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# Consumption of fast food, sugar-sweetened beverages, artificially-sweetened beverages and allostatic load among young adults

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ABSTRACT

This study investigates the associations between recent consumption of fast foods, sugar-sweetened beverages, and artificially-sweetened beverages on level of allostatic load, a measure of cumulative biological risk, in young adults in the US. Data from Wave IV of the National Longitudinal Study of Adolescent to Adult Health were analyzed. Negative binomial regression models were used to estimate the associations between consumption of fast foods, sugar-sweetened, and artificially-sweetened beverages and allostatic load. Poisson and logistic regression models were used to estimate the associations between these diet parameters and combined biomarkers of physiological subsystems that comprise our measure of allostatic load. All analyses were weighted and findings are representative of young adults in the US, ages 24–34 in 2008 (n = 11,562). Consumption of fast foods, sugar-sweetened, and artificially-sweetened beverages were associated with higher allostatic load at a bivariate level. Accounting for demographics and medication use, only artificially-sweetened beverages remained significantly associated with allostatic load. When all three dietary components were simultaneously included in a model, both sugar- and artificially-sweetened beverage consumption were associated with higher allostatic load. Differences in allostatic load emerge early in the life course and young adults consuming sugar- or artificially-sweetened beverages have higher allostatic load, net of demographics and medication use. Public health messages to young adults may need to include cautions about both sugar- and artificially-sweetened beverages.

## 1. Introduction

The detrimental Fernstrom health effects of a "poor" diet (e.g., consumption of foods high in calories, fat, sugar, sodium, and foods that are highly processed) are well-known (Bahadoran et al., 2015). Excessive consumption of fast foods (which are often highly processed, fatty, and high in calories and sodium) is associated with increased risks of obesity, insulin dysregulation, systemic inflammation (Bahadoran et al., 2015; Marlatt et al., 2016), and metabolic syndrome (Marlatt et al., 2016). In addition, sugar-sweetened beverages are associated with increased risk of incident hypertension (Xi et al., 2015), cardiovascular disease (Xi et al., 2015), obesity (Hu and Hu, 2013), and metabolic syndrome (Crichton et al., 2015; Høstmark, 2010). Although less studied, recent research suggests that artificially-sweetened beverages may increase risk for metabolic syndrome (Crichton et al., 2015) and type 2 diabetes (Pepino, 2015). Cumulative biological risk, operationalized as allostatic load (AL), is one early warning indicator of future disease risk, but only a few studies have examined the relationship between diet and AL (Mattei et al., 2011, 2013). The research presented here investigates the associations between consumption of fast foods, sugar- and artificially-sweetened beverages, and AL in a national sample of young adults.

AL, a measure of cumulative burden of dysregulation across multiple physiological systems, increases over time with exposure to environmental and social stressors, resulting in biological wear and tear (McEwen, 2007; Seeman et al., 1997). AL is a composite measure of physiological biomarkers that comprise multiple physiological systems including cardiovascular, metabolic, neuroendocrine, and inflammatory (McEwen, 2007). Even small changes in single biomarkers, often sub-clinical, when considered in combination can increase risk for later health problems. For example, AL is a more powerful predictor of subsequent cardiovascular disease and all-cause mortality than individual, single-system indices historically used to predict risk (Karlamangla et al., 2006; Seeman et al., 1997). There is no one

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standardized operational definition of AL with respect to the specific biomarkers included, rather, what is important is the inclusion of biomarkers representative of multiple physiological systems (Beckie, 2012). Differences in AL emerge early in the life course, during childhood and adolescence (Rainisch and Upchurch, 2013), and persist both across and within all racial/ethnic groups (Borrell et al., 2010). Thus, lifestyle factors like diet that contribute to differences in AL early in the life course can indicate leverage points for timely intervention and prevention.

