# Association of chronic spinal pain with diet quality

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## Abstract

**Introduction:** Chronic spinal pain is disabling and has high personal and societal costs. Risk factors include behavioral factors; however, little is known about the role of diet quality and its association with spinal pain. Higher diet quality and consumption of macronutrients that drive higher diet quality were hypothesized to be associated with lower odds of having spinal pain.

**Methods:** An analysis of a population-based data set (NHANES cycle 2009–2010) was conducted. Diet quality was calculated using the Healthy Eating Index 2015 (score 0–100). To examine odds of pain related to dietary intake, generalized linear regressions were used adjusting for relevant covariates.

**Results:** Of 4123 participants (mean age 43.5 ± 0.44 [SD], 2167 [52.6%] female), 800 (19.4%) reported chronic spinal pain. People with chronic spinal pain consumed similar amounts of calories to those with no spinal pain (2137 ± 44.5 vs 2159.9 ± 27.7), but had significantly poorer diet quality compared to people without spinal pain (51.97 ± 0.65 vs 54.31 ± 0.39, $P = 0.007$). From multivariate analyses, individuals with diet quality in the highest tertile on Healthy Eating Index-2015 were 24% less likely to report chronic spinal pain relative to those in the lowest tertile. Higher fruit, whole grain, and dairy intake were associated with 20% to 26% lower likelihood (all $P$ for trend $<0.028$) of chronic spinal pain. Added sugars were associated with 49% increased odds of chronic spinal pain ($P$ for trend $= 0.002$).

**Conclusion:** Although causality cannot be assumed, this study supports continued investigation into the role of nutritional quality as a factor that may impact pain.

**Keywords:** Spinal pain, Diet quality, Added sugar, Macronutrients, NHANES, Fruit

## 1. Introduction

Spinal pain, that is pain in the back, neck, and hip, affects 54% to 80% of adults and is a leading cause of physical disability and associated sequelae including decreased quality of life, unemployment, and mood disorders.[24] Spinal pain is also a major contributor to opioid usage, which has led to high rates of dependency and mortality.[7,26] The costs associated with chronic spinal pain are approximately $253B annually.[2]

Despite chronic spinal pain's significant negative consequences, little is understood about its etiology. A large proportion of people with low back pain are considered to have "nonspecific"[23] pain with 85% of patients having no known underlying cause.[13,18,23] Risk factors for chronic spinal pain are varied including psychological factors such as stress, anxiety, and depression,[20] and lifestyle factors such as decreased physical activity and obesity.[35] Diet seems to be a risk factor for chronic pain and disability,[19] but aspects of diet quality and chronic pain have not been thoroughly examined. Mechanisms linking diet to chronic pain could include modulation of the gut–brain axis—where diet-driven alterations or changes in gut-derived neurotransmitters may lead to changes in brain neurotransmitter levels such as glutamate influencing the development of chronic pain.[16,27] Moreover, understanding the link between diet quality and chronic spinal pain could, if causal, give clinicians and pain sufferers another tool to help decrease the presence of pain by increasing pain sufferers diet quality. Dietary factors and patterns associated with chronic pain, however, remain poorly characterized.

Using cross-sectional data from a national representative sample, the objective of this study was to determine differences in diet quality, quantified using the Healthy Eating Index-2015, and macronutrient consumption, for people with and without spinal pain. We hypothesized that higher diet quality was associated with lower odds of having spinal pain and that higher consumption of macronutrients that drive lower diet quality such as higher consumption of added sugars, low fiber, and high saturated fat were associated with higher odds of having spinal pain. Understanding dietary drivers of chronic pain can inform interventions and future mechanistic research.

# 2. Methods

## 2.1. Sample

Our sample was derived from the National Health and Nutrition Examination Survey (NHANES) cycle 2009-2010. NHANES is an ongoing nationally representative sample of the resident civilian noninstitutionalized U.S. population to assess nutritional status, health, and lifestyle factors administered by the Centers for Disease Control and Prevention National Center for Health Statistics. All NHANES participants provided written informed consent to be involved in data collection and the National Center for Health Statistics Ethics Review Board approved both the collection of the NHANES data and posting of the files for public use.

