	3470 (97.0)	3907 (96.9)	3411 (95.8)	3604 (95.4)	2890 (96.4)	3051 (96.4)	2915 (96.8)	2797 (95.9)	2708 (97.6)	2175 (95.4)
High school graduate or GED	93 (2.2)	100 (2.5)	89 (2.8)	126 (3.5)	52 (2.9)	44 (2.2)	50 (2.1)	76 (3.4)	61 (2.1)	77 (3.8)
Some college	29 (0.8)	30 (0.7)	52 (1.4)	47 (1.0)	24 (0.7)	28 (1.5)	22 (1.1)	24 (0.6)	14 (0.3)	15 (0.8)
Adults										
Number	3044	3553	3148	3374	3616	4019	3447	3609	3455	3052
Female	1657 (51.2)	1880 (50.4)	1649 (50.8)	1804 (50.7)	1832 (52.1)	2072 (50.7)	1734 (50.2)	1892 (50.6)	1808 (51.1)	1615 (51.0)
Age										
19-29 years old	1000 (27.1)	1166 (25.5)	1083 (25.7)	1221 (24.9)	961 (25.9)	1130 (25.1)	1032 (25.4)	983 (26.1)	956 (26.6)	815 (26.5)
30-39 years old	727 (29.9)	816 (26.8)	724(25.5)	777 (25.4)	933 (23.3)	954 (24.1)	829 (23.5)	892 (23.4)	853 (23.7)	736 (24.5)
40-49 years old	688 (25.0)	846 (27.7)	715(25.6)	772 (26.3)	878 (26.6)	1036 (26.2)	781 (24.3)	897 (24.2)	830 (22.8)	707 (22.3)
50-59 years old	530 (18.0)	642 (20.0)	536 (23.2)	604 (23.4)	844 (24.2)	899 (24.6)	805 (26.8)	837 (26.3)	816 (27.0)	794 (26.7)
Family PIR										
<1.30	831 (22.5)	953 (21.4)	920 (22.4)	908 (17.3)	1075 (22.5)	1355 (23.9)	1225 (27.3)	1212 (27.4)	985 (21.9)	855 (23.6)
1.30-3.49	941 (33.4)	1207 (33.0)	1080 (33.9)	1160 (34.4)	1173 (30.7)	1293 (34.2)	1023 (32.2)	1086 (32.4)	1254 (36.0)	1023 (34.1)
≥3.50	889 (44.1)	1181 (45.6)	992 (43.7)	1182 (48.3)	1061 (46.9)	1001 (41.9)	962 (40.5)	1046 (40.2)	934 (42.2)	826 (42.3)

NHANES: National Health and Nutrition Examination; Family PIR: Ratio of family income to poverty; GED: general equivalency diploma.
†Percentages were adjusted for NHANES survey weights to be nationally representative.
‡"Other" includes race/ethnicity other than non-Hispanic black, non-Hispanic white and Hispanic, including multiracial.

Table 1. Demographic characteristics by survey cycle (cont.)

Components	No. of components (Weighted%)†									
Period	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
Adults										
Race/ethnicity										
Mexican American	889 (7.4)	832 (8.2)	643 (9.1)	790 (9.1)	729 (9.7)	826 (9.7)	390 (9.7)	527 (10.9)	622 (10.6)	464 (10.8)
Other Hispanic	215 (8.0)	167 (6.1)	109 (3.3)	131 (3.2)	432 (5.5)	437 (5.9)	313 (6.9)	334 (6.4)	440 (7.2)	279 (7.8)
Non-Hispanic White	1215 (67.7)	1668 (69.6)	1516 (69.9)	1486 (69.5)	1503 (67.2)	1770 (65.0)	1205 (62.8)	1476 (61.4)	1051 (59.5)	962 (56.7)
Non-Hispanic Black	605 (11.7)	742 (11.6)	744 (12.4)	808 (12.4)	785 (12.1)	743 (12.2)	914 (12.4)	717 (12.2)	770 (12.2)	705 (12.7)
Other‡	120 (5.2)	144 (4.5)	136 (5.3)	159 (5.9)	167 (5.6)	243 (7.2)	625 (8.1)	555 (9.2)	572 (10.5)	642 (11.9)
Education										
Less than high school diploma	1014 (20.8)	969 (16.7)	755 (15.6)	809 (14.6)	1007 (18.5)	1053 (17.7)	669 (14.9)	666 (14.3)	684 (13.2)	504 (10.3)

NHANES: National Health and Nutrition Examination; Family PIR: Ratio of family income to poverty; GED: general equivalency diploma.
†Percentages were adjusted for NHANES survey weights to be nationally representative.
‡"Other" includes race/ethnicity other than non-Hispanic black, non-Hispanic white and Hispanic, including multiracial.

