

CLINICAL RESEARCH ARTICLE



Diet quality scores associated with improved cardiometabolic measures among African American adolescents

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BACKGROUND: The Reversing the Negative cardiovascular Effects on Weight (ReNEW) Clinic is a prospective cohort study in children and adolescents (≤ 21 years) at the Johns Hopkins Children's Center.

METHODS: Cross-sectional analysis between diet quality using the Alternative Healthy Eating Index (AHEI-2010), pro-inflammatory potential using the Children's Dietary Inflammatory Index (C-DII), and cardiometabolic outcomes. AHEI-2010 and C-DII scores were assessed by median intake determined from the sample distribution and associated with cardiometabolic measures using linear regression models. Changes in measures were evaluated in a sub-sample of participants invited to attend follow-up visits due to the presence of hypertensive blood pressure ($n = 33$).

RESULTS: Participants ($n = 90$) reported an average energy intake of 1790 kcal/day ($SD \pm 734$), AHEI-2010 score of 55.04 ($SD \pm 9.86$) (range: 0 to 110) and C-DII score of $-0.12 (\pm 0.86)$ (range -5 to 5). Participants with higher quality/anti-inflammatory diets trended towards more favorable cardiometabolic measures at baseline. Among the sub-sample ($n = 33$), there was a significant reduction in total energy ($m = -302$ kcal/day; p -value = 0.03) but no change in AHEI-2010 (p -value = 0.73) or C-DII score (p -value = 0.85) over follow-up.

CONCLUSIONS: Despite stable diet quality scores, outpatient dietary and behavioral counseling may be an effective tool to reduce energy intake in youth with overweight/obesity and elevated blood pressure.

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IMPACT:

- Diet quality scores among obese, hypertensive, African American adolescents were low and reflect a pro-inflammatory diet.
- Reported intake was negligible for fruits, whole grains, nuts, and legumes, and well above the daily limit for sodium and saturated fat.
- Participants with high quality/anti-inflammatory diet quality scores trended toward improved cardiometabolic measures.
- Outpatient dietary counseling resulted in reduced total energy intake.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death in the United States (US) among adults.¹ In children and adolescents, trends over the past twenty years show a steady increase in the prevalence of obesity,² incidence of Type 2 Diabetes Mellitus (DM)³ as well as the persistent prevalence of hypertension⁴ making CVD risk a major public health problem in youth. Results from the SEARCH for Diabetes in Youth Study suggest that between 2002 and 2015, non-Hispanic (NH-) black youth have an increased risk of Type 2 DM, with the incidence rising by 6% per year.³ Moreover, in 2015–2016 NH-black adolescents were 60% more likely to have obesity² and twice as likely to have hypertension⁴ than NH-white youth.

Epidemiological evidence has consistently highlighted diet as a modifiable risk factor to prevent the development of cardiometabolic conditions in healthy US adolescents from the general population.^{5–8} Fruit and vegetable intake in this group has been inversely associated with abdominal obesity and metabolic syndrome.^{7,8} In addition to select components, overall diet quality has been associated with cardiometabolic conditions. Youth with higher adherence scores to the Healthy Eating Index (HEI) have lower serum cholesterol and improved glucose tolerance.⁹ Adolescents who consume a more pro-inflammatory diet, as measured by the dietary inflammatory index (DII), have higher waist circumference measures than those consuming more anti-inflammatory diets.¹⁰

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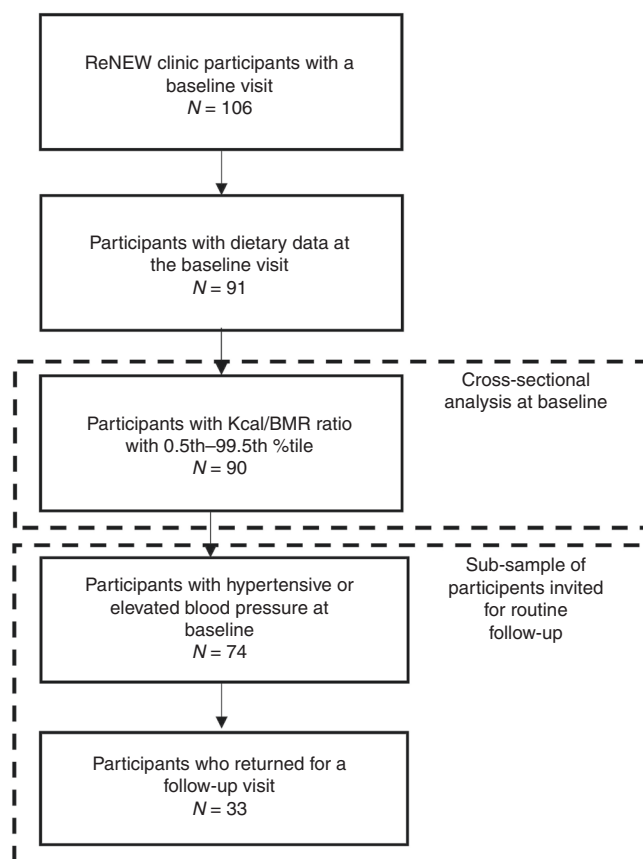


Fig. 1 Flow diagram of ReNEW clinic participants included in the study. Among participants enrolled in the ReNEW clinic cohort study ($N = 106$; Fig. 1), only those with dietary data were considered for the cross-sectional analysis ($N = 91$). Of the sub-group of participants with dietary data who were invited to receive routine follow-up care ($n = 74$), 33 attended follow-up visits within 12-months of baseline.

There are a limited number of studies that have examined the association of diet quality with cardiometabolic health in groups at high risk for the development of CVD. In addition, there is a need to establish and promote clinical interventions that are effective at improving diet intake and diet quality. The ReNEW Clinic is an interdisciplinary clinic in Baltimore, MD focused on the evaluation and treatment of obesity and hypertension in children and adolescents (≤ 22 years of age). Youth receiving treatment in this clinic are invited to participate in the ReNEW Clinic Cohort study, a prospective, longitudinal observational study of consecutive patients from the clinic. The majority of cohort participants are African American adolescents at high risk for the development of cardiovascular disease, which is an understudied group. The purpose of the present study is to 1. Investigate the cross-sectional association between diet quality and anthropometric/cardiometabolic traits among ReNEW Clinic Cohort study participants at baseline and, 2. Evaluate changes in dietary and cardiometabolic measures in a sub-sample of participants who were invited to attend follow-up visits due to the presence of hypertensive blood pressure.

METHODS

The ReNEW Clinic Cohort Study (NCT03816462) is human subjects research that has been approved by the Johns Hopkins IRB (IRB00056175).¹¹ Enrollment began in January 2015 and is ongoing through September 2025 with the goal to recruit 200 participants. This is a preliminary cross-sectional

analysis of participants who were recruited between January 2015 through December 2020.