In the 2009-2010 NHANES cycle (https://www.cdc.gov/nchs/data/series/sr_02/sr02_160.pdf),[11] all adults aged 20 to 69 years were invited to complete the Arthritis Questionnaire. Participants were asked if they had pain, aching, or stiffness almost every day for at least 6 weeks continuously in areas along the back, neck, or hip regardless of pain severity. Participants were also asked to indicate what area(s) (neck, upper back, middle back, lower back, hip, buttocks, or rib cage) they were experiencing pain and if they reported pain, aching, or stiffness in that area "all of the time, it never completely goes away." Participants who responded "Yes" to experiencing pain in at least one area, eg, lower back, all of the time and that never completely went away were categorized as having chronic spinal pain. Individuals who answered "No" to these questions were categorized as the "no spinal pain" group.

## 2.2. Diet intake, quality, and macronutrients

NHANES collected dietary data using two 24-hour dietary recalls (the first through an in-person interview and the second through telephone 3–10 days later).[8] Daily totals of food, energy (Kcalories, kcal), and 64 nutrients and/or food components were calculated using the 2009-2010 U.S. Department of Agriculture's (USDA's) Food Patterns Equivalent Database based on the Food and Nutrient Database for Dietary Studies 5 (FNDDS 5.0).[6] Participants were excluded if energy intakes were implausible (less than 600 kcal/d or greater than 6000 kcal/d).

We calculated the percent dietary macronutrients for protein, carbohydrates, fiber, added sugar, total fat, saturated fat, monounsaturated fat, and polyunsaturated fat by multiplying the grams of the given macronutrient by 4 (if protein or carbohydrate) or 9 (if fat) dived by total daily kcal multiplied by 100. We used the HEI-2015 to assess diet quality.[15] The HEI-2015 total score ranges from 0 to 100 with higher scores indicating higher diet quality. Adequacy components receive points for higher dietary intake, which included total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein, seafood and plant proteins, and unsaturated fat to saturated fat ratio, and moderation components receive points for lower dietary intake, which included refined grains, saturated fat, sodium, and added sugars (**Table 1**).

## 2.3. Covariates

### 2.3.1. Body mass index, age, sex, race/ethnicity, and socioeconomic status

Body mass index (BMI) was defined as weight in kilograms divided by the square of height in meters. Participants self-reported if their sex was male or female, the age in years at the time of screening, and their race/ethnicity (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, and other race including multiracial). Socioeconomic status was assessed using the poverty/income ratio—the ratio between household income and the U.S. poverty threshold.

### 2.3.2. Physical activity

We calculated monthly metabolic equivalent (MET) minutes to assess participants' leisure time physical activity. To calculate total average weekly MET minutes, each participant indicated if they had engaged in any of 62 different physical activities, eg, walking, yard work, in the past 30 days, the duration of these activities, and if the activity was moderate or vigorous in intensity. Each physical activity (inclusive of the duration and intensity) was assigned a MET value based on the compendium of physical activity.[1] The monthly total MET minutes for each participant was calculated by summing the MET minutes for all activities.

### 2.3.3. Pain medication

To assess for confounding of the association of diet and spinal pain by pain medication usage, we also assessed whether study participants reported taking any pain-associated prescription drugs. Pain medications were grouped into 5 classes: Opioids (codeine, fentanyl, hydrocodone, hydrocodone/acetaminophen, hydromorphone, meperidine, methadone, morphine, oxycodone, oxycodone/acetaminophen, and oxycodone/naloxone), NSAIDs (aspirin, ibuprofen, celecoxib, indomethacin, diclofenac, oxaprozin, piroxicam, and naproxen), centrally acting drugs (antiepileptic drugs and antidepressants: Tricyclic antidepressants: (TCA: amitriptyline, nortriptyline, imipramine, clomipramine, doxepin, and desipramine; Selective serotonin reuptake inhibitors: paroxetine and fluoxetine; Selective norepinephrine reuptake inhibitors: venlafaxine, duloxetine, and milnacipran), antiepileptics (gabapentin, carbamazepine, pregabalin, and phenytoin), and cannabis.