Table 2. HEI-2015 scores of children and adults in the US

Components	Component scores (95% CI)†						
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012
Children							
Total fruits	3.05 (2.67, 3.43)	2.86 (2.21, 3.52)	2.99 (2.70, 3.28)	3.10 (2.89, 3.30)	3.21 (2.94, 3.48)	3.26 (3.10, 3.42)	3.33 (3.08, 3.58)
Whole fruits	4.22 (3.67, 4.77)	3.92 (2.94, 4.90)	4.12 (3.80, 4.45)	3.13 (2.90, 3.35)	3.36 (3.02, 3.70)	3.43 (3.18, 3.67)	3.54 (3.26, 3.81)
Total vegetables	2.54 (2.33, 2.76)	2.48 (2.30, 2.67)	2.47 (2.34, 2.59)	2.39 (2.28, 2.50)	2.38 (2.23, 2.53)	2.33 (2.21, 2.45)	2.30 (2.18, 2.42)
Greens and beans	1.41 (1.07, 1.75)	1.16 (0.89, 1.42)	1.22 (0.99, 1.45)	1.28 (1.04, 1.52)	1.38 (1.13, 1.63)	1.47 (1.20, 1.73)	1.63 (1.38, 1.88)
Whole grains	1.69 (1.36, 2.01)	1.90 (1.68, 2.13)	1.58 (1.37, 1.78)	1.72 (1.47, 1.98)	1.90 (1.68, 2.13)	2.33 (2.20, 2.47)	2.62 (2.42, 2.83)
Dairy	7.26 (6.53, 7.99)	7.84 (7.16, 8.52)	7.67 (7.43, 7.91)	7.70 (7.45, 7.95)	7.66 (7.44, 7.88)	8.14 (7.82, 8.46)	8.03 (7.80, 8.26)
Total protein foods	4.04 (3.73, 4.36)	4.06 (3.79, 4.32)	4.17 (4.05, 4.29)	4.15 (3.98, 4.31)	4.27 (4.15, 4.40)	4.26 (4.10, 4.43)	4.19 (4.02, 4.35)
Seafood and plant proteins	2.47 (1.89, 3.04)	2.43 (1.85, 3.01)	2.89 (2.61, 3.16)	2.63 (2.23, 3.04)	2.43 (2.21, 2.64)	2.66 (2.39, 2.93)	2.90 (2.60, 3.20)
Fatty acids	3.41 (2.77, 4.05)	3.42 (2.89, 3.95)	3.26 (2.98, 3.54)	3.14 (2.89, 3.39)	3.22 (2.99, 3.45)	3.37 (3.16, 3.58)	3.50 (3.21, 3.79)
Refined grains	4.99 (4.26, 5.72)	4.81 (4.25, 5.38)	4.89 (4.56, 5.23)	4.91 (4.50, 5.32)	5.20 (4.77, 5.62)	4.68 (4.28, 5.08)	4.86 (4.55, 5.18)
Sodium	4.81 (4.25, 5.38)	5.55 (5.04, 6.05)	5.49 (5.21, 5.77)	5.15 (4.79, 5.51)	5.07 (4.68, 5.45)	4.56 (4.21, 4.91)	4.94 (4.63, 5.25)
Added sugars	3.50 (2.65, 4.35)	4.00 (3.47, 4.52)	4.63 (4.19, 5.08)	5.00 (4.74, 5.26)	5.10 (4.84, 5.36)	5.46 (5.08, 5.84)	5.48 (5.24, 5.73)
Saturated fats	5.33 (4.67, 5.99)	5.71 (5.28, 6.14)	5.39 (5.07, 5.71)	5.21 (5.03, 5.39)	5.36 (5.08, 5.64)	5.70 (5.49, 5.92)	5.69 (5.44, 5.94)
Total scores	48.7 (47.0, 50.5)	50.1 (48.2, 52.1)	50.8 (49.4, 52.1)	49.5 (48.7, 50.4)	50.5 (48.8, 52.3)	51.7 (50.6, 52.7)	53.0 (51.8, 54.3)
Adults							
Total fruits	2.43 (2.11, 2.76)	2.86 (2.53, 3.18)	2.29 (2.00, 2.57)	2.30 (2.25, 2.34)	2.35 (2.33, 2.38)	2.59 (2.46, 2.72)	2.41 (2.27, 2.55)
Whole fruits	3.55 (2.90, 4.21)	4.21 (3.62, 4.80)	3.37 (3.05, 3.69)	2.43 (2.39, 2.46)	2.69 (2.65, 2.72)	2.84 (2.66, 3.02)	2.70 (2.50, 2.90)
Total vegetables	3.55 (3.35, 3.75)	3.57 (3.35, 3.78)	3.49 (3.38, 3.60)	3.45 (3.42, 3.48)	3.39 (3.37, 3.40)	3.42 (3.29, 3.54)	3.46 (3.35, 3.56)
Greens and beans	2.40 (1.95, 2.85)	2.50 (2.19, 2.82)	2.34 (2.08, 2.61)	2.50 (2.46, 2.54)	2.62 (2.57, 2.68)	2.62 (2.39, 2.85)	2.83 (2.64, 3.02)
Whole grains	1.63 (1.41, 1.86)	2.12 (1.89, 2.34)	1.72 (1.50, 1.94)	2.07 (2.01, 2.12)	2.05 (1.99, 2.10)	2.56 (2.30, 2.82)	2.81 (2.53, 3.09)
Dairy	5.13 (3.40, 6.85)	5.49 (4.92, 6.05)	5.34 (5.10, 5.57)	5.60 (5.55, 5.64)	5.63 (5.58, 5.68)	6.08 (5.87, 6.30)	5.56 (5.33, 5.80)
Total protein foods	4.80 (4.62, 4.98)	4.71 (4.56, 4.85)	4.74 (4.66, 4.83)	4.79 (4.76, 4.81)	4.80 (4.78, 4.81)	4.80 (4.73, 4.86)	4.80 (4.74, 4.86)
Seafood and plant proteins	3.67 (3.21, 4.14)	3.67 (3.13, 4.20)	3.71 (3.45, 3.98)	3.84 (3.75, 3.93)	3.86 (3.80, 3.93)	3.84 (3.55, 4.12)	3.87 (3.69, 4.05)
Fatty acids§	4.78 (3.75, 5.81)	4.46 (3.83, 5.10)	4.61 (4.35, 4.86)	4.43 (4.38, 4.47)	4.48 (4.42, 4.55)	4.78 (4.54, 5.02)	5.16 (4.92, 5.40)
Refined grains	6.18 (5.76, 6.61)	5.83 (5.16, 6.49)	5.76 (5.36, 6.16)	6.19 (6.14, 6.24)	6.15 (6.10, 6.19)	6.15 (5.82, 6.48)	6.25 (6.00, 6.51)
Sodium	4.53 (3.78, 5.28)	4.92 (4.37, 5.47)	4.81 (4.54, 5.07)	4.38 (4.35, 4.42)	4.22 (4.19, 4.26)	3.66 (3.43, 3.88)	3.97 (3.78, 4.17)
Added sugars	4.36 (3.57, 5.14)	4.82 (4.18, 5.46)	5.71 (5.41, 6.01)	6.18 (6.14, 6.21)	6.01 (5.97, 6.05)	6.32 (6.03, 6.61)	6.38 (6.09, 6.68)
Saturated fats	6.08 (5.62, 6.55)	6.49 (5.93, 7.05)	5.91 (5.60, 6.22)	5.75 (5.71, 5.80)	5.85 (5.77, 5.92)	6.46 (6.23, 6.69)	6.40 (6.07, 6.74)
Total scores¶	53.1 (50.6, 55.6)	55.6 (53.7, 57.6)	53.8 (52.5, 55.1)	53.9 (53.7, 54.1)	54.1 (53.9, 54.3)	56.1 (54.6, 57.6)	56.6 (55.6, 57.7)