Few studies have examined the contributions of diet on AL and to our knowledge, none have assessed diet and AL in a national sample of individuals. Poorer diet quality is associated with higher AL and less-healthy values of individual biomarkers comprising AL (Mattei et al., 2011, 2013). In particular, a dietary pattern characterized by meat and French fry consumption was associated with higher AL in older Puerto Ricans living in the US (Mattei et al., 2011). Another study found that individuals who consume diets following American Heart Association guidelines have lower AL and healthier cardiometabolic markers (Sotos-Prieto et al., 2015). However, these studies did not examine the contributions of fast foods, sugar-sweetened beverages, or artificially-sweetened beverages. Other studies, while not of AL, have shown that consumption of sugar-sweetened beverages is associated with higher values for blood pressure (Duffey et al., 2010), high sensitivity C-reactive protein (hsCRP) (Kosova et al., 2013), waist circumference (Kosova et al., 2013), body mass index (BMI) (Nissinen et al., 2009), homeostatic model assessment insulin resistance (HOMA-IR) (Lin et al., 2016), and lower values of high-density lipoprotein (HDL) cholesterol (Kosova et al., 2013). Moreover, consumption of artificially-sweetened beverages is associated with the biological parameters comprising metabolic syndrome (Crichton et al., 2015; Pepino, 2015) in some but not all studies (Reid et al., 2016). Consuming fast foods is associated with a range of biomarkers, including higher BMI, larger waist circumference, higher plasma triglycerides, higher HOMA-IR, and lower serum concentrations of HDL (Duffey et al., 2009; Kant et al., 2015). BMI in adolescence is associated with multiple cardiovascular biomarkers in young adulthood (Gooding et al., 2016) suggesting the importance of early identification of specific modifiable risk factors. The purpose of this descriptive study was to investigate the associations between recent consumption of fast foods, sugar-sweetened beverages, and artificially-sweetened beverages and AL in young adults ages 24–34. We hypothesized that young adults who consumed more fast food, drank more sugar-sweetened beverages, or artificially-sweetened beverages would have higher AL than their non-consuming counterparts, net of demographic and other characteristics.

## 2. Methods

### 2.1. Study design and survey description

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a nationally representative sample of adolescents who were enrolled in grades 7–12 during the 1994–1995 school year. Details of the study design have been described elsewhere (Harris et al., 2013). Four waves of data have been collected, the most recent in 2008. At Wave I, the original sample consisted of 80 high schools and 52 middle schools. A subset of students participated in the longitudinal component of the study (referred to as the "in-home sample") (n = 20,745). The study was administered by trained interviewers using an audio computer-assisted self interview (audio-CASI) technique. At Wave IV, anthropometric and biomarker data were collected. Approximately 80% (n = 15,701) of the original, eligible Wave I sample was re-interviewed at Wave IV when respondents were ages 24–34. The current study used data from Wave IV and received approval from the institution's review board for human subjects. The analytic sample included only those individuals with sample weights, valid data on all biomarkers, and a valid age. In addition, because those who identified as "Other" races were a small, heterogeneous group, they were excluded. Last, women who were pregnant at the time of interview were also excluded because of pregnancy's effects on biomarker profiles. The final sample size was 11,562.

### 2.2. Measures

#### 2.2.1. Allostatic load score

Ten biological parameters were used to create a composite AL score where individuals scored 1 for each biomarker on which they were in the least healthy two deciles of the sample or 0 otherwise. AL included: cardiovascular markers of 1) systolic blood pressure, 2) pulse rate, and 3) pulse pressure; metabolic markers of 4) waist circumference, 5) BMI, 6) glycated hemoglobin (HbA1c), 7) total cholesterol, and 8) HDL cholesterol; and inflammatory markers of 9) hsCRP and 10) the Epstein-Barr viral (EBV) capsid antigen IgG (Mcdade et al., 2000). These ten biomarkers represent multiple physiological systems and have been commonly used in past AL research (Beckie, 2012; Carlson and Chamberlain, 2005; Chyu and Upchurch, 2011). Also we selected biomarkers that were less sensitive to fasting requirements (84% reported fasting times < 9 h prior to interview). Composite AL scores were constructed using empirical cutoff points based on the weighted distribution of the analytic sample and a count-based summation method, following others (Beckie, 2012; Carlson and Chamberlain, 2005; Chyu and Upchurch, 2011; Seeman et al., 1997; Singer et al., 2004; Upchurch et al., 2015). Lipids were reported in deciles so the 80th percentile value was used as the cutoff for high risk for all biomarkers except for HDL, for which the 20th percentile value was used. AL is scored from 0 to 10 where lower AL represents lower risk and better health.

#### 2.2.2. Protocols for collection of physical measures

Trained and certified field interviewers conducted the anthropometric measurements and blood collection. Height was measured to the nearest 0.5 cm; shoes and accessories that could affect measurement were removed. Weight was measured to the nearest 0.1 kg using a calibrated, digital scale. Waist circumference was measured to the nearest 0.5 cm at the superior border of the iliac crest. Blood pressure was assessed with an oscillometric blood pressure monitor. Three readings were taken at 30 second intervals and blood pressure and pulse rate were constructed as the average of measures 2 and 3. A single pulse pressure measure was constructed as the average of the difference between systolic and diastolic pressures using measures 2 and 3.