## 2.4. Statistical analysis

Descriptive statistics were calculated for continuous variables using means for averages and standard errors as measures of variation, and proportions for categorical variables. Stratified descriptive statistics were calculated for individuals reporting spinal pain, or not, and unadjusted differences between groups were estimated using the Wilcoxon rank-sum test for continuous variables and the $\chi^2$ test for categorical variables. Generalized linear regression models with a quasibinomial link function, using pain status as the outcome, calculated the odds of pain with respect to dietary intake. Dietary intake, in the form of HEI scores or macronutrient consumption as percent of total caloric intake, was modeled as tertiles, except for the HEI scores for total protein intake, whole fruit intake, and seafood and plant proteins, where there was not enough population variation to calculate tertiles. In regression models, the lowest tertile of HEI score or macronutrient consumption was used as the reference category. Generalized linear regression models were run first unadjusted, and then run adjusted for the covariates age, sex, race, BMI, total caloric intake, total monthly METs, and pain medication use (any pain medication vs none). Statistical significance of associations in the generalized linear regression model was estimated using the likelihood ratio test. In addition, we calculated 95% confidence intervals around all odds ratios using the Wald method. All analyses were adjusted for the NHANES survey weights to account for the complex survey design of NHANES. Analyses were conducted using the *survey* package in R version 3.6.0.[21,22]

**Table 1**

Healthy Eating Index 2015* components and scoring standards (modified from HEI-2015 total and component scoring standards https://www.fns.usda.gov/how-hei-scored component scoring standards accessed July 31, 2019).

| HEI 2015 component | Maximum score | Standard for maximum score | Standard for minimum score |
|---|---|---|---|
| Adequacy† (higher scores indicates higher consumption) | | | |
|    Total fruit‡ | 5 | ≥0.8 cup equivalent per 1,000 kcal | No fruit |
|    Whole fruit§ | 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 |
|    Beans and greens‖ | 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 acid** | 10 | (PUFAs + MUFAs)/SFAs ≥2.5 | (PUFAs + MUFAs)/SFAs ≤ 1.2 |
| Moderation†† (higher scores indicates lower consumption) | | | |
|    Refined grain | 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 |
|    Saturated fats | 10 | ≤8% of energy | ≥16% of energy |
|    Added sugars | 10 | ≤6.5% of energy | ≥26% of energy |

* Intakes between the minimum and maximum standards are scored proportionately.
† Adequacy components are foods and/or nutrients that are encouraged in the diet. As such, higher scores indicate higher intakes of these foods and nutrients, because higher intakes are wanted.
‡ Includes 100% fruit juice.
§ Includes all forms except juice.
‖ Includes legumes (beans and peas).
¶ Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.
# Includes seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).
** Ratio of polyunsaturated and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).
†† Moderation components are foods and/or nutrients that are discouraged in the diet. As such, higher scores indicate lower intakes of these foods and nutrients, because lower intakes are wanted.
HEI, Healthy Eating Index.

## 3. Results

### 3.1. Respondent characteristics

The total number of adults screened in 2009-2010 NHANES was 6,684. Of these, 5001 answered the sociodemographic and arthritis questionnaires and 4151 also had complete dietary data, prescription medication use, and the physical activity data. Twenty-eight people were excluded due to having unrealistic low or high caloric intake. Eight hundred (19.4%) of the 4123 participants indicated they had chronic spinal pain.

### 3.2. Comparison of demographic characteristics: chronic spinal pain versus no spinal pain

We first compared the distribution of demographic characteristics between those individuals who reported chronic spinal pain and those who did not, which is presented in **Table 2**. Individuals who reported chronic spinal pain tended to be older, women, non-Hispanic white, have a higher BMI, lower poverty/income ratio were more likely to report taking a pain-associated medication across the 5 assessed categories (opioids, cannabis, NSAIDs, centrally acting, or other) or any pain-associated medication. Of note, individuals with chronic spinal pain consumed approximately the same number of calories as did those without pain (2159 vs 2137 kcal, P = 0.960).

### 3.3. Comparison of Healthy Eating Index components and macronutrient intake between chronic spinal pain versus no spinal pain

Next, we compared unadjusted differences in dietary components and macronutrient intake between study participants reporting chronic spinal pain vs not (**Table 3**). The Total HEI score was significantly lower in participants reporting chronic spinal pain. Individuals who reported spinal pain had significantly lower scores across multiple HEI components reflecting dietary adequacy, including total fruit, whole fruit, whole grains, dairy, and fatty acid intake. In addition, participants reporting chronic spinal pain also had significantly lower component scores reflecting dietary moderation, including sodium, saturated fat, and added sugars. Similarly, there were significant differences in dietary macronutrients as percent of calories, where individuals reporting chronic spinal pain consumed significantly less protein, more saturated fat, and more added sugar.