Study sample

Participants between birth and 22 years of age with overweight or obesity who are referred to the clinic for evaluation of elevated blood pressure are eligible. At their clinic visit, interested participants and their guardians are invited to join the ReNEW Clinic Cohort Study, an observational research cohort study. Participants in the cohort study agree to have their clinical data abstracted from the electronic medical record (EMR) and entered into a longitudinal clinic registry. The study is discussed with participants in the presence of their parent or legal guardian and those who agree to participant sign consent (≥ 18 years) or assent (< 18 years) as appropriate. Cohort participants who present with an elevated or hypertensive blood pressure at their initial visit are invited to attend follow-up visits to receive routine care every 3–6 months ($n = 88/106$; 90% of the original cohort), whereas those who are found to have a normal blood pressure at their initial visit are invited for an additional follow-up visit at 6 months for additional weight management and to screen for the development of elevated or hypertensive BP if desired.

At clinic visits, standardized information is collected on blood pressure, anthropometrics, diet history, and other clinical data measurements. Among participants enrolled in the ReNEW clinic cohort study ($N = 106$; Fig. 1), only those with dietary data were considered for the cross-sectional analysis ($N = 91$). Of the sub-group of participants with dietary data who were invited to receive routine follow-up care ($n = 74$), 33 attended follow-up visits within 12-months of baseline ($m = 1.5 \pm 0.8$ visits). For the purpose of this study, follow-up was identified as the furthest visit with dietary data ($m = 7.2 \pm 3.2$ months of baseline).

During ReNEW clinic visits, youth meet with and receive treatment from the clinical team. Patients and families receive interdisciplinary pediatric care and meet with a pediatric nephrologist, research dietitian, a behavioral psychologist, and a physical therapist at each clinic visit. Children and their families receive nutrition education on a variety of topics including increasing fruits/vegetables, limiting sodium intake, promoting sugar-free beverages, healthy alternative snacks, promoting three meals per day, and portion control individualized to the participant and then reiterated with the behavioral psychologist. Youth in this clinic are incentivized with prizes for healthy lifestyle choices and prior to the beginning of COVID-19 were offered a healthy snack to try at each visit (cross-sectional: $n = 87/90$; sub-sample: baseline- $n = 71/74$ Follow-up- $n = 33/33$). Barriers to weight management are addressed and free-standing scales, as well as 3–6 months YMCA memberships, were offered to youth between 2015–2019.

Baseline characteristics

Demographic characteristics of participants are collected at baseline visits. Participant's age was abstracted from the EMR via the filed date of birth. Sex was obtained from participant self-report or via EMR filed sex (male, female). Race/ethnicity was obtained from forms detailing participants self-described race at the baseline clinic visit. Average household income is a continuous variable determined from U.S. census estimates of zip-code level data based on participant/parent-reported home address.

Documented medical history including presence of overweight/obesity, obstructive sleep apnea, high cholesterol, pre-diabetes and diabetes (type 2) was obtained from the participants EMR confirmed by physician diagnosis. Birth information (history of prematurity and birth weight) was collected via self-report from baseline data collection forms. Birth weight data was used to classify participants as low birth weight (< 2.5 kg), normal birth weight (2.5 – < 4.0 kg) or high birth weight (≥ 4.0 kg). Self-reported family history including obesity, hypertension, heart attack, high cholesterol, diabetes (type 1 or type 2), and kidney disease was collected on health history forms at baseline visits.

Dietary intake assessment and diet quality exposures

Dietary measures are collected at baseline and follow-up via self-report either through 3-days diet records that are completed prior to the clinic and then reviewed by the research dietitian with the participant and their family or by the guided 24-h recall at the clinic visit (3-day diet record: $n = 27/90$ or 30%, 24-h recalls: $n = 63/90$ or 70%). Both instruments relied on free form reporting of food items and portion sizes that was then confirmed with the dietitian utilizing standard measures (i.e., cups, tablespoons) with visual aids to assist accurate reporting. Brand names

or similar items were collected whenever possible and probing questions were utilized to identify commonly forgotten items. Individual foods and amounts reported for each day of the 3-days diet record or for single day 24-h recall were uploaded into the Nutrition Data System for Research (NDSR) software (versions 2014–2019).^{12,13} NDSR data files 04 (nutrient data at the daily totals) and 09 (food group serving counts at the daily totals) were exported from NDSR into Stata where information was linked to the clinic visit the data was collected at as either a single 24-h recall or an average of the 3-days diet record.

Diet quality was determined using the Alternative Healthy Eating Index (AHEI-2010) and the Children's Dietary Inflammatory Index (C-DII) following the specific criteria for each index.^{14,15} The AHEI-2010 index was selected based on the inclusion of select dietary components that have been positively or negatively associated with cardiometabolic health including fruits/vegetables,¹⁶ nuts/legumes,¹⁷ unsaturated fatty acids, red/processed meat,¹⁸ sugar-sweetened beverages (SSB)¹⁹ and sodium.²⁰ The C-DII was additionally selected as a dietary measure because anti-inflammatory diets have been associated with improvements in lipid profile¹⁰ and decreased likelihood of overweight/obesity in adolescents.²¹ Potassium is not included in either index but was described in this study as higher intakes have been inversely associated with blood pressure in adolescents.^{22,23}

AHEI. The Alternative Healthy Eating Index (AHEI-2010) score is based on 11 components of dietary intake scored from 0 to 10 (worst to best) with the total score ranging between 0 and 110 (higher = better diet quality).¹⁴ The calculation of the AHEI-2010 score within this sample was based on reported consumption of fruit (servings per day), vegetables (servings per day), whole grains (g/d), nuts and legumes (servings per day), omega-3 fatty acid (mg/d), polyunsaturated fatty acid (PUFA; %kcal), trans fat (% kcal) red/processed meat (servings per day), SSB (servings per day), sodium (mg/d) and alcohol (drinks/d). Scoring criteria for individual food component was taken from the original paper by Chiuve et al.¹⁴ except for alcohol which was scored between 0 and 2.5; with non-drinkers ($n = 88$; 98% of the sample) receiving a score of 2.5 and moderate drinkers ($n = 2$; 2% of the sample) receiving a score of 0.