#### 2.2.3. Protocols for laboratory assessments

Following standardized procedures, whole blood spot samples were obtained from a finger prick and collected on a seven-spot capillary whole blood collection card. The card was dried for 3 h and overnight shipped to the University of Washington Medical Center Immunology Lab, in Seattle, WA for assay. The cards were stored at − 70 °C until processing. Additional details of the specific laboratory protocols and tests have been published elsewhere (Entzel et al., 2014).

#### 2.2.4. Consumption of fast food, sugar-sweetened beverages, and artificially-sweetened beverages

Information on fast food, sugar-sweetened beverage, and artificially-sweetened beverage consumption in the past 7 days was collected using 3 questions asked of participants, for example, "How many times in the past seven days did you eat food from a fast food restaurant, such as McDonald's, Burger King, Wendy's, Arby's, Pizza Hut, Taco Bell, or Kentucky Fried Chicken or a local fast food restaurant?" Categorical variables for food and beverage consumption were created based on the empirical distributions of the measures. For both fast food and sugar-sweetened beverage consumption, the final variables were coded as: 0 times, 1–3 times, 4–7 times, and 8 or more times per week. For diet and other artificially-sweetened beverage consumption, the final variable was coded as: 0, 1, 2, and 3 or more times per week due to the less-frequent consumption of artificially-sweetened beverages.

#### 2.2.5. Demographics and medication use

Age was coded as a categorical variable (24–27, 28–30, and 31–34). Gender was coded as a dichotomy. Race/ethnicity was based on self-identification and priority was given to any mention of being Hispanic (non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic Asian). Nativity status was coded as a dichotomy (US born, non-US born). Educational attainment was coded as: less than high school, high school or high school equivalence, some college, bachelor's degree, and post-baccalaureate. Annual household income was coded as: less than $25,000, $25,000–49,999, $50,000–74,999, and $75,000 or more. Last, we also controlled for medications (i.e., for treatment of diabetes, cholesterol, and anti-inflammatory medications) taken in the last 24 h that could affect the biomarkers used to construct AL.

### 2.3. Analyses

All analyses were conducted in Stata statistical software (SE version 13.1) using the Wave IV sample weights that adjust for complex sample design, selection, and non-response (Stata Statistical Software, 2013). Missing data accounted for < 1% of all variables except for household income. When small numbers of missing data occurred, the modal category of that variable was assigned. For income, we imputed a predicted value using multivariate regression that included age, race/ethnicity, nativity status, gender, education, and income. Results did not vary when conducted on a subsample of observations with complete data.

Separate negative binomial regression models were used to estimate the effects fast food, sugar-sweetened beverages, and artificially-sweetened beverages on AL, adjusting for demographics, and medication usage. Adjusted coefficients and incidence rate ratios obtained from the negative binomial regressions (IRR) are presented. Then, we investigated the combined effects of the three diet components on AL in one multivariate model. Last, we looked at the effects of fast food, sugar-sweetened beverages, and artificially-sweetened beverages on the system-specific parameters comprising AL; that is, we also examined their effects on cardiovascular, metabolic, and inflammatory systems separately. For subsystem analyses, Poisson regression and logistic regression were used, these are the most appropriate tests given the distribution of these outcome variables (a left-skewed distribution in the case of the cardiovascular and metabolic subsystems and a binary outcome in the case of the inflammatory marker). All multivariate models controlled for demographics and medication use by including the variables age, race/ethnicity, nativity status, gender, education, income, and medications for diabetes, high cholesterol, and inflammation, even when those variables are not listed in the tables.

## 3. Results

Table 1 shows the demographics, diet components, and mean AL score of young adults. Mean age was 28.8 (not shown); there were similar percentages of men and women. The majority of young adults were White (70%), followed by Black, Hispanic, and Asian and the majority was US born. Over 60% had at least some college education. Over half reported an annual household income of $50,000 or more. Almost one-quarter of young adults reported no fast food consumption in the past week and over half reported consuming fast food 1–3 times while few reported 8 or more times. In contrast, only 13% reported no sugar-sweetened beverage consumption in the past week and close to half reported drinking 8 or more beverages. About half of young adults did not drink any artificially-sweetened beverages and slightly over 20% reported drinking 3 or more in the past week. Last, mean AL was 1.93 (range 0–9).