### 3.4. Association of Healthy Eating Index components and macronutrient intake and chronic spinal pain

We calculated the association between dietary intake patterns and spinal pain with logistic regression (**Table 4**). For the total HEI score, individuals in the highest tertile were 24% less likely to report chronic spinal pain relative to those in the lowest tertile. Individuals in the highest tertile of total fruit and whole fruit were also significantly less likely to report spinal pain. For the moderation HEI scores, only the added sugar score was significantly associated with chronic pain, where individuals in the highest score tertile (reporting the least added sugar intake) were 29% less likely to report chronic spinal pain. Individuals in the highest tertile of added sugar intake were 41% more likely to report chronic pain, relative to individuals in the lowest tertile. Similar results were observed for individuals in the second tertile of added sugar intake, who were 46% more likely to report chronic pain relative to individuals who consumed the lowest amount of added sugar.

## 4. Discussion

Roughly 19% of our sample reported chronic spinal pain. This proportion is lower than the 54% to 80% reported in epidemiological studies, but similar to the rates of any chronic pain

## Table 2

**Sociodemographic and clinical characteristics of respondents with spinal pain compared to those reporting no spinal pain.**

| | No spinal pain (n = 3323) | Spinal pain (n = 800) | P* |
|---|---|---|---|
| **Demographics** | | | |
| Age (mean years) ± SE | 42.9 ± 0.4 | 46.0 ± 0.6 | <0.001* |
| Women, no. (%) | 1695 (51) | 472 (59) | 0.033† |
| Race, no. (%) | | | <0.001† |
| Non-Hispanic white | 1469 (44) | 422 (53) | |
| Non-Hispanic black | 606 (18) | 133 (17) | |
| Mexican Americans | 669 (20) | 145 (18) | |
| Other Hispanics | 385 (12) | 73 (9) | |
| Other | 194 (6) | 27 (3) | |
| Poverty/income ratio ±SE | 3.12 ± 0.05 | 2.79 ± 0.10 | 0.004* |
| **Clinical characteristics** | | | |
| BMI, kg/m$^2$ (mean ± SE) | 28.4 ± 0.2 | 30.2 ± 0.4 | <0.001* |
| Average weekly MET minutes (mean ± SE) | 3425.9 ± 176.0 | 530.3 ± 193.1 | 0.024* |
| Kcal (mean ± SE) | 2159.9 ± 27.7 | 2137.3 ± 44.5 | 0.960* |
| **Pain medications, no. (%)** | | | |
| Any pain medication‡ | 387 (12) | 258 (32) | <0.001† |
| Opioid§ | 117 (4) | 113 (14) | <0.001† |
| Cannabis | 0 (0) | 1 (~0) | 0.030† |
| NSAIDs‖ | 132 (4) | 91 (11) | <0.001† |
| Centrally acting¶ | 160 (5) | 104 (13) | <0.001† |
| Other# | 44 (1) | 52 (6) | <0.001† |

\* From survey-weighted Kruskal–Wallis test.

† From survey-weighted $\chi^2$ test.

‡ Number of respondents who took at least 1 of the 5 pain categories. Total number of respondents of "Any Pain Medication" is less than the total number of respondents in the individual categories, eg, NSAIDs, because some respondents indicated that they were taking more than one category of pain medication.

§ Opioids = codeine, fentanyl, hydrocodone, hydrocodone/acetaminophen, hydromorphone, meperidine, methadone, morphine, oxycodone, oxycodone/acetaminophen, and oxycodone/naloxone.

‖ NSAIDs = aspirin, ibuprofen, celecoxib, indomethacin, diclofenac, oxaprozin, piroxicam, and naproxen.

¶ Centrally acting drugs = antiepileptic drugs and antidepressants: tricyclic antidepressants: (TCA: amitriptyline, nortriptyline, imipramine, clomipramine, doxepin, and desipramine), selective serotonin reuptake inhibitors: (SSRI: paroxetine and fluoxetine), selective norepinephrine reuptake inhibitors (SNRI: venlafaxine, duloxetine, and milnacipran), and Anti-epileptics including gabapentin, carbamazepine, pregabalin, and phenytoin. Respondents may have been taking these medications for reasons other than chronic pain.