C-DII. The C-DII score is a calculated parameter based on 25 components of dietary intake with total scores roughly ranging between -5 and 5 (lower = better diet quality).¹⁵ The calculation of the C-DII score within this sample was based on 25 nutrients and food components including total energy (kcal/day), protein (g/day), carbohydrate (g/day), total fat (g/day), saturated fat (g/day), mono-unsaturated fatty acid (MUFA) (g/day), PUFA (g/day), cholesterol (mg/day), dietary fiber (g/day), Vitamin A (RE/day), Vitamin D (mcg/day), Vitamin E (AT EQ/day), Vitamin C (mg/day), beta-carotene (mcg/day), thiamin (mg/day), riboflavin (mg/day), niacin (mg/day), folate (mg/day), Vitamin B₆ (mg/day), Vitamin B₁₂ (mcg/day), magnesium (mg/day), iron (mg/day), selenium (mcg/day), zinc (mg/day) and alcohol (grams/day). To derive the individual C-DII scores, the global average intake was subtracted from the reported daily intake of each nutrient and divided by the standard deviation of the global daily intake, obtaining a z-score which was converted into a centered percentile score.²⁴ This score was then multiplied with an overall inflammatory effect score. All 25 nutrient-specific effect scores were then summed to obtain the total C-DII score.¹⁵

Cardiometabolic characteristics

Anthropometric measures including height (cm), weight (kg), and waist circumference (cm) are collected at baseline and follow-up as a part of the clinical care process. Height is measured once to the nearest 0.1 cm using a wall-mounted stadiometer. Weight is measured once to the nearest 0.1 kg using a digital scale. Height and weight measurements were used to calculate age and sex standardized body mass index (BMI) z-scores (BMIz) using the CDC 2000 growth reference population in participants ≤ 18 years with weight status classified as "Underweight" < 5 th %tile, "Normal" 5th– < 85 th %tile, "Overweight" 85th – < 95 th %tile or "Obese" ≥ 95 th %tile.²⁵ BMI was calculated as weight (kilograms) over squared height (meters²) in participants 19–21 years with weight status classified as "Underweight" < 18.5 kg/m², "Normal" 18.5–24.9 kg/m², "Overweight" 25–29.9 kg/m², or Obese ≥ 30 kg/m².²⁶

Waist circumference. Waist circumference (WC) was measured by the trained research dietitian using Rosscraft anthropometric tape around the participant's umbilicus at the end of normal expiration.²⁷ WC was measured to the nearest 0.1 cm. Waist circumference measurements were

used to calculate age and sex standardized WC z-scores (z-WC) based on NHANES III data.²⁸

Blood pressure. Blood pressure was measured at each clinic visit by the same individual (TMB) via manual auscultation after 5 min of rest in the right upper arm with a calibrated aneroid sphygmomanometer. Cuff size was determined via mid-upper arm circumference measurement. Children were seated with legs uncrossed, feet on the ground, back supported and arm supported during the measurements.²⁹ Three measurements were taken 30 s apart and averaged together for one composite measurement at each clinic visit for systolic and diastolic blood pressure (SBP, DBP). Blood pressure index was calculated as raw, mean blood pressure divided by the age, sex, and height specific blood pressure at the 95th percentile (%tile) for all participants (95%tile measures at 17 years of age were used for those > 17 years); blood pressure index ≥ 1 can be interpreted as an abnormal blood pressure across all age/sex/height categories. Hypertensive BP was identified based on the American Academy of Pediatrics (AAP) 2017 Clinical Practice Guidelines (12 years, SBP or DBP ≥ 95 th %tile; ≥ 13 years, SBP or DBP $\geq 130/80$ mmHg).²⁹

Left ventricular mass index. Left ventricular mass index (LVMI) was determined in participants who received an echocardiogram as left ventricular mass in grams/(height in cm)^{2.7}. LVMI_{index} was calculated as LVMI divided by the age/sex standardized LVMI measures at the 95th %tile; LVMI_{index} > 1 was classified as left ventricular hypertrophy.³⁰

Plasma Glucose and Hemoglobin A1c. Plasma glucose was measured in mg/dL from participant serum samples. Fasting status was not identified, therefore impaired fasting glucose status could not be determined. Hemoglobin A1c (HbA1c) was measured in those suspected of being at risk for diabetes. Pre-diabetes and diabetes thresholds were based on American Diabetes Association criteria (pre-diabetes: HbA1c $\geq 5.7\%$ & HbA1c $\leq 6.4\%$; Diabetes: HbA1c $\geq 6.5\%$).³¹

Lipid markers. Lipid profile (total cholesterol, serum HDL-cholesterol, triglycerides) were measured in mg/dL from participant serum samples. Non-HDL cholesterol was determined by subtracting HDL-cholesterol from total cholesterol. Low HDL-cholesterol was identified based on National Heart Lung and Blood Institute (NHLBI) guidelines (HDL < 40 mg/dL).³²

Medications. Participants self-reported use of prescribed medications at baseline visits that was then confirmed via the EMR. Additionally, participants could be prescribed medications at clinic visits based on clinical status and physician diagnosis. Participants were considered to be taking blood pressure medication if they reported use or were prescribed angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, beta blockers, alpha blockers, alpha-beta blockers, calcium channel blockers, centrally acting alpha-2 agonist, direct vasodilators, diuretic-loop, diuretic-potassium sparing, diuretic-thiazide and combination antihypertensive medications. Diabetes medication use was confirmed if participants were taking or prescribed insulin and/or oral hypoglycemic agents.

Data analyses

Categorical variables were presented as numbers with percentages. Continuous variables were visualized to determine the distribution of sample characteristics and presented as means with standard deviation. Non-normally distributed data were presented as medians with inter-quartile range. Participants with unrealistic reporting of energy intake were excluded from the analysis determined as kilocalorie/basal metabolic rate ratio (Kcal/BMR) ratio < 0.5 th percentile or > 99.5 th percentile.³³ Baseline characteristics are presented from the ReNEW Clinic Cohort overall ($n = 106$) and among the final sample with realistic dietary data ($n = 90$). Differences in baseline characteristics between samples were explored by independent *t*-tests for continuous variables and by chi-square tests for categorical characteristics. Average and median dietary intake was compared with recommended guidelines and thresholds utilizing the Dietary Guidelines for Americans (DGA),³⁴ the scoring criteria from Chiuve et al.¹⁴ and the Dietary Reference Intakes (DRI) specific to each nutrient.^{35–37}

Cross-sectional associations between diet quality (comparing higher quality/anti-inflammatory vs. lower quality/pro-inflammatory diets determined via median split AHEI-2010 and C-DII scores based on the sample distribution) and cardiometabolic characteristics [SBP Index, DBP Index, SBP (mmHg), DBP (mmHg), LVMI (g/m^{2.7}), BMIz, z-WC, HbA1c (%) and non-

HDL cholesterol (mg/dL)] were evaluated using linear regression models. All models controlled for age (years), sex (boys, girls), daily energy intake (scaled per 1000 kcal), and average neighborhood household income (annual in US dollars). Models for SBP Index, DBP Index, SBP, DBP, and LVMI also controlled for blood pressure medication (yes, no); model for HbA1c additionally controlled for diabetes medication (yes, no). Additional covariates explored that did not significantly impact the association were race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), low birth weight (yes, no; defined as birth weight <2.5 kg), and family history (overweight/obesity, hypertension, diabetes).