Table 2 shows the bivariate and multivariate results for the associations between fast food, sugar-sweetened beverages, and artificially-sweetened beverages and level of AL in young adults. All multivariate models included demographics, medication use, and the diet-related variable being tested. For fast foods (Models 1 and 2), there was a small but significant and positive association between consuming these foods 1–3 times per week and higher AL when compared to no consumption; this association became non-significant when other variables were included in the model. For sugar-sweetened beverages (Models 3 and 4), compared to no beverages consumed, there was a significant and positive association between drinking 4–7 or 8 or more beverages and higher AL. Again, this association became non-significant in the multivariate model. However, for artificially-sweetened beverages, the significant and positive association between consumption and AL was not only maintained but became stronger in the multivariate model (Models 5 and 6). Compared to those who consumed 0 artificially-sweetened beverages in the past week, those who consumed 3 or more had an AL level that was 22% higher ($p < 0.001$). In fact, consumption of any amount of artificially-sweetened beverages was associated with a significantly higher AL.

Table 3 shows the results of regressions when all three diet components were simultaneously considered. Now, compared to individuals drinking 0 sugar-sweetened beverages, those drinking any amount had significantly higher AL. Compared to those consuming 0 artificially-sweetened beverages, those drinking any (1, 2, or 3 or more) had significantly higher AL. (In analyses not shown, drinkers of artificially-

**Table 1**
Demographics, diet components and allostatic load young adults 24–34, National Study of Adolescent to Adult Health, US, 2008 (n = 11,562).

| Demographics | % |
|---|---|
| Age | |
| 24–27 | 35.5 |
| 28–30 | 50.6 |
| 31–34 | 13.9 |
| Gender | |
| Men | 50.7 |
| Women | 49.3 |
| Race/ethnicity | |
| White | 69.7 |
| Black | 15.0 |
| Hispanic | 12.0 |
| Asian | 3.3 |
| Nativity status | |
| US born | 96.0 |
| Foreign born | 4.0 |
| Education | |
| < High school | 9.2 |
| High school/GED | 27.4 |
| Some college | 34.1 |
| Bachelor's degree | 18.4 |
| Post-baccalaureate | 10.8 |
| Income | |
| < $24,999 | 18.0 |
| $25,000–49,999 | 31.8 |
| $50,000–74,999 | 23.2 |
| $75,000 + | 27.0 |
| Fast food, sugar-sweetened, and diet beverage consumption, past week | |
| Fast food | |
| 0 | 23.2 |
| 1–3 | 54.8 |
| 4–7 | 18.5 |
| 8 + | 3.5 |
| Sugar-sweetened beverages | |
| 0 | 12.7 |
| 1–3 | 16.2 |
| 4–7 | 23.3 |
| 8 + | 47.8 |
| Artificially-sweetened beverages | |
| 0 | 56.3 |
| 1 | 10.7 |
| 2 | 13.5 |
| 3 + | 19.5 |
| Mean AL (SD) | 1.93 (1.67) range (0–9) |

Weighted percentages and mean. AL = Allostatic Load; SD = Standard Deviation.

**Table 2**
Separate bivariate and multivariate regression results of consumption of fast food, sugar-sweetened beverages, and artificially-sweetened beverages on allostatic load among young adults 24–34, National Study of Adolescent to Adult Health, US, 2008 (n = 11,562).

| Fast food | Bivariate regression | | Multivariate regression | |
|---|---|---|---|---|
| | Model 1: fast food bivariate | | Model 2: fast food multivariate | |
| | Coefficient | IRR | Coefficient | IRR |
| 0 | – | – | – | – |
| 1–3 | 0.100** | 1.10 | 0.048 | 1.05 |
| 4–7 | 0.062 | 1.06 | − 0.014 | 0.99 |
| 8 + | 0.058 | 1.06 | − 0.038 | 0.96 |

| Sugar-sweetened beverages | Bivariate regression | | Multivariate regression | |
|---|---|---|---|---|
| | Model 3: sugar-sweetened beverages bivariate | | Model 4: sugar-sweetened beverages multivariate | |
| | Coefficient | IRR | Coefficient | IRR |
| 0 | – | – | – | – |
| 1–3 | 0.045 | 1.05 | 0.052 | 1.05 |
| 4–7 | 0.085* | 1.09 | 0.064 | 1.07 |
| 8 + | 0.077* | 1.08 | 0.028 | 1.03 |

| Artificially-sweetened beverages | Bivariate regression | | Multivariate regression | |
|---|---|---|---|---|
| | Model 5: artificially-sweetened beverages bivariate | | Model 6: artificially-sweetened beverages multivariate | |
| | Coefficient | IRR | Coefficient | IRR |
| 0 | – | – | – | – |
| 1 | 0.095* | 1.10 | 0.132** | 1.14 |
| 2 | 0.057 | 1.06 | 0.126*** | 1.13 |
| 3 + | 0.127*** | 1.14 | 0.195*** | 1.22 |

