Research article

Dietary intake and adherence to the 2010 Dietary Guidelines for Americans among individuals with chronic spinal cord injury: A pilot study

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Objective: To investigate dietary intake and adherence to the 2010 Dietary Guidelines for Americans in individuals with chronic spinal cord injury (SCI) and able-bodied individuals.

Design: A pilot study of dietary intake among a sample of individuals with SCI > 1 year ago from a single site compared with able-bodied individuals.

Participants/methods: One hundred black or white adults aged 38–55 years old with SCI > 1 year and 100 age-, sex-, and race-matched adults enrolled in the Coronary Artery Risk Development in Young Adults (CARDIA) study. Dietary intake was assessed by the CARDIA dietary history. Linear regression analysis was used to compare dietary intake between the subjects with SCI and those enrolled in the CARDIA study. Further, adherence to the 2010 Dietary Guidelines for dairy, fruits, and vegetables, and whole-grain foods was assessed.

Results: Compared with CARDIA participants, participants with SCI consumed fewer daily servings of dairy (2.10 vs. 5.0, $P < 0.001$), fruit (2.01 vs. 3.64, $P = 0.002$), and whole grain foods (1.20 vs. 2.44 $P = 0.007$). For each food group, fewer participants with SCI met the recommended servings compared with the CARDIA participants. Specifically, the participants with SCI and in CARDIA who met the guidelines were, respectively: dairy, 22% vs. 54% ($P < 0.001$), fruits and vegetables 39% vs. 70% ($P = 0.001$), and whole-grain foods 8% vs. 69.6% ($P = 0.001$).

Conclusions: Compared with able-bodied individuals, SCI participants consumed fewer daily servings of fruit, dairy, and whole grain foods than proposed by the 2010 Dietary Guideline recommendations. Nutrition education for this population may be warranted.

Keywords: Spinal cord injury, Dietary intake, 2010 Dietary Guidelines for Americans

Introduction

Spinal cord injuries result in changes in body composition^{1–5} and limitations in physical activity^{6–9} that lead to decreased energy expenditure.^{10–13} These changes are associated with central obesity^{14–17} and other cardiovascular disease (CVD) risk factors such as dyslipidemia,^{18–22} glucose intolerance^{16,18,23–25} and diabetes,^{26,27} and markers of inflammation^{9,28} and endothelial activation²⁹ that are correlated with

increases in CVD.^{30–32} As a result, CVD, specifically coronary heart disease has emerged as a leading cause of death in individuals with chronic spinal cord injury (SCI).^{33–35}

A substantial body of evidence supports whole-grain foods, fruits, and vegetables, and low-fat dairy products as being key aspects of the 2010 Dietary Guidelines for Americans.³⁶ Prudent or healthy diets rich in whole-grain foods, fruits, and vegetables, and low-fat dairy products are associated with lower prevalence of diabetes^{37,38} and CVD^{39–42} in the general population. Whole-grain beneficially affects lipid profiles,^{43–45}

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inflammation^{45,46} insulin sensitivity,^{45,47} and is inversely associated with weight gain and central adiposity.^{48,49} Fruit and vegetable intake has been associated with lower blood pressure,^{50,51} inflammation,^{46,52} and risk of metabolic syndrome and central adiposity,^{53,54} as well as a slower rate of weight gain.^{49,55} Consumption of greater than five servings/day of fruits and vegetables is associated with the lowest risk of CVD relative to less than three servings/day.⁵⁶ Low-fat dairy has a beneficial effect on body weight and waist circumference,⁵⁷ blood pressure,