Differences in general characteristics of those who were invited to attend follow-up visits ($n = 74$) who attended ($n = 33$) or did not attend ($n = 41$) follow-up visits were explored and presented in supplemental tables. Differences in cardiometabolic characteristics and dietary intake over follow-up among the sub-sample who attended follow-up visits ($n = 33$) were evaluated using longitudinal linear or logistic mixed-effects models with robust variance. Differences in total energy intake by type of dietary education received were explored and presented in a Supplemental Figure. Significance was set at p -value < 0.05. Stata 14 was used for all analyses.^{38–40}

RESULTS

Of the 106 participants enrolled in the ReNEW clinic cohort (Fig. 1), 91 provided dietary data at their baseline visit (86% of baseline sample). One participant was excluded for unrealistic intake (defined as kcal/BMR ratio <0.5th or >99.5th %tile) thus the final sample was comprised of 90 at baseline. Participants in the final sample ($N = 90$; Table 1) were on average 13.4 years ($SD \pm 3.9$ years; age range 4–21 years), majority male ($n = 51$; 57%) and most identified as non-Hispanic Black ($n = 73$; 81%). Based on zip-code level census data of participants, the median neighborhood household income was 54 K/year (IQR: 40– 69 K), and around 10% of households in the area fall below the poverty line. Based on documented medical history, the majority of the sample ($n = 79$; 88%) had a history of overweight/obesity and around 1 in 3 were medically diagnosed with obstructive sleep apnea ($n = 25$; 28%) or pre-diabetes/type 2 diabetes ($n = 25$; 28%). The average birth weight was 3.09 (± 0.82 kg) and around 1 in 4 participants ($n = 19$; 23%) were classified as having low-birth weight (<2.5 kg). Family history of co-morbidities was high overall and highest for hypertension ($n = 75$; 83%) and diabetes type 1 or type 2 ($n = 59$; 66%). There were no significant differences in demographic characteristics between the final sample with dietary data included in the cross-sectional analysis and the total ReNEW clinic.

Based on BMIz (≤ 18 years; $n = 81$) and BMI (>18 years; $n = 9$) all of the participants were classified as overweight ($n = 6$; 7%) or obese ($n = 84$; 93%) at baseline (Table 2) and average waist circumference z-score was 2.66 ($SD \pm 0.69$). Based on blood pressure percentiles (≤ 12 years; $n = 40$) and raw blood pressure measures (≥ 13 years; $n = 50$), 48% of participants had blood pressure in the hypertensive range.²⁹ Of participants with LVMI measures ($n = 82$), 72% of children had left ventricular hypertrophy.³⁰ Average HbA1c was 6.1% ($SD \pm 1.5$), with 26% ($n = 19$) of participants having an HbA1c in the pre-diabetic range and 13% ($n = 9$) with HbA1c in diabetic range. The average HDL-cholesterol was 45.2 mg/dL ($SD \pm 10.3$), and 32% of participants had low HDL-cholesterol based on NHLBI thresholds.³² The average non-HDL cholesterol was 115.4 mg/dL ($SD \pm 33.9$), and 16% of participants had elevated non-HDL cholesterol. Almost 40% of participants were on blood pressure medications ($n = 35$), and 13% were on diabetes medications ($n = 12$) at baseline.

The majority of the dietary data (70%) were collected as 24-h recalls at the clinic visit and the remaining (30%) were collected as 3-days food records. At baseline, the average AHEI score of participants was 55.04 ($SD \pm 9.86$), and the average C-DII score of participants was -0.12 ($SD \pm 0.86$) (Table 3). Participants reported consuming an average of 1790 kcal/day ($SD \pm 734$), and intake increased with higher age categories. Percent of energy from fat,

Table 1. Baseline characteristics of the overall ReNEW clinic cohort ($N = 106$) and participants included in the final sample ($n = 90$).

	ReNEW clinic cohort	Final sample for analysis	p -value ^a
Sample size	$N = 106$	$N = 90$	
Age, mean \pm SD	13.4 ± 3.9	13.4 ± 3.9	0.75
Male sex, n (%)	64 (60.4)	51 (56.7)	0.06
Race/ethnicity, n (%)			
Non-Hispanic Black	82 (77.4)	73 (81.1)	0.05
Non-Hispanic White	14 (13.2)	8 (8.9)	
Hispanic	6 (5.7)	5 (5.6)	
Other ^b	4 (3.8)	4 (4.4)	
SES Census Information, median (IQR) ^c			
Less than high school education, %	16.1 (9.4–21.7)	16.1 (10.4–21.7)	0.81
Population unemployed, %	7.7 (4.8–13.7)	7.9 (4.8–14.1)	0.35
Average household income (annual in US dollars)	55.5 K (39.4–72.5 K)	54.2 (39.6–68.8 K)	0.12
Households receiving public assistance, %	4.7 (2.1–10.1)	4.8 (2.3–10.3)	0.84
Below than poverty line, %	9.4 (4.2–19.6)	9.9 (4.6–22.7)	0.11
Documented medical history, n (%)			
Overweight/obesity	94 (88.7)	79 (87.8)	0.49
Obstructive sleep apnea	31 (29.3)	25 (27.8)	0.43
High cholesterol	9 (8.5)	7 (7.8)	0.53
Pre-diabetes (Type 2)	18 (17.0)	13 (14.4)	0.10
Diabetes (Type 2)	15 (14.2)	12 (13.3)	0.57
Early life/gestational factors			
Prematurity, n (%) ^d	16 (15.1)	14 (15.6)	0.75
Birth weight ^d , mean \pm SD	3.05 ± 0.84	3.09 ± 0.82	0.28
Birth weight classification, n (%)			
Low birth weight	24 (24.5)	19 (23.2)	0.78
Normal birth weight	66 (67.4)	56 (68.3)	
High birth weight	8 (8.2)	7 (8.5)	
Reported family history, n (%) ^e			
Obesity	15 (14.2)	13 (14.4)	0.84
Hypertension	88 (83.0)	75 (83.3)	0.84
Heart attack	31 (29.3)	24 (26.7)	0.17
High cholesterol	33 (31.1)	26 (28.9)	0.24
Diabetes (Type 1 or Type 2)	69 (65.1)	59 (65.6)	0.81
Kidney disease	21 (19.8)	18 (20.0)	0.91

^aIndependent t -tests or chi-square tests performed between participant characteristics and sample groups (ReNEW Clinic Cohort and Final Sample).

^bOther race/ethnicity includes Asian, multi-racial, and unspecified.

^cSocioeconomic status (SES) information based on patient census tract information.