# Other = acetaminophen, tramadol, baclofen.

BMI, body mass index; MET, metabolic equivalents; kcal, kilocalorie.

reported by 45-year-olds,[24] which was approximately the sample mean. We have 2 main findings to highlight. First, despite consuming a similar amount of total calories, individuals reporting chronic spinal pain had a significantly poorer overall diet quality score, even after adjusting for key clinical and sociodemographic cofounders. Differences in diet quality between the 2 groups spanned both macronutrients and HEI component scores, with individuals with spinal pain consuming significantly less protein, fruit, whole grains, and dairy, while consuming more sodium, saturated fat, and added sugars. Second, the type of sugar consumed was associated with chronic spinal pain. Natural sugar intake from fruits was associated with a 25% to 30% lower likelihood of chronic spinal pain, even when intake was as low as 0.64 cups per 1000 kcal/d and regardless of form (fruit juice, fresh, frozen, or dried fruit). For a 2000 kcal per day diet, this would represent roughly 1 1/3 cups of fruit, which is less than the USDA-recommended daily goal of 2 cups of fruit or fruit juice or 1 cup of dried fruit.[9] In contrast to natural sugars, added sugars were associated with increased odds of chronic spinal pain (~46%). The association with spinal pain was seen with added sugar as low as 8.8% of total dietary intake, approximately 5.5 tsp per 1000 kcal/d. This amount is less than the USDA[34] and World Health Organization[30] dietary recommendations for added sugar (<10% of daily calories), although greater than the American Heart Association recommendations of no more than 9 tsp per day for men and no more than 6 tsp per day for women.[3]

Our results are consistent with other studies that have examined the association of diet quality in various chronic pain disorders.[4,12,14] Diet quality, measured using the HEI-2005, was lower in normal-weight women with migraines or severe headaches compared to women without migraines, although there was no significant difference in dietary patterns by migraine

status between underweight, overweight, or obese women. In older (>55 years) women, HEI-2005 total scores were significantly lower in women with arthritis, as well as several HEI-2005 component scores: whole fruit, total fruit, whole grains, and oils.[14] Furthermore, in individuals with rheumatoid arthritis,[5] lower diet quality, as assessed with HEI-2010, was associated with increased morning stiffness and higher C-reactive protein, and poor diet quality was negatively associated with hs-C-reactive protein and erythrocyte sedimentation rate in Swedish adults with rheumatoid arthritis.[4] Higher diet quality was associated with decreased disability and a 44% decreased likelihood of having chronic pain in 6,989 people with multiple sclerosis.[12] In contrast to our results, however, diet quality graded as "least optimal" to "optimal" based on food groups and macronutrients was not associated with neck and back pain in 1424 male and female adolescents in Western Australia.[32] The differences in how diet quality was assessed, with a nonvalidated score, and the difference in demographics of the study participants could explain the difference in our results.

The association between chronic spinal pain and lower diet quality could be due to maladaptive changes in how people eat after a diagnosis of chronic pain. Research suggests that people with chronic pain experience poorer dietary habits due to negative impacts on their ability to shop and prepare foods (due to decreased physical functioning), side effects from pain medications, and reduced appetite.[14] Eating high-sugar nutrient-dense foods confers analgesic effects and enhances pain tolerance in both animals and humans.[29] As such, people with chronic pain may "comfort eat" to cope with their pain. This maladaptive behavior seems to be an indirect effect driven by stress, distress tolerance, and pain catastrophizing rather than the presence of pain itself.[29]

**Healthy Eating Index 2015* components and scoring standards and dietary macronutrient intake of respondents with spinal pin compared to those reporting no spinal pain.**