HEI: Healthy Eating index; NHANES: National Health and Nutrition Examination; APC: Annual percent change; AAPC: average annual percent change (AAPC). Joinpoint regression model was used to estimate the parameters.
†Data were adjusted for NHANES survey weights to be nationally representative. Higher scores indicate greater adherence to the 2015 Dietary Guidelines for Americans.
‡Values may not equal the difference between the beginning and ending estimates because of rounding.
§Ratio of polyunsaturated fatty acids and monounsaturated fatty acids to saturated fatty acids.
¶Total score was the sum of 13 component scores.

Table 2. HEI-2015 scores of children and adults in the US (cont.)

Components	2013-2014	2015-2016	2017-2018	Difference between 1999-2000 and 2017-2018 ‡	*p* for difference (1999-2000 vs 2017-2018)
Children					
Total fruits	3.14 (2.86, 3.41)	3.10 (2.86, 3.33)	3.10 (3.05, 3.15)	0.05 (0.05, 0.05)	<0.001
Whole fruits	3.40 (3.12, 3.69)	3.42 (3.18, 3.66)	3.48 (3.44, 3.53)	-0.74 (-0.74, -0.74)	<0.001
Total vegetables	2.29 (2.18, 2.41)	2.42 (2.31, 2.53)	2.09 (2.06, 2.12)	-0.45 (-0.45, -0.45)	<0.001
Greens and beans	1.71 (1.44, 1.99)	1.70 (1.50, 1.91)	1.29 (1.17, 1.40)	-0.12 (-0.12, -0.12)	<0.001
Whole grains	3.03 (2.65, 3.42)	3.41 (3.07, 3.76)	3.03 (2.95, 3.10)	1.34 (1.34, 1.34)	<0.001
Dairy	7.86 (7.62, 8.10)	7.56 (7.14, 7.98)	7.01 (6.95, 7.07)	-0.25 (-0.25, -0.25)	<0.001
Total protein foods	4.32 (4.14, 4.49)	4.26 (4.08, 4.43)	4.16 (4.12, 4.20)	0.12 (0.12, 0.12)	<0.001
Seafood and plant proteins	2.78 (2.50, 3.06)	2.93 (2.74, 3.11)	2.69 (2.63, 2.74)	0.22 (0.22, 0.22)	<0.001
Fatty acids	3.22 (2.85, 3.59)	3.25 (3.06, 3.43)	3.42 (3.35, 3.49)	0.01 (0.01, 0.01)	<0.001
Refined grains	4.76 (4.50, 5.01)	4.72 (4.29, 5.16)	4.93 (4.87, 5.00)	-0.06 (-0.06, -0.06)	<0.001
Sodium	4.50 (4.10, 4.91)	4.39 (4.14, 4.65)	5.20 (5.17, 5.23)	0.39 (0.39, 0.39)	<0.001
Added sugars	5.99 (5.59, 6.40)	6.48 (6.28, 6.68)	6.38 (6.27, 6.48)	2.88 (2.88, 2.88)	<0.001
Saturated fats	5.36 (5.00, 5.71)	4.65 (4.41, 4.89)	4.81 (4.74, 4.88)	-0.52 (-0.52, -0.52)	<0.001
Total scores	52.4 (51.0, 53.7)	52.3 (51.0, 53.6)	51.6 (51.4, 51.8)	2.86 (2.84, 2.88)	<0.001
Adults					
Total fruits	2.32 (2.14, 2.50)	2.45 (2.21, 2.69)	2.16 (1.95, 2.36)	-0.27 (-0.27, -0.27)	<0.001
Whole fruits	2.70 (2.49, 2.91)	2.86 (2.60, 3.11)	2.67 (2.37, 2.96)	-0.88 (-0.88, -0.88)	<0.001
Total vegetables	3.32 (3.17, 3.48)	3.42 (3.27, 3.56)	3.18 (3.05, 3.31)	-0.37 (-0.37, -0.37)	<0.001
Greens and beans	2.84 (2.62, 3.07)	2.93 (2.62, 3.25)	2.44 (2.15, 2.72)	0.04 (0.04, 0.04)	<0.001
Whole grains	2.56 (2.36, 2.75)	2.76 (2.55, 2.98)	2.31 (1.96, 2.66)	0.68 (0.68, 0.68)	<0.001
Dairy	5.83 (5.58, 6.08)	5.46 (5.28, 5.64)	5.22 (5.00, 5.43)	0.09 (0.07, 0.11)	<0.001
Total protein foods	4.80 (4.76, 4.83)	4.82 (4.77, 4.88)	4.75 (4.66, 4.85)	-0.05 (-0.05, -0.05)	<0.001
Seafood and plant proteins	4.01 (3.88, 4.15)	3.95 (3.67, 4.23)	3.77 (3.42, 4.11)	0.1 (0.1, 0.1)	<0.001
Fatty acids§	4.80 (4.65, 4.95)	4.78 (4.48, 5.07)	4.54 (4.16, 4.93)	-0.24 (-0.25, -0.23)	<0.001
Refined grains	6.16 (5.91, 6.41)	6.60 (6.40, 6.79)	6.28 (6.03, 6.53)	0.1 (0.1, 0.1)	<0.001
Sodium	3.88 (3.59, 4.17)	3.58 (3.25, 3.91)	3.88 (3.67, 4.10)	-0.65 (-0.65, -0.65)	<0.001
Added sugars	6.41 (6.19, 6.63)	6.92 (6.60, 7.25)	6.84 (6.49, 7.19)	2.48 (2.48, 2.48)	<0.001
Saturated fats	6.04 (5.86, 6.22)	5.48 (5.20, 5.76)	5.15 (4.85, 5.45)	-0.93 (-0.93, -0.93)	<0.001
Total scores¶	55.7 (54.7, 56.7)	56.0 (54.5, 57.5)	53.2 (51.1, 55.3)	0.08 (0.01, 0.15)	<0.01