^dHistory of prematurity is self-reported on all participants at baseline. Birth weight data obtained in 98 subjects (missing $n = 8$) and used to classify participants as low birth weight (<2.5 kg), normal birth weight (2.5–<4.0 kg) or high birth weight (≥ 4.0 kg).

^eFamily history (mother/father, siblings, grandparents) is self-reported from parents at baseline.

protein, and carbohydrate were 33.3%, 17.3%, and 49.3%, respectively. Compared with recommendations, median intake was negligible for fruit and nuts/legumes (0.00 servings/day) and low for vegetables (1.63 servings/day) and whole grains (4.7 g/day). Median intake of dietary fat, vitamins, and minerals are also presented in Table 3. Notably, median intake was high for saturated fat (11% of total energy) and sodium (3191 mg/day) but

Table 2. Cardiometabolic measures of participants included in the final sample ($N = 90$).

	Final sample
Sample size	$N = 90$
<i>Anthropometrics, mean \pm SD</i>	
BMIz (≤ 18 years) $n = 81$	2.56 ± 0.38
BMI, kg/m^2 (> 18 years) $n = 9$	47.6 ± 12.1
<i>Cardiometabolic measures, mean \pm SD</i>	
WC (cm) ^a	112.2 ± 21.7
z-WC ^a	2.66 ± 0.69
BP, mmHg ^b	
SBP, mmHg	124.0 ± 15.2
DBP, mmHg	66.3 ± 10.9
BP index ^b	
SBP index	0.98 ± 0.06
DBP index	0.75 ± 0.11
Left ventricular mass index, $\text{g}/\text{m}^{2.7}$ (LVMI) ^c	49.7 ± 13.6
LVMI index ^d	1.35 ± 0.33
Glucose, mg/dL ^e	100.3 ± 47.6
Hemoglobin A1c, % ^f	6.1 ± 1.5
Total cholesterol, mg/dL ^g	160.6 ± 32.1
HDL-cholesterol, mg/dL ^g	45.2 ± 10.3
Non-HDL cholesterol, mg/dL ^g	115.4 ± 33.9
Serum triglycerides, mg/dL ^g	111.5 ± 66.9
<i>Cardiometabolic Classification based on objective clinical measures, n/total (%)</i>	
Overweight/obese ^h	90/90 (100.0)
Hypertensive BP ⁱ	43/90 (47.8)
Left ventricular hypertrophy ^d	59/82 (72.0)
Pre-diabetes ^f	19/72 (26.4)
Diabetes ^f	9/72 (12.5)
Low HDL-cholesterol ^g	23/73 (31.5)
Elevated non-HDL cholesterol ^g	12/73 (16.4)
<i>Medications, n/total (%)</i>	
Blood pressure medication ^j	35/90 (38.9)
Diabetes medication ^k	12/89 (13.3)

BMIz body-mass index z-score, BMI body mass index, WC waist circumference, z-WC waist circumference z-score, BP blood pressure, SBP systolic blood pressure, DBP diastolic blood pressure, LVMI left ventricular mass index, HDL high-density lipoprotein cholesterol.

^aWaist Circumference (cm) ($n = 80$). Waist circumference measurements were used to calculate age and sex standardized WC Z-scores using the NHANES III growth reference population.²⁸

^bBlood pressure measured in all participants ($n = 90$). Blood pressure index was calculated as the mean of replicate blood pressure in mmHg divided by the age, sex, and height specific blood pressure at the 95th percentile (%tile) for all participants (95%tile measures at 17 years of age were used for those > 17 years).

^cLeft ventricular mass index (LVMI) determined in patients who received an echocardiogram ($n = 82$).

^dLVMI index was calculated as LVMI divided by the age/sex standardized LVMI measures at the 95th %tile; LVMI index > 1 was classified as left ventricular hypertrophy.³⁰

^ePlasma glucose ($n = 76$). Fasting status not determined.

^fHemoglobin A1c ($n = 72$). Pre-diabetes and diabetes thresholds based on ADA criteria (pre-diabetes: $\text{HbA1c} \geq 5.7\%$ & $\text{HbA1c} \leq 6.4\%$; diabetes: $\text{HbA1c} \geq 6.5\%$).³¹

^gTotal cholesterol, serum HDL-cholesterol, and serum triglycerides ($n = 73$). Non-HDL cholesterol was determined by subtracting HDL-cholesterol from total cholesterol. Low-HDL based on NHLBI guidelines defined as $\text{HDL} < 40$ mg/dL . Elevated non-HD defined as non-HDL cholesterol ≥ 145 mg/dL .³²

^hClassification of weight status based on age and sex standardized Body Mass Index (BMI) z-scores (12–18 years) or BMI (kg/m^2) (19–21 years) and determined as follows: 12–18 years “Underweight” $< 5\%$ %tile, “Normal” 5th – 85th %tile, “Overweight” 85th – 95th %tile or “Obese” $\geq 95\%$ %tile; 19–21 years “Underweight” < 18.5 kg/m^2 , “Normal” 18.5–24.9 kg/m^2 , “Overweight” 25–29.9 kg/m^2 , or Obese ≥ 30 kg/m^2 .²⁶

ⁱHypertensive BP was determined based on the American Academy of Pediatrics (AAP) 2017 Clinical Practice Guidelines (≤ 12 years, SBP or DBP $\geq 95\%$ %tile; ≥ 13 years, SBP or DBP $\geq 130/80$ mmHg).²⁹

^jAntihypertensive medications included angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, beta blockers, alpha blockers, alpha-beta blockers, calcium channel blockers, centrally acting alpha-2 agonist, direct vasodilators, diuretic-loop, diuretic-potassium sparing, diuretic-thiazide, and combination antihypertensive medications.

^kDiabetes medications included insulin and oral hypoglycemic agents.

low for MUFA (11% of total energy), PUFA (8% of total energy), beta-carotene (534 mcg/day), Vitamin D (3.8 mcg/day), Vitamin E (6.6 alpha-tocopherol equivalents/day), potassium (1828 mg/day) and magnesium (205 mg/day). Reported intake of remaining dietary components met recommendations for goal ranges (fat, protein, carbohydrate), daily goal intake (omega-3 fatty acid, Vitamin A, Vitamin C, Vitamin B₆, thiamin, riboflavin, niacin, total folate, zinc, selenium) as well as daily limits (red/processed meat, SSB, alcohol, cholesterol, trans fat, iron).

Associations between diet quality, pro-inflammatory diet, and cardiometabolic measures at baseline can be found in Tables 4 and 5. There were no significant associations between diet quality scores and cardiometabolic components. However, there were non-significant trends toward lower cardiometabolic measures (SBP, DBP, LVMI, HbA1c, non-HDL-C) with higher AHEI-2010 scores and lower cardiometabolic measures (SBP, DBP, LVMI, BMIz, z-WC, HbA1c, HDL-C) with more anti-inflammatory diet scores.

There were no significant differences in baseline characteristics between the sub-sample of participants invited to follow-up ($N = 74$) who attended follow-up visits ($n = 33$) compared with those who did not attend follow-up visits ($n = 41$) (Supplemental Table 1). However, compared with those who did not attend follow-up visits, participants who did tend to be younger, male, and have a higher neighborhood household income. Changes in cardiometabolic characteristics from baseline to follow-up among those who attended follow-up visits ($n = 33$) are presented in Supplemental Table 2. There were no significant differences in average clinical or laboratory measures from baseline to follow-up, nor were there significant changes in presence of cardiometabolic conditions. However, the percentage of participants prescribed blood pressure medications increased from 46% at baseline to 64% at follow-up.

Among the participants who attended follow-up visits ($n = 33$), all participants received nutrition education at the baseline visit that comprises increasing fruits/vegetables ($n = 30$; 91%), limiting sodium intake ($n = 30$; 91%), promoting sugar-free beverages ($n = 22$; 67%), portion control ($n = 17$; 52%), healthy alternative snacks ($n = 16$; 48%), and promoting three meals per day ($n = 12$; 36%). Over follow-up, there were significant reductions in energy intake ($m = -302$ kcal/day; p -value=0.03) that was mainly driven by changes reported among adolescents 9–13 years ($m = -660$ kcal/day; p -value = 0.01). There were no significant changes in reported intake of food groups/drinks, dietary fat, vitamins or minerals nor were there significant changes in AHEI-2010 (p -value = 0.73) or C-DII scores (p -value = 0.85) across follow-up controlling for total energy intake.

There were differences in the reported reduction of total energy intake over follow-up by the type of dietary education received at baseline (Supplemental Fig. 1). Participants who received nutrition education on portion control reported the largest reduction in total energy intake (-380 kcal/d) followed by limiting sodium

Table 3. Diet quality of participants included in the final sample ($n = 90$) compared with recommendations.

	Final sample	Recommendations ^a
Sample size	$N = 90$	
<i>Diet quality scores, mean \pm SD</i>		
AHEI-2010 score ^b	55.04 ± 9.86	0 to 110 (higher = better)
C-DII score ^c	-0.12 ± 0.86	-5 to 5 (lower = anti-inflammatory)
<i>Total intake, mean \pm SD</i>		
Energy, kcal (total sample)	1792 ± 734	—
4–8 years ($n = 13$)	1539 ± 379	—
9–13 years ($n = 33$)	1740 ± 690	—
14–18 years ($n = 39$)	1770 ± 440	—
19–21 years ($n = 5$)	1923 ± 868	—
Dietary fiber, g/d	13.3 ± 7.5	22–31 g/d (goal)^d
Fat, %	33.3 ± 7.5	20–35% (goal) ^d
Protein, %	17.3 ± 5.8	10–35% (goal) ^d
CHO, %	49.3 ± 9.2	45–65% (goal) ^d
<i>Food groups/drinks, median (IQR)</i>		
Fruit, servings/d	0.00 (0.00, 1.00)	4 servings/d (goal)^e
Vegetable, servings/d	1.63 (0.63, 2.49)	5 servings/d (goal)^e
Whole Grains, g/d	4.7 (0.0, 31.9)	75–90 g/d (goal)^e
Nuts & Legumes, servings/d	0.00 (0.00, 0.00)	1 serving/d (goal)^e
Red/Processed Meat, servings/d	0.30 (0.00, 1.59)	1.5 servings/d (limit) ^e
SSB, servings/d	0.56 (0.00, 1.50)	1 serving/d (limit) ^e
Alcohol, drinks/d	0.00 (0.00, 0.00)	0 servings/d (limit) ^e
<i>Dietary fat, median (IQR)</i>		
Cholesterol, mg/d	210 (118, 304)	<300 mg/d (limit) ^d
Saturated fat, % kcal	10.7 (8.5, 12.2)	10% kcal (limit)^d
MUFA, % kcal	11.1 (9.3, 13.2)	15% kcal (goal)^d
PUFA, % kcal	8.2 (5.8, 10.7)	10% kcal (goal)^e
Trans fat, % kcal	0.8 (0.5, 1.2)	1% kcal (limit) ^d
Omega-3 FA, mg/d	1650 (1040, 2344)	250 mg/d (goal) ^d
<i>Vitamins, median (IQR)</i>		
Vitamin A (RE/d)	516 (272, 944)	400–900 RE/d (goal) ^f
Beta-carotene, mcg/d	534 (173, 1625)	600–1500 mcg/d (goal)^f
Vitamin D, mcg/d	3.8 (1.8, 7.7)	15 mcg/d (goal)^f
Vitamin E, AT EQ/d	6.6 (4.3, 9.4)	7–11 AT EQ/d (goal)^f
Vitamin C, mg/d	45.0 (24.2, 98.5)	45–75 mg/d (goal) ^f
Vitamin B ₆ , mg/d	1.6 (1.1, 2.3)	0.6–1.3 mg/d (goal) ^f
Vitamin B ₁₂ , mg/d	3.3 (1.9, 5.2)	1.2–2.4 mg/d (limit)^f
<i>Minerals, median (IQR)</i>		
Thiamin, mg/d	1.6 (1.0, 2.2)	0.6–1.2 mg/d (goal) ^f
Riboflavin, mg/d	1.7 (1.1, 2.4)	0.6–1.3 mg/d (goal) ^f
Niacin, mg/d	22.0 (17.1, 29.8)	8–16 mg/d (goal) ^f
Total folate, mcg/d	288 (222, 535)	200–400 mcg/d (goal) ^f
Iron, mg/d	11.2 (8.2, 17.2)	8–15 mg/d (limit) ^f
Sodium, mg/d	3191 (2252, 3718)	1500–2300 mg/d (limit)^f
Potassium, mg/d	1828 (1402, 2424)	2300–3000 mg/d (goal)^f
Magnesium, mg/d	205 (155, 272)	240–410 mg/d (goal)^f
Zinc, mg/d	8.6 (6.3, 12.5)	8–11 mg/d (goal) ^f
Selenium, mcg/d	107 (78, 137)	30–55 mg/d (goal) ^f

AHEI-2010 alternative healthy eating index, C-DII children's dietary inflammatory index, CHO carbohydrate, SSB sugar-sweetened beverages, MUFA mono-unsaturated fatty acid, PUFA polyunsaturated fatty acid, FA fatty acid, RE retinol equivalents, AT EQ alpha-tocopherol equivalents. Bold values indicate that intake was below or above recommended range.

^aSample intakes (average or median) that do not meet recommended goals or limits are bolded.