| HEI 2015 component | No spinal pain (n = 3342) | Spinal pain (n = 800) | P† |
|---|---|---|---|
| Total HEI (mean ± SE) | 54.31 ± 0.39 | 51.97 ± 0.65 | 0.007 |
| Adequacy‡ (higher scores indicates higher consumption) | | | |
| Total fruit§ (mean ± SE) | 2.51 ± 0.03 | 2.29 ± 0.07 | 0.011 |
| Whole fruit‖ (mean ± SE) | 2.62 ± 0.04 | 2.36 ± 0.08 | 0.005 |
| Total vegetables (mean ± SE) | 3.30 ± 0.03 | 3.21 ± 0.08 | 0.304 |
| Beans and greens¶ (mean ± SE) | 1.92 ± 0.06 | 1.77 ± 0.10 | 0.210 |
| Whole grains (mean ± SE) | 2.78 ± 0.08 | 2.50 ± 0.11 | 0.022 |
| Dairy# (mean ± SE) | 5.79 ± 0.07 | 5.53 ± 0.09 | 0.024 |
| Total protein foods (mean ± SE) | 4.50 ± 0.03 | 4.45 ± 0.04 | 0.137 |
| Seafood and plant proteins** | 2.92 ± 0.07 | 2.79 ± 0.10 | 0.220 |
| Fatty acid†† (mean ± SE) | 5.03 ± 0.12 | 4.53 ± 0.14 | 0.015 |
| Moderation‡‡ (higher scores indicates lower consumption) | | | |
| Refined grain (mean ± SE, % of kcal) | 6.03 ± 0.11 | 6.30 ± 0.14 | 0.090 |
| Sodium (mean ± SE, % of kcal) | 3.73 ± 0.08 | 4.10 ± 0.12 | 0.016 |
| Saturated fats (mean ± SE, % of kcal) | 6.39 ± 0.12 | 5.94 ± 0.10 | 0.003 |
| Added sugars (mean ± SE, % of kcal) | 6.78 ± 0.06 | 6.17 ± 0.11 | 0.0003 |
| Macronutrients as percentage of kcal | | | |
| Protein (mean ± SE, % of kcal) | 16.10 ± 0.13 | 15.68 ± 0.18 | 0.048 |
| Fat (mean ± SE, % of kcal) | 33.07 ± 0.25 | 33.56 ± 0.30 | 0.208 |
| Saturated fat (mean ± SE, % of kcal) | 10.67 ± 0.12 | 11.18 ± 0.11 | 0.003 |
| Monounsaturated fat (mean ± SE, % of kcal) | 11.86 ± 0.10 | 12.02 ± 0.13 | 0.274 |
| Polyunsaturated fat (mean ± SE, % of kcal) | 7.50 ± 0.07 | 7.28 ± 0.13 | 0.142 |
| Carbohydrate (mean ± SE, % of kcal) | 49.15 ± 0.27 | 49.27 ± 0.30 | 0.912 |
| Fiber (mean ± SE, % of kcal) | 3.42 ± 0.05 | 3.22 ± 0.07 | 0.091 |
| Added sugar (mean ± SE, % of kcal) | 12.64 ± 0.16 | 14.17 ± 0.33 | 0.0003 |

* Intakes between the minimum and maximum standards are scored proportionately.
† Survey-weighted Wilcoxon P values.
‡ Adequacy components are foods and/or nutrients that are encouraged in the diet. As such, higher scores indicate higher intakes of these foods and nutrients, because higher intakes are wanted.
§ Includes 100% fruit juice.
‖ Includes all forms except juice.
¶ Includes legumes (beans and peas).
# Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.
** Includes seafoods, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).
†† Ratio of polyunsaturated and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).
‡‡ Moderation components are foods and/or nutrients that are discouraged in the diet. As such, higher scores indicate lower intakes of these foods and nutrients, because lower intakes are wanted.
HEI, Healthy Eating Index.

Eating a lower-quality diet could potentially increase the risk of developing spinal pain. There is emerging evidence about the role of the gut–brain axis on the development of chronic pain.[17] Diet quality and added sugars are some of the most important influencers of gut microbiota composition.[28,33] Changes in gut microbiota composition can lead to changes in gut-derived neurotransmitters that in turn can influence brain neurotransmitter levels. These changes in brain neurotransmitter can then influence the development of chronic pain.[25,27]

Our study had several limitations. There was no measurement of pain severity or pain interference in daily life. In addition, respondents in the no spinal pain group could have chronic pain at other sites, for example, knee osteoarthritis, because neither a universal assessment of pain nor a comprehensive investigation of other chronic pain diagnoses was conducted. The presence of chronic pain in the no spinal pain group would, however, attenuate the association between diet and chronic spinal pain. Also, another limitation was that the determination of chronic pain was based entirely on the self-assessment data given by the survey respondents, and was not necessarily diagnosed by a physician or pain specialist.

Importantly, we were unable to assess causality due to the cross-sectional nature of the data. As such, it is unclear if poor diet quality leads to an increased risk of developing chronic spinal pain or if chronic spinal pain leads to individuals eating a poorer quality diet or both. Either scenario, however, has negative implications for health because lower diet quality has significant impacts on mortality and morbidity.

This study also had several strengths. The sample was derived from an ethnically and racially diverse nationally representative sample.[31] Information was available on both over-the-counter and prescription pain medications allowing us to control for the impact of different categories of medication on the association between diet and chronic spinal pain. We were able to assess participants' physical activity. Because healthy habits often congregate with one another, such as exercising and healthy diet, and higher levels of physical activity are associated with lower chronic pain, it was important to control for cofounding impact of physical activity in our models.

In summary, diet quality was significantly lower in those with chronic spinal pain. Those with chronic spinal pain consumed significantly less whole grains, dairy, fruit, and fiber, while also consuming more saturated fat and sugar. Although it is unclear if lower diet quality causes chronic spinal pain, it would be still be appropriate to counsel patients with chronic spinal pain to: (1) identify and limit sources of added sugar in their diets and (2) replace added sugars with natural ones. This dietary guidance is consistent with the 2015-2020 USDA Dietary Guidelines for

**Table 4**

**The association between the odds of chronic spinal pain, HEI 2015*, HEI components, and dietary macronutrients.**

| HEI 2015 total score and components | Tertiles* (unless otherwise indicated) | Crude model†, odds ratio, 95% confidence intervals | Multivariate model†, odds ratio, 95% confidence intervals |
|---|---|---|---|
| Total HEI‡ | T2 (47.3–58.4) | 0.90 (0.64–1.28) | 0.98 (0.72–1.33) |
| | T3 (58.4–94.2) | 0.72 (0.56–0.92)¶¶ | 0.76 (0.60–0.97) |
| | *P*trend | 0.021 | 0.09 |
| Adequacy (higher scores indicate higher intake)§ | | | |
| Total fruit‖ | T2 (0.92–4.01) | 0.92 (0.74–1.16) | 0.92 (0.74–1.14) |
| | T3 (4.01–5.00) | 0.74 (0.63–0.86)## | 0.70 (0.61–0.81)¶¶ |
| | *P*trend | 0.002 | 0.009 |
| Whole fruit¶# | T2 (0.296– 5) | 0.78 (0.68–0.90)¶¶ | 0.76 (0.65–0.89)¶¶ |
| | *P*trend | 0.003 | 0.027 |
| Total vegetables | T2 (2.48–4.33) | 1.03 (0.76–1.39) | 1.02 (0.72–1.44) |
| | T3 (4.33–5.00) | 0.88 (0.67–1.17) | 0.89 (0.61–1.28) |
| | *P*trend | 0.391 | 0.554 |
| Beans and greens** | T2 (0.03–3.48) | 0.94 (0.75–1.17) | 1.00 (0.77–1.30) |
| | T3 (3.48–5.00) | 0.83 (0.62–1.10) | 0.94 (0.67–1.31) |
| | *P*trend | 0.231 | 0.748 |
| Whole grains | T2 (0.14– 3.00) | 0.85 (0.65–1.12) | 0.83 (0.59–1.18) |
| | T3 (3.00–10.00) | 0.76 (0.62–0.95)¶¶ | 0.80 (0.64–1.018) |
| | *P*trend | 0.028 | 0.145 |
| Dairy†† | T2 (3.75– 7.13) | 0.94 (0.79–1.12) | 0.98 (0.79–1.23) |
| | T3 (7.13–10.00) | 0.80 (0.69–0.94)¶¶ | 0.80 (0.67–0.97) |
| | *P*trend | 0.013 | 0.074 |
| Total protein foods | Not enough variation to test | | |
| Seafood and plant proteins‡‡# | T2 (1.15– 5) | 0.87 (0.72–1.07) | 0.97 (0.79–1.19) |
| | *P*trend | 0.204 | 0.798 |
| Fatty acid§§ | T2 (3.09– 6.56) | 0.82 (0.63–1.07) | 0.82 (0.65–1.04) |
| | T3 (6.56–10.00) | 0.74 (0.58–0.96)¶¶ | 0.79 (0.60–1.03) |
| | *P*trend | 0.037 | 0.151 |
| Moderation (higher scores indicate lower intake)‖‖ | | | |
| Refined grain | T2 (4.10– 8.14) | 1.17 (0.93–1.46) | 1.19 (0.95–1.49) |
| | T3 (8.14–10.00) | 1.20 (0.98–1.45) | 1.12 (0.90–1.38) |
| | *P*trend | 0.095 | 0.409 |
| Sodium | T2 (1.99– 5.55) | 1.00 (0.73–1.37) | 0.99 (0.72–1.38) |
| | T3 (5.55–10.00) | 1.18 (0.95–1.46) | 1.13 (0.93–1.39) |
| | *P*trend | 0.169 | 0.303 |
| Saturated fat | T2 (5.31–8.61) | 0.86 (0.72–1.03) | 0.87 (0.69–1.08) |
| | T3 (8.61–10.00) | 0.71 (0.57–0.88)## | 0.78 (0.61–1.00) |
| | *P*trend | 0.006 | 0.102 |
| Added sugar | T2 (5.46–8.83) | 0.97 (0.79–1.19) | 1.04 (0.88–1.24) |
| | T3 (8.83–10.00) | 0.68 (0.55–0.83)## | 0.71 (0.58–0.88)¶¶ |
| | *P*trend | 0.002 | 0.029 |
| Macronutrients as a percentage of kcal | | | |
| Protein | T2 (14.13–17.2) | 0.71 (0.54–0.94) | 0.74 (0.57–0.95) |
| | T3 (17.22–47.0) | 0.76 (0.59–1.00) | 0.78 (0.56–1.09) |
| | *P*trend | 0.068 | 0.213 |
| Total fat | T2 (29.42–35.6) | 1.03 (0.77–1.37) | 0.97 (0.72–1.34) |
| | T3 (35.6–68.4) | 1.21 (0.94–1.55) | 1.10 (0.83–1.46) |
| | *P*trend | 0.141 | 0.496 |
| Saturated fat | T2 (9.11–11.77) | 1.21 (0.93–1.58) | 1.12 (0.81–1.55) |
| | T3 (11.77–25.79) | 1.431 (1.14–1.75)## | 1.29 (1.02–1.64) |
| | *P*trend | 0.004 | 0.090 |
| Monounsaturated fat | T2 (10.30–12.8) | 1.05 (0.78–1.41) | 0.99 (0.73–1.33) |
| | T3 (12.82–40.2) | 1.15 (0.86–1.52) | 1.05 (0.79–1.39) |
| | *P*trend | 0.360 | 0.729 |
| Polyunsaturated fat | T2 (6.025– 8.03) | 0.91 (0.76–1.09) | 0.98 (0.83–1.15) |
| | T3 (8.03–23.04) | 0.76 (0.56–1.03) | 0.78 (0.57–1.06) |
| | *P*trend | 0.092 | 0.186 |
| Carbohydrate | T2 (46.3–54.2) | 1.01 (0.85–1.20) | 0.99 (0.83–1.19) |
| | T3 (54.2–85.0) | 1.01 (0.88–1.16) | 0.96 (0.85–1.08) |
| | *P*trend | 0.857 | 0.557 |
| Fiber | T2 (2.57– 3.75) | 0.79 (0.64–0.98)¶¶ | 0.80 (0.65–0.97)¶¶ |
| | T3 (3.75– 13.32) | 0.80 (0.59–1.08) | 0.83 (0.57–1.20) |
| | *P*trend | 0.156 | 0.369 |
| Added sugar | T2 (8.80–15.40) | 1.44 (1.16–1.78)## | 1.46 (1.13–1.91)## |
| | T3 (15.40–70.90) | 1.49 (1.21–1.83)## | 1.41 (1.14–1.73)¶¶ |
| | *P*trend | 0.002 | 0.028 |

* The comparison category is the lowest tertile or median for that HEI score or macronutrient intake.
† Odds ratio and 95% confidence intervals calculated using binomial survey weighted general linear models with spinal pain (yes/no) as the dependent variable and tertile of the HEI total, HEI component scores, or dietary macronutrient as percentage of daily kcal as the independent variables. The multivariate model also adjusted for age, sex, body mass index (BMI), race/ethnicity, poverty/income ratio, daily kcal, daily total metabolic equivalents (METs), and pain medication.
‡ Intakes between the minimum and maximum standards are scored proportionately.
§Adequacy components are foods and/or nutrients that are encouraged in the diet. As such, higher scores indicate higher intakes of these foods and nutrients, because higher intakes are wanted.
‖ Includes 100% fruit juice.
¶ Includes all forms except juice.
# Split by medians due to lack of variability in macronutrient intake.
** Includes legumes (beans and peas).
†† Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.
‡‡ Includes seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).
§§ Ratio of polyunsaturated and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).
‖‖ Moderation components are foods and/or nutrients that are discouraged in the diet. As such, higher scores indicate lower intakes of these foods and nutrients, because lower intakes are wanted.
¶¶ *P*value <0.05.
## *P*value <0.0.
HEI, Healthy Eating Index.

America.[10] The USDA has excellent resources to help with this process (https://www.usda.gov/topics/food-and-nutrition).[34] Future research should focus on the directionality of chronic spinal pain and the diet quality association, the mechanisms—both biological and behavioral—driving this association, and examine if these associations are also found in other chronic pain conditions and populations.

## Disclosures

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