HEI: Healthy Eating index; NHANES: National Health and Nutrition Examination; APC: Annual percent change; AAPC: average annual percent change (AAPC). Joinpoint regression model was used to estimate the parameters.

†Data were adjusted for NHANES survey weights to be nationally representative. Higher scores indicate greater adherence to the 2015 Dietary Guidelines for Americans.

‡Values may not equal the difference between the beginning and ending estimates because of rounding.

§Ratio of polyunsaturated fatty acids and monounsaturated fatty acids to saturated fatty acids.

¶Total score was the sum of 13 component scores.

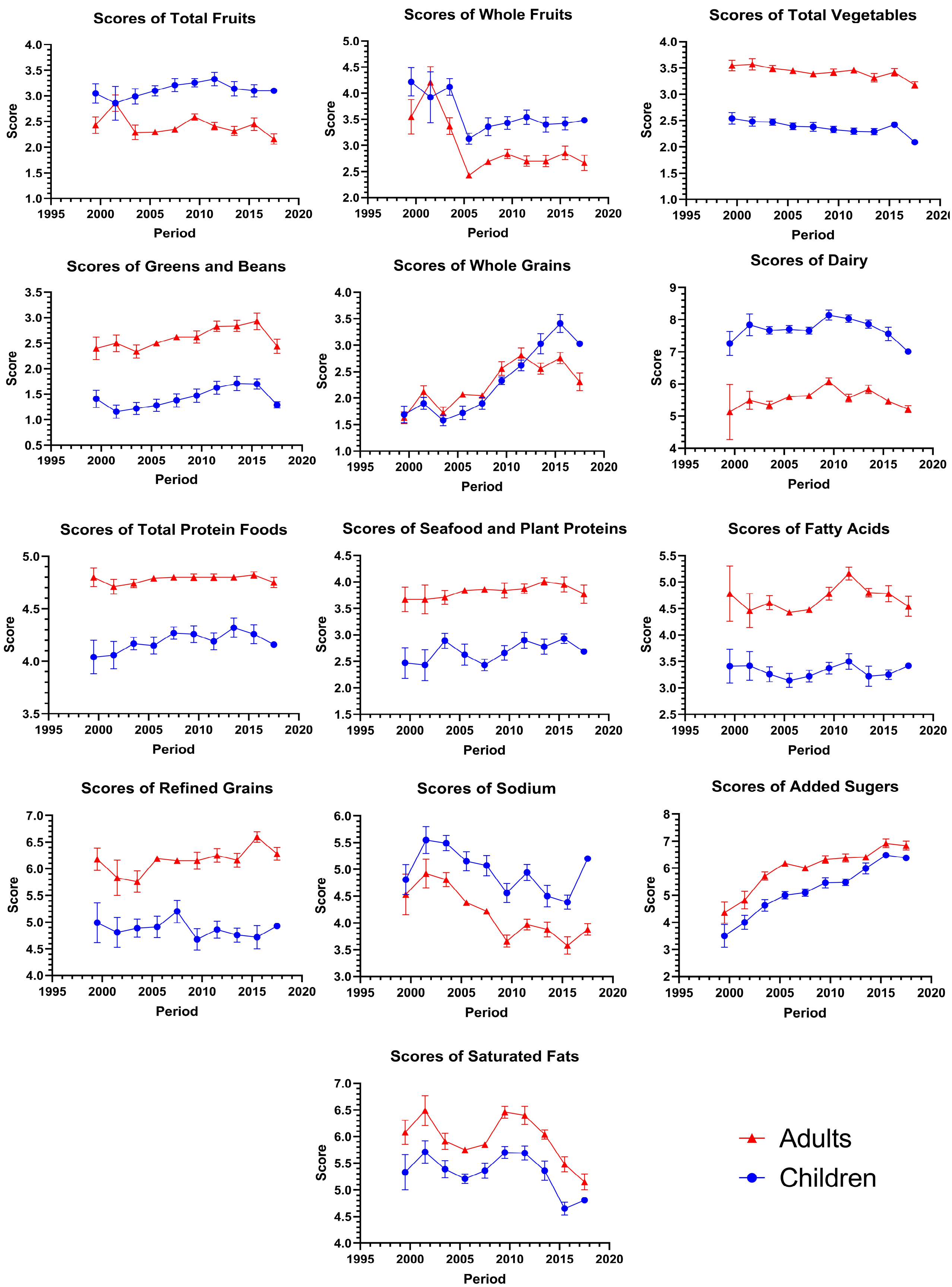

Figure 2. Trends in Estimated Component Scores of HEI-2015 Among US Children Aged 2-18 and Adults Aged 19-59 by NHANES Survey Cycle From 1999-2000 to 2017-2018. Data are weighted to be nationally representative, adjusted by demographic factors using the MCMC method to estimate distributions of usual intake for foods. Data points indicate estimated means; error bars indicate standard errors. Analyses of trends were based on NHANES cycles from 1999-2000 to 2017-2018 using the joinpoint regression model. $p<0.01$ for joinpoint for total fruits in 2011-2012, dairy in 2013-2014, and $p<0.05$ for joinpoint for whole fruits in 2005-2006, greens and beans and total protein foods in 2013-2014 among children; $p<0.05$ for parallelism for trends of greens and beans and added sugars between children and adults; $p<0.05$ for coincidence for trends of total fruits, whole fruits, total vegetables, greens and beans, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars and saturated fats among children and adults.

adults' trends were increasing/decreasing monotonically in all 13 components scores.

With a significant joinpoint, total score of diet quality in children was increasing (from 1999-2000 to 2013-2014; APC 0.6%; 95% CI: 0.1% to 1.1%; p for APC <0.05) at first then came down (from 2013-2014 to 2017-2018; APC -0.6%; 95% CI: -2.7% to 1.6%; p for APC=0.5). Among five component scores with a joinpoint in children, there were 4 increasing in the first period then decreasing during the second period including greens and beans, dairy, total protein foods, which were increased during 1999-2000 to 2013-2014 then decrease during 2013-2014 to 2017-2018, and total fruits (First Period: from 1999-2000 to 2011-2012; APC 0.9%; 95% CI: 0.3% to 1.5%; p for APC <0.05. Second Period: from 2011-2012 to 2017-2018; APC -1.0%; 95% CI: -2.1% to 0.0%; p for APC=0.1). Meanwhile score of whole fruits was decreasing (from 1999-2000 to 2005-2006; APC -5.1%; 95% CI: -7.2% to -2.9%; p for APC<0.05) at first then going up (from 2005-2006 to 2017-2018; APC 0.3%; 95% CI: -0.0% to 0.7%; p for APC=0.1).