^bAHEI-score ranges from 0 to 110 (higher = better diet quality). Score increases with a higher intake of Fruit, Vegetables, Whole Grains, Nuts & Legumes, PUFA, and Omega-3 fatty acid. Score decreases with higher intake of red/processed meat, SSB, trans fat, and sodium. Alcohol is scored between 0 (moderate alcohol consumption) – 2.5 (non-drinkers).

^cC-DII score ranges from -5 to 5 (lower = better diet quality). Score increases (pro-inflammatory) with higher consumption of energy, fat, protein, carbohydrate, cholesterol, saturated fat, Vitamin B₁₂, and iron. Scores decreases (anti-inflammatory) with higher consumption of alcohol, fiber, MUFA, PUFA, Vitamin A, beta-carotene, Vitamin D, Vitamin E, Vitamin C, Vitamin B₆, thiamin, riboflavin, niacin, folate, magnesium, zinc, and selenium.

^dRecommendations based on the Dietary Guidelines for Americans (DGA).³⁴ Range for fiber-based account for differences by age/sex. Percent of calories from macronutrients compared to the acceptable micronutrient distribution ranges (AMDR).

^eRecommendations based on the daily goals and thresholds proposed by Chiuve et al.¹⁴

^fRecommendations based on the Dietary Reference Intakes (DRI) with ranges account for differences by age/sex.^{38–41}

intake (-374 kcal/d), healthy alternative snacks (-267 kcal/d), sugar-free beverages (-236 kcal/d), increasing fruits/vegetables (-203 kcal/d), and promotion of 3 meals per day (-154 kcal/d).

DISCUSSION

Participants enrolled in the ReNEW clinic cohort study are youth with substantial obesity and multiple comorbid cardiovascular disease risk factors placing them at high risk for developing CVD in their lifetime. Average AHEI-2010 score was 55.04, which suggests 50% adherence to recommendations to achieve an optimal diet quality (out of a total of 110).¹⁴ The average C-DII score of participants was -0.10, which is roughly equivalent to 51% adherence to nutrient intake goals for an anti-inflammatory diet (out of a total range of 10).¹⁵ While not reaching statistical significance, children with greater diet quality as determined by AHEI had improved cardiometabolic point estimates at baseline than children with lower diet quality. Further, children with lower inflammatory diet scores had more favorable cardiovascular measures compared to those with higher inflammatory measures at baseline. While these AHEI-2010 and C-DII scores did not change significantly over time, caloric intake did decrease with intensive dietary counseling to promote optimal diet quality, which achieved one of the clinical goals.

Diet quality scores in this high-risk sample were similar to estimates of diet quality in other youth populations. The average HEI scores of children 4–19 years participating in the Supplemental Nutrition Assistance Program (SNAP) was 45.6 (SD \pm 0.6), roughly translating to 46% adherence to the dietary guidelines for Americans.⁴¹ The average DII scores of children 9–17 years from Spain was 0.24 (SD \pm 1.67), indicating adherence to 49% of recommendations for an anti-inflammatory diet (out of a total range of 20).⁴² Thresholds were established for realistic energy reporting, and interpretation of average intake should take into account the age range of participants (4–21 years). Average calorie intake was presented over the total sample and stratified by age demonstrating increasing intake with higher age categories at baseline. Percent of energy was distributed within the ranges for acceptable macronutrient distribution for fat, protein, and carbohydrate.³⁴

Considering AHEI-2010 components, median intake was lower than recommendations for fruits, vegetables, whole grains, nuts/legumes, and PUFA.^{14,34} Median intake was within daily limits set for red/processed meat, SSB, and alcohol; however median sodium intake (3191 mg) was well above the daily limit based

Table 4. Association between average diet quality score and blood pressure/LVMI measures.

	Outcomes ^{a,b}				
	SBP index ^c	DBP index ^c	SBP ≥ 13 years (mmHg)	DBP ≥ 13 years (mmHg)	LVMI (g/m ^{2.7}) ^d
Sample size	N = 90	N = 90	N = 50	N = 50	N = 82
AHEI-2010 score ^e					
Low diet quality	Reference	Reference	Reference	Reference	Reference
High diet quality	−0.02 (−0.07, 0.02)	0.01 (−0.05, 0.06)	−3.11 (−11.35, 5.12)	−1.33 (−8.24, 5.59)	−0.88 (−6.85, 5.09)
C-DII score ^f					
Pro-inflammatory diet	Reference	Reference	Reference	Reference	Reference
Anti-inflammatory diet	−0.00 (−0.05, 0.05)	−0.01 (−0.07, 0.06)	−2.51 (−11.56, 6.55)	−1.27 (−8.85, 6.31)	−0.84 (−8.06, 6.38)

SBP systolic blood pressure, DBP diastolic blood pressure, LVMI left ventricular mass index, AHEI-2010 alternative healthy eating index 2010, C-DII children's dietary inflammatory index.

^aEach column represents a separate regression model to estimate the effect of quantile diet quality score on continuous outcomes (SBP index, DBP index, SBP, DBP, LVMI). Beta-coefficients and confidence intervals (C.I.) presented.

^bAll models controlled for age (years), sex (boys, girls), total energy intake (scaled per 1000 kcal), average neighborhood household income (annual in US dollars), and blood pressure medication (yes, no).

^cBlood pressure index was calculated as raw, mean blood pressure divided by the age, sex, and height specific blood pressure at the 95th percentile (%tile) for all participants (95thtile measures at 17 years of age were used for those >17 years).

^dLeft ventricular mass index (LVMI) determined in patients who received an echocardiogram ($n = 82$).

^eAverage AHEI-2010 score broken into groups based on the median intake of the sample. Range of scores: low diet quality (below median: 34.56–54.65), high diet quality (above median: 55.19–78.80) (higher score/quantile = higher diet quality).

^fAverage C-DII score broken into groups based on the median intake of the sample. Range of scores: pro-inflammatory diet (above median: 0.05–1.22), anti-inflammatory diet (below median: −2.14 to −0.04) (lower score/quantile = more anti-inflammatory diet).

on the Dietary Guidelines for Americans (DGA; 2300 mg/day limit).^{14,34} Comparing intake of dietary components considered pro-inflammatory with the DGA or dietary reference intake (DRI) ranges based on age and sex, median intake of dietary components considered pro-inflammatory was high for saturated fat, and above the DRI for Vitamin B₁₂.^{34,35} Intake of dietary components considered anti-inflammatory was low for dietary fiber, MUFA, PUFA, beta-carotene, Vitamin D, Vitamin E, and magnesium.^{35–37} Intake of all remaining dietary components did not cross the upper limit of recommended thresholds for pro-inflammatory components and met the DRI for anti-inflammatory components. Given the low reported intake of fruit/vegetables in the sample, unsurprisingly, median potassium intake (1828 mg) compared with the DGA (2300–3000 mg/day) was low.³⁴

Over the course of follow-up, participants in the sub-group reported a decrease in energy intake ($m = -302$ kcal/day) within 12-months follow-up from a clinical program centered on educational approaches to promote lifestyle change. Type of education received impacted reported reductions in total energy intake, which was highest when participants received education on portion control at baseline (−380 kcal/d). Although there were no significant reductions in anthropometric or laboratory risk factors for CVD over the course of follow-up, findings should be considered in the context of this high-risk study sample were even maintaining anthropometric measures between clinic visits is a positive outcome. Not all participants had a documented medical diagnosis of overweight/obesity ($n = 79/90$) even though all of them presented to the clinic overweight or obese. Therefore, it is unclear what level of education participants had received prior to enrollment. Although all participants who attended follow-up visits received nutrition education at the baseline visit, the majority only had 1 follow-up within 7 months of baseline. In addition, education alone may not be enough to change dietary behaviors⁴³ and do not address barriers of accessibility and affordability to healthy foods.⁴⁴ A systematic review evaluating interdisciplinary interventions lasting between 3 months and 3 years on adolescent weight loss indicated that few programs impacted weight and often initial weight loss observed in participants was not sustainable.⁴⁵

Participants with higher quantile AHEI-2010 scores and more anti-inflammatory diets trended towards lower SBP, DBP, LVMI, HbA1c, and non-HDL-C. Participants with anti-inflammatory diets also trended toward lower BMI and WC z-scores that may have reached significance with a larger sample size. The C-DII is made up of individual nutrients and does not account for the synergistic interactions of bioactive components found in whole foods.⁴⁶ Reported intake was within thresholds/daily limits for the majority of foods/nutrients, but was lower than recommended for fruits/vegetables, fiber, nuts/legumes, MUFA, PUFA, fat-soluble vitamins, potassium and magnesium and elevated for saturated fat, Vitamin B₁₂ and sodium. Nutrition counseling with continued emphasis on the promotion of fruits/vegetables while limiting sodium intake may benefit from the addition of healthy dietary fat (promoting nuts/legumes, MUFA, PUFA; limiting saturated fat) as a more comprehensive approach to improve clinical outcomes.

LIMITATIONS

Participants referred into the ReNEW clinic cohort study are referred based on the presence of overweight/obesity and elevated BP, limiting the generalizability of the cross-sectional findings from baseline. Furthermore, there were a limited number of participants ($n = 33/74$; 46%) with follow-up visits within 12-months of their baseline visit. In addition to these analyses being underpowered, the frequency and number of return visits among ReNEW adolescents varied by whether or not there was presence of elevated blood pressure at baseline, which may have introduced selection bias in the analysis of change from baseline to follow-up visit.⁴⁷ Another limitation is that dietary data was collected via different collection techniques (24-h recall, 3-day diet record), however, both instruments relied on free form reporting confirmed by the research dietitian. The majority of dietary data (70%) was collected by 24-h recall, which tends to underestimate total energy intake and does not capture usual intake.⁴⁸ However, children were interviewed by a highly trained research dietitian to assist with the accuracy of the reporting. These caveats should be taken into account when interpreting the non-significant associations between diet and cardiometabolic health.

Table 5. Association between average diet quality score and anthropometric/cardiometabolic measures.

	Outcomes ^{a,b}			
	BMIz (≤ 18 years)	z-WC	HbA1c (%) ^c	Non-HDL C (mg/dL)
Sample size	N = 80	N = 80	N = 72	N = 73
AHEI-2010 score ^d	Reference	Reference	Reference	Reference
Low diet quality	0.06 (−0.11, 0.24)	0.03 (−0.28, 0.34)	−0.39 (−1.11, 0.33)	−14.15 (−29.33, 1.03)
High diet quality				
C-DII score ^e	Reference	Reference	Reference	Reference
Pro-inflammatory diet	−0.18 (−0.39, 0.02)	−0.21 (−0.57, 0.15)	−0.11 (−0.99, 0.79)	−3.99 (−23.04, 15.06)
Anti-inflammatory diet				

BMIz body mass index z-score, z-WC waist circumference z-score, HbA1c hemoglobin A1c, non-HDL C non-high density lipoprotein cholesterol, AHEI-2010 alternative healthy eating index 2010, C-DII children's dietary inflammatory index.

^aEach column represents a separate regression model to estimate the effect of quantile diet quality score on continuous outcomes (BMIz, z-WC, HbA1c, non-HDL C). Beta-coefficients and confidence intervals (C.I.) presented.

^bAll models controlled for age (years), sex (boys, girls), total energy intake (scaled per 1000 kcal), and average neighborhood household income (annual in US dollars).

^cModels additionally controlled for insulin/oral agent medication (yes, no).

^dAverage AHEI-2010 score broken into groups based on the median intake of the sample. Range of scores: low diet quality (below median: 34.56–54.65), high diet quality (above median: 55.19–8.80) (higher score/quantile = higher diet quality).

^eAverage C-DII score broken into groups based on the median intake of the sample. Range of scores: pro-inflammatory diet (above median: 0.05–1.22), anti-inflammatory diet (below median: −2.14 to −0.04) (lower score/quantile = more anti-inflammatory diet).

CONCLUSIONS

More favorable scores trended toward improved cardiometabolic measures in high-risk, majority Black adolescents. However, likely due to the small sample size, these associations did not reach statistical significance. As such, they should be explored in larger studies. While our nutrition education did not improve diet quality among these high-risk adolescents over up to a year of follow-up, outpatient dietary counseling did result in reduced total energy intake in obese, hypertensive children and adolescents.

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AUTHOR CONTRIBUTIONS

K.D.-S., T.M.B., and V.G.L. conceptualized the analyzes. K.D.-S. analyzed data and wrote the first draft of the manuscript. T.M.B. is the PI of the ReNEW Clinic Cohort Study, enrolls participants, and delivers medical care to individuals in the study. D.V. is the research dietitian for the ReNEW Clinic Cohort Study, educates patients on dietary choices, collects dietary data, inputs data into NDSR, and provided dietary data linked to clinic visits. V.G.L. was involved in the manuscript preparation and oversaw all aspects, including the analyses and writing. L.E.C, N.M, and S.R. gave feedback to the analyses, and contributed to interpreting the findings. All authors approved the final manuscript

COMPETING INTERESTS

The authors declare no competing interests.

CONSENT STATEMENT

The ReNEW Clinic Cohort Study (NCT03816462) is human subjects research that has been approved by the Johns Hopkins IRB (IRB00056175). Participants in the cohort study agree to have their clinical data abstracted from the electronic medical record (EMR) and entered into a longitudinal clinic registry. The study is discussed with participants in the presence of their parent or legal guardian and those who agree to participant sign consent (≥ 18 years) or assent (< 18 years) as appropriate.

ADDITIONAL INFORMATION

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