All analyses are weighted. Multivariate model includes age, gender, race/ethnicity, nativity status, education, income and medication use. IRR = Incident Rate Ratio; CI = Confidence Interval.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

sweetened beverages were more likely to be female, White, and have higher levels of education and income: several of the factors associated with lower AL. In contrast, consumers of sugar-sweetened beverages were more likely to be male, non-White, and have lower levels of education and income: factors associated with higher AL. Also, those taking diabetes medication were more likely to consume artificially-sweetened beverages and less likely to consume sugar-sweetened beverages.)

Additional multivariate analysis of the biomarkers for each subsystem (i.e., cardiovascular, metabolic, and inflammatory systems) was performed (see Appendix). Overall, consumption of fast food was not significantly associated with any of the three subsystem biomarkers. There was an association between consumption of sugar-sweetened beverages and poorer cardiovascular markers. Last, there was a strong significant association between consumption of artificially-sweetened beverages and poorer values of metabolic markers and an inflammatory marker (hsCRP).

## 4. Discussion

This descriptive study finds a positive association between two of the three specific dietary components and AL in young adults living in the US. Contrary to our expectations, consumption of fast foods is not associated with higher AL. However, we find that consumption of artificially-sweetened beverages is associated with higher AL and when we include these three dietary components into a model together, consumption of sugar-sweetened beverages is significantly associated with higher AL.

**Table 3**
Multivariate regression results of consumption of fast foods, sugar-sweetened beverages, and artificially-sweetened beverages on allostatic load among young adults 24–34, National Study of Adolescent to Adult Health, US, 2008 (n = 11,562).

| | Multivariate regression | |
|---|---|---|
| | Model 7: fast food, sugar-sweetened beverages, artificially-sweetened beverages | |
| | Coefficient | IRR |
| Fast food | | |
| 0 | – | – |
| 1–3 | 0.037 | 1.04 |
| 4–7 | − 0.015 | 0.98 |
| 8 + | − 0.045 | 0.96 |
| Sugar-sweetened beverages | | |
| 0 | – | – |
| 1–3 | 0.081* | 1.08 |
| 4–7 | 0.119** | 1.13 |
| 8 + | 0.108* | 1.11 |
| Artificially-sweetened beverages | | |
| 0 | – | – |
| 1 | 0.133** | 1.14 |
| 2 | 0.133*** | 1.14 |
| 3 + | 0.221*** | 1.25 |

All analyses are weighted. Multivariate model includes age, gender, race/ethnicity, nativity status, education, income and medication use. IRR = Incident Rate Ratio.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Although there is support from other studies that excessive consumption of fast foods is associated with increased risk of obesity, insulin resistance, and increased systemic inflammation (Duffey et al., 2009; Kant et al., 2015), our study did not find an association with AL. The lack of significant results may be due, in part, to problems of measurement. Add Health asked about "fast foods" rather than specific food items and did not record information on quantity, calories, levels of sodium, or fat in the food consumed. The few previous AL studies that have examined diet included specific food types and groups (e.g., fruits, fish, etc.), macronutrients (e.g., fats, sugars), and micronutrients such as sodium and found that individuals consuming more fats, sugars, and sodium have higher AL (Mattei et al., 2011, 2013). These studies were conducted with a regional sample of Hispanics (Puerto Ricans living in Boston), and thus are somewhat limited in generalizability. Future studies examining the impact of diet and food quality on AL in a national population should include a more comprehensive set of measures to more accurately assess dietary practices, including more specific information (type, amount, and frequency) on dietary intake of fat, sugar, sodium and other key nutrients.

Our finding that consumption of artificially-sweetened beverages is associated with higher AL contributes to the literature demonstrating correlation between consumption of diet beverages and poorer health outcomes (Fernstrom, 2015; Nettleton et al., 2009) although not all authors have found this relationship (Reid et al., 2016). In several large national studies, some of which were longitudinal, consumption of artificially-sweetened beverages was predictive of obesity (Fernstrom, 2015), and development of metabolic syndrome and type 2 diabetes (Crichton et al., 2015; Nettleton et al., 2009). The work presented here aligns with these earlier studies because our measure of AL includes parameters that reflect cardiovascular, metabolic, and inflammatory risks for subsequent health problems, such as metabolic syndrome.