Among 8 component scores changing monotonically in children, two components had a significant upward trend including whole grains, and added sugars (p for APC <0.05) during the study period. Whereas two components had a significant downward trend including total vegetables and saturated fats (p for APC <0.05). For adults, total scores and all 13 component scores of diet quality were changing monotonically. Total score of adults was increasing (APC = AAPC 0.3%; 95% CI: 0.0% to 0.6%; p for APC <0.05) significantly during 10 cycles. In 10 component scores which increasing, greens and beans, whole grains, seafood and plant proteins, and fatty acids increased significantly (p for APC <0.05). Meanwhile, in 3 component scores which decreasing, there were two component scores including total vegetables and sodium decreasing significantly (p for APC <0.05).

Differences in trends between children and adults

There were differences between children's and adults' trends in parallelism and coincidence of both total score and component scores. Total score of diet quality between children (AAPC 0.3%; 95% CI: -0.1% to 0.8%) and adults (AAPC 0.3%; 95% CI: 0.0% to 0.6%) showed no difference between trends in parallelism (p for parallelism=0.60) (Table 3), but a significant difference in coincidence (intercept -7.7±3.7 among children; intercept -2.3±2.5 among adults; p for coincidence <0.05).

Among trends for 13 component scores of diet quality, trends of greens and beans (p for parallelism <0.05) and added sugars (p for parallelism <0.05) showed a significant difference between children and adults while trends of total fruits, whole fruits, total vegetables, greens and beans, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats were different in coincidence (p for coincidence <0.05) between children and adults. The only one with a good coincidence between children and adults is trend of whole grains (p for coincidence=0.36) (Table 3). More details could be found in in the Supplementary table 2.

DISCUSSION

There were three main findings in this research, which had not been reported before. First, compared with adults aged 19-59, trends of diet quality in children aged 2-18 were more likely to change from 1999 to 2018 in the US. Specifically, the trends of the total score and five component scores of children's diet quality had a significant trend-change, while none component was found to have a trend-change among adults. Second, although children and adults had different numbers of joinpoints, no significant difference of trends was found between them by parallelism test except added sugars, and greens and beans. It demonstrated that the homogeneity of dietary trend between children and adults would still existed, and it might be caused by the volatility of children's diet quality when facing the environment changes with time.[32] Third, trends of total score and most components score except whole grains between children and adults were considered different by coincidence test, and children had a worse overall diet quality during the study period according to the model parameter. It demonstrated that the current major public health problem in diet quality was that the quality of children's diet was inherently worse than that in adults. Therefore, immediate macro public health initiatives are required through various way to improve the quality of children's diet.

Compared with previous studies, our research showed its superiority of applying the most advanced approach to estimate diet quality and its trends uniformly. Recently, two serial cross-sectional studies[15,16] of NHANES reported that the total score of HEI-2015 had risen with a steady upward trend during 1999-2000 to 2015-2016 cycle. Compared with them, adults aged 19 to 59 instead of over 20 were chosen as participants in this study, which can effectively reduce the intra-group differences within adults and ensure the comparability with children aged 2 to 18. Moreover, the MCMC method was uniformly applied in both children and adults to estimate usual intakes and usual diet quality in our research, whose results were adjusted for demographic factors in each cycle. It would made diet quality between children and adults more comparable. What's more, a larger standard error was produced by the skip of a reducing dataset step when generating BRR weights, which made our analysis more conservative and reliable.

There is some hypothesis of underlying mechanism to explain the result. First, children's diet quality is closely related to adults' diet quality. Among numerous factors affecting the diet quality in childhood, family factor is the most important one.[32] Not only parents' diet habits would directly affect children's diet habits, but children would also become parents after years and their habits would affect their own children. It also explains why children and adults have no significantly different trends by parallelism test in this study. It inspires that the effect of interventions for a single population should be multidimensional, changing the quality of dietary quality in children or adults would improve that in another indirectly. Second, the eating habits of children (2-18 years old) had a high variability,[32] which might lead to greater volatility of dietary trend in children, resulting in significant trend-change in joinpoint regression model. For adults, such

Table 3. Trends of HEI-2015 scores of children and adults from 1999 to 2018

	Children					
	Period 1†	HEI-2015 score APC, % (95% CI)	Period 2†	HEI-2015 score APC, % (95% CI)	AAPC, %, 1999-2018 (95% CI)	*p* for joinpoint§
Total fruits	1999-2000 to 2011-2012	0.9 (0.3, 1.5)	2011-2012 to 2017-2018	-1.0 (-2.1, 0.0)	0.3 (-0.1, 0.7)	<0.01
Whole fruits	1999-2000 to 2005-2006	-5.1 (-7.2, -2.9)	2005-2006 to 2017-2018	0.3 (-0.0, 0.7)	-1.5 (-2.1, -0.9)	0.046
Total vegetables	--	--	1999-2000 to 2017-2018	-1.2 (-1.7, -0.7)	-1.2 (-1.7, -0.7)	0.212
Greens and beans	1999-2000 to 2013-2014	3.1 (1.0, 5.2)	2013-2014 to 2017-2018	-6.4 (-13.8, 1.6)	0.9 (-0.9, 2.8)	0.023
Whole grains	--	--	1999-2000 to 2017-2018	3.7 (2.6, 4.8)	3.7 (2.6, 4.8)	0.460
Dairy	1999-2000 to 2013-2014	0.4 (-0.1, 1.0)	2013-2014 to 2017-2018	-3.2 (-6.8, 0.4)	-0.4 (-1.1, 0.3)	<0.01
Total protein foods	1999-2000 to 2013-2014	0.4 (-0.0, 0.8)	2013-2014 to 2017-2018	-0.9 (-2.8, 1.1)	0.1 (-0.3, 0.5)	0.021
Seafood and plant proteins	--	--	1999-2000 to 2017-2018	0.1 (-0.7, 0.9)	0.1 (-0.7, 0.9)	0.547
Fatty acids	--	--	1999-2000 to 2017-2018	0.4 (-0.0, 0.7)	0.4 (-0.0, 0.7)	0.464
Refined grains	--	--	1999-2000 to 2017-2018	0.1 (-0.2, 0.3)	0.1 (-0.2, 0.3)	0.326
Sodium	--	--	1999-2000 to 2017-2018	0.1 (-0.7, 0.8)	0.1 (-0.7, 0.8)	0.059
Added sugars	--	--	1999-2000 to 2017-2018	2.3 (1.8, 2.9)	2.3 (1.8, 2.9)	0.375
Saturated fats	--	--	1999-2000 to 2017-2018	-1.0 (-1.6, -0.4)	-1.0 (-1.6, -0.4)	0.055
Total score	1999-2000 to 2013-2014	0.6 (0.1, 1.1)	2013-2014 to 2017-2018	-0.6 (-2.7, 1.6)	0.3 (-0.1, 0.8)	0.046

	Adults				
	Period †‡	HEI-2015 score APC, % (95% CI)	*p* for joinpoint §	*p* for parallelism	*p* for coincidence
Total fruits	1999-2000 to 2017-2018	0.2 (-1.0, 1.3)	0.526	0.511	<0.05
Whole fruits	1999-2000 to 2017-2018	0.9 (-1.7, 3.6)	0.053	0.329	<0.05
Total vegetables	1999-2000 to 2017-2018	-0.5 (-0.8, -0.2)	0.417	0.050	<0.05
Greens and beans	1999-2000 to 2017-2018	1.2 (0.4, 2.0)	0.070	<0.05	<0.05
Whole grains	1999-2000 to 2017-2018	2.7 (1.2, 4.2)	0.789	0.235	0.360
Dairy	1999-2000 to 2017-2018	-0.1 (-0.6, 0.5)	0.089	0.746	<0.05
Total protein foods	1999-2000 to 2017-2018	0.0 (-0.0, 0.1)	0.309	0.142	<0.05
Seafood and plant proteins	1999-2000 to 2017-2018	0.4 (0.1, 0.7)	0.111	0.409	<0.05
Fatty acids	1999-2000 to 2017-2018	0.9 (0.3, 1.6)	0.647	0.161	<0.05
Refined grains	1999-2000 to 2017-2018	0.3 (-0.0, 0.7)	0.538	0.192	<0.05
Sodium	1999-2000 to 2017-2018	-1.6 (-2.3, -0.9)	0.283	0.063	<0.05
Added sugars	1999-2000 to 2017-2018	0.5 (-0.5, 1.5)	0.105	<0.05	<0.05
Saturated fats	1999-2000 to 2017-2018	0.1 (-0.8, 1.1)	0.133	0.419	<0.05
Total score	1999-2000 to 2017-2018	0.3 (0.0, 0.6)	0.763	0.598	<0.05

HEI: Healthy Eating index; NHANES: National Health and Nutrition Examination; APC: Annual percent change; AAPC: average annual percent change (AAPC). Joinpoint regression model was used to estimate the parameters.

†Periods were based on cycles, divided by joinpoints.

‡Only one period was there among all component scores in adults, with no joinpoints.

§$p<0.05$ indicates that there was a trend-change during the study period.

trend changes existed, but the volatility was slighter. Third, children like to eat snacks, and the lack of control over their own eating behavior is another important reason that causes the quality of children's diet to be worse than that of adults. Therefore, the fundamental to improve the diet quality of the whole population is to change the dietary habits of children.

Measures to improve the diet quality of children are multifaceted and multi-linked. Since the effect is lagging, continuous efforts are needed to be put into this area. There had already been some national strategies[33-35] that took comprehensive interventions in schools, homes, businesses, and other places to improve the diet quality of children, which had impacted the intake of added sugar and benefited children's health, and modelling study showed that policy about increasing the price of unhealthy food, such as high sugar snacks, could reduce BMI and prevalence of obesity.[36] However, many obstacles to improve the dietary quality among children are still alive, the way to improve diet quality is still long.

Overall, this study has several strengths. It quantitatively analyzed and compared trends in diet quality between children and adults using the latest data from NHANES. Different from the limitations of general linear regression, the joinpoint regression analysis model can be used to test the change of long-term trend and compare different trends, which provides more details to deal with actual dietary quality problems. Meanwhile, several limitations merit considered. First, errors occurred when using the self-reported dietary information through 24 hours recalls to estimate dietary intake. However, in this study, the NCI method and one more 24-hour recalls implemented from 2003-2004 cycle were used to reduce random and systematic errors. Second, the changes in survey methods during the research period may bring systematic errors to the trend analysis, but all the changes in survey methods have been compared with related research by the researchers and confirmed that would not cause qualitative changes to the research results. Third, there might be systematic bias in directly comparing the HEI-2015 scores between children and adults. However, as a popular diet quality assessment tool for both children and adults, HEI-2015 is still the best comparison tool. Meanwhile, the trend-based comparison in this research also reduced the internal bias of assessment tool. Forth, overall diet quality trends and comparisons cannot be representative of all subgroups. Studies had shown[15,32] that subgroups with different sociodemographic characteristics had different diet quality characteristics. Therefore, further studies and comparisons are needed in future researches especially among key subgroups with a poor diet quality.

Overall, different trends of diet quality were estimated between children and adults in the US from 1999-2018, although there were still some similarities in parallelism. It indicated our hypothesis was accepted.

Conclusion

The diet quality of children was worse and more variable than that of adults, which called more strategy and public health action to improve diet quality especially among children in the US.

AUTHOR DISCLOSURES

The authors declared that they have no conflict of interest. This work is supported by Lideshuren Project of School of Public Health, Peking University Health Science Center to Dr Yu, and Dr Huang; The study funders did not contribute or play a role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication. The authors confirm that there are no conflicts of interest and no financial or personal relationships with other people or organizations that can inappropriately influence this work. The views expressed in the submitted article are the authors' own without considerations of any official position of the institution or funder.

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Supplementary table 1. Scoring scheme of the Healthy Eating Index (HEI) 2015

HEI-2015 components[†]	Maximum points	Standard for maximum score[‡]	Standard for minimum score of zero[‡]
Total fruits	5	≥0.8 cup equivalent per 1,000 kcal	No fruit
Whole fruits	5	≥0.4 cup equivalent per 1,000 kcal	No whole fruit
Total vegetables	5	≥1.1 cup equivalent per 1,000 kcal	No vegetables
Greens and beans[§]	5	≥0.2 cup equivalent per 1,000 kcal	No dark-green vegetables or legumes
Whole grains	10	≥1.5 ounce equivalent per 1,000 kcal	No whole grains
Dairy	10	≥1.3 cup equivalent per 1,000 kcal	No dairy
Total protein foods	5	≥2.5 ounce equivalent per 1,000 kcal	No protein foods
Seafood and plant proteins	5	≥0.8 ounce equivalent per 1,000 kcal	No seafood or plant proteins
Fatty acids[¶]	10	(PUFAs + MUFAs) / SFAs ≥2.5	(PUFAs + MUFAs)/SFAs ≤1.2
Refined grains	10	≤1.8 ounce equivalent per 1,000 kcal	≥4.3 ounce equivalent per 1,000 kcal
Sodium	10	≤1.1 grams per 1,000 kcal	≥2.0 grams per 1,000 kcal
Added sugars	10	≤6.5% of energy	≥26% of energy
Saturated fats	10	≤8% of energy	≥16% of energy

[†]Total score ranges from 0 to 100 as sum of all component scores, to represent an overall diet quality.
[‡]All standards represent amounts per 1,000 kcal (sometimes shown as percentage of energy) except for Fatty Acids, intakes between the minimum and maximum standards are scored proportionately.
[§]Legumes includes dry beans and peas.
[¶]PUFA: polyunsaturated fatty acids; MUFA: monounsaturated fatty acids; SFA: saturated fatty acids.

Supplementary table 2. Parameters of Joinpoint Regression Model in analysis of HEI-2015

HEI-2015 components	Group	Period †	Parameter	Parameter estimate	t	*p*
Total fruits	child	Intercept 1	-17.33	4.48	-3.87	0.01
	child	Intercept 2	22.01	8.22	2.68	0.04
	child	Slope 1	0.01	0.00	4.12	0.01
	child	Slope 2	-0.01	0.00	-2.54	0.05
	child	Slope 2 - Slope 1	-0.02	0.00	-4.21	0.01
	adult	Intercept	-2.36	10.01	-0.24	0.82
	adult	Slope	0.00	0.00	0.32	0.76
Whole fruits	child	Intercept 1	105.76	17.71	5.97	0.00
	child	Intercept 2	-5.00	2.81	-1.78	0.14
	child	Slope 1	-0.05	0.01	-5.89	0.00
	child	Slope 2 - Slope 1	0.06	0.01	6.17	0.00
	child	Slope 2	0.00	0.00	2.22	0.08
	adult	Intercept	-17.50	22.63	-0.77	0.46
	adult	Slope	0.01	0.01	0.82	0.44
Total vegetables	child	Intercept	24.79	4.35	5.70	0.00
	child	Slope	-0.01	0.00	-5.52	0.00
	adult	Intercept	10.60	2.72	3.90	0.00
	adult	Slope	0.00	0.00	-3.45	0.01
Greens and beans	child	Intercept 1	-60.75	15.93	-3.81	0.01
	child	Intercept 2	134.10	64.66	2.07	0.09
	child	Slope 1	0.03	0.01	3.83	0.01
	child	Slope 2	-0.07	0.03	-2.07	0.09
	child	Slope 2 - Slope 1	-0.10	0.03	-2.93	0.03
	adult	Intercept	-23.12	7.07	-3.27	0.01
	adult	Slope	0.01	0.00	3.40	0.01
Whole grains	Combined‡	Intercept	-67.36	5.92	-11.37	0.00
	Combined‡	Slope	0.03	0.00	11.52	0.00
Dairy	child	Intercept 1	-6.74	4.56	-1.48	0.20
	child	Intercept 2	68.33	29.16	2.34	0.07
	child	Slope 1	0.00	0.00	1.93	0.11
	child	Slope 2	-0.03	0.01	-2.28	0.07
	child	Slope 2 - Slope 1	-0.04	0.01	-2.55	0.05
	adult	Intercept	3.42	4.93	0.69	0.51
	adult	Slope	0.00	0.00	-0.34	0.74
Total protein foods	child	Intercept 1	-5.89	3.23	-1.82	0.13
	child	Intercept 2	19.13	15.77	1.21	0.28
	child	Slope 1	0.00	0.00	2.27	0.07
	child	Slope 2	-0.01	0.01	-1.12	0.31
	child	Slope 2 - Slope 1	-0.01	0.01	-1.56	0.18
	adult	Intercept	0.84	0.59	1.42	0.19
	adult	Slope	0.00	0.00	1.22	0.26
Seafood and plant proteins	child	Intercept	-0.70	6.86	-0.10	0.92
	child	Slope	0.00	0.00	0.25	0.81
	adult	Intercept	-6.19	2.55	-2.42	0.04
	adult	Slope	0.00	0.00	2.95	0.02
Fatty acids‡	child	Intercept	-5.95	3.14	-1.90	0.09
	child	Slope	0.00	0.00	2.29	0.05
	adult	Intercept	-17.09	5.80	-2.95	0.02
	adult	Slope	0.01	0.00	3.21	0.01
Refined grains	child	Intercept	0.40	2.52	0.16	0.88
	child	Slope	0.00	0.00	0.47	0.65
	adult	Intercept	-4.63	3.11	-1.49	0.17
	adult	Slope	0.00	0.00	2.07	0.07
Sodium	child	Intercept	0.08	6.49	0.01	0.99
	child	Slope	0.00	0.00	0.24	0.82
	adult	Intercept	33.80	6.14	5.50	0.00
	adult	Slope	-0.02	0.00	-5.26	0.00

†Two intercepts and slopes were reported when there was a significant joinpoint during the whole period.
‡The combined group includes children and adults because of their significantly coincident intercept and slope tested by coincidence test.

Supplementary table 2. Parameters of Joinpoint Regression Model in analysis of HEI-2015 (cont.)

HEI-2015 components	Group	Period †	Parameter	Parameter estimate	t	*p*
Added Sugars	child	Intercept	-44.98	4.63	-9.71	0.00
	child	Slope	0.02	0.00	10.10	0.00
	adult	Intercept	-8.85	8.56	-1.03	0.33
	adult	Slope	0.01	0.00	1.24	0.25
Saturated Fats	child	Intercept	22.31	5.50	4.05	0.00
	child	Slope	-0.01	0.00	-3.76	0.01
	adult	Intercept	-1.16	8.27	-0.14	0.89
	adult	Slope	0.00	0.00	0.35	0.73
	child	Intercept 1	-7.74	3.68	-2.10	0.09
	child	Intercept 2	15.25	17.15	0.89	0.41
	child	Slope 1	0.01	0.00	3.17	0.02
	child	Slope 2	-0.01	0.01	-0.66	0.54
	child	Slope 2 - Slope 1	-0.01	0.01	-1.31	0.25
	adult	Intercept	-2.33	2.54	-0.92	0.39
	adult	Slope	0.00	0.00	2.49	0.04

†Two intercepts and slopes were reported when there was a significant joinpoint during the whole period.
‡The combined group includes children and adults because of their significantly coincident intercept and slope tested by coincidence test.