Especially for the metabolic subsystem, greater consumption of artificially-sweetened beverages is associated with poorer profiles. While the physiological etiology of the negative outcomes associated with these beverages is incompletely understood, artificial sweeteners may increase cravings and consumption of sugar-sweetened, energy dense foods and beverages and decrease ability to accurately estimate intake (Swithers and Davidson, 2008), increasing BMI and adiposity (Fernstrom, 2015).

Consumption of sugar-sweetened beverages is associated with higher AL in our study and this finding similarly contributes to a well-established body of literature demonstrating a link between consumption of sugar beverages and poorer health outcomes (Dhingra et al., 2007; Duffey et al., 2010). The other studies looking at this relationship have shown a strong and consistent link between these drinks and especially cardiovascular markers that precede disease, even in young populations (Duffey et al., 2010). The subsystem analyses confirm these earlier findings showing a significant association between sugar-sweetened beverages and less healthy cardiovascular markers. Sugar-sweetened beverages become significantly associated with AL only after controlling for consumption of artificially-sweetened beverages in our study. We suspect this occurs because despite both beverage types being associated with higher AL, different groups of people are more likely to consume artificial- and sugar-sweetened beverages, and these groups, due to their demographic differences, have inverse profiles of AL. Earlier research shows individuals who drink sugar-sweetened beverages are more likely to be Black or Hispanic, male, and have lower income and education levels (Bortsov et al., 2011; Cohen et al., 2010; Rehm et al., 2008) while those who drink artificially-sweetened beverages are more likely to be White, female, and have higher levels of education (Nettleton et al., 2009).

### 4.1. Limitations

We were limited by the use of cross-sectional data that do not allow us to draw causal connections between the variables, specifically there is the possibility that those who have cardiometabolic health problems may be more likely to consume artificially-sweetened beverages, making it difficult to determine the directionality of the relationship between artificially-sweetened beverages and AL. In addition, there are limited measures of food and drink consumption in the Add Health dataset and there is a lack of information on detailed dietary components that other studies have used (Crichton et al., 2015; Høstmark, 2010; Mattei et al., 2011, 2013). Further, we assessed food and beverage intake over the past week and AL, which is a cumulative measure of physiological dysregulation. Ideally, a comprehensive diet history and biomarkers assessed over multiple time periods would help to disentangle the temporal relationship between the two. In particular, a more comprehensive dietary profile including types of food, amounts, and preparation would be useful. However, diet in childhood is associated with diet in later life (Mikkilä et al., 2004) so current intake may sufficiently approximate past intake for the purposes of this study.

### 4.2. Strengths

This study uses a large, recent dataset that is nationally representative of the US population ages 24–34, thus, we provide results that are generalizable to young adults. We identify specific dietary factors, some of which have been historically understudied, that are associated with differences in AL early in the life course. The use of AL as an outcome is an additional strength of the study as it is a robust and early indicator of physiological wear and tear on the body. Our focus on early adulthood captures an important phase of life in which risk profiles for disease begin to emerge, and also a period in which health behaviors can be altered: indicating a timely spot for intervention.

### 4.3. Implications

From a population health perspective, there have been numerous recent campaigns concerning the negative consequences of sugar-sweetened beverages but few efforts to educate about artificially-sweetened beverages. It may be that consumers of artificially-sweetened beverages choose these over sugar-sweetened ones thinking this substitution may be more health promoting. In fact, it may not be a healthy decision, as artificially-sweetened beverages are also associated with AL, and perhaps consumers ought to look towards unsweetened beverages to limit caloric and artificial beverage consumption altogether. This is of particular importance given the obesity epidemic in the US and these results suggest that further research should be done to probe the links between sugar- and artificially-sweetened beverages, fast food, and the interrelated consumption patterns of these dietary choices for young adults. Further research is needed to determine the causal connections and etiology between artificially-sweetened beverages and AL. This line of research should be continued to help shape food and dietary programs and policies that support healthy consumption for young adults.

### 4.4. Conclusions

Differences in AL, an early warning indicator of later health problems, emerge early in the life course and young adults consuming sugar- or artificially-sweetened beverages have higher AL. With more investigation, public health messages to young adults may need to include cautions about both sugar-sweetened beverages and artificially-sweetened beverages. These findings provide another caveat for creating health campaigns that focus on a single health message that may be associated with the adoption of other potentially unhealthy behaviors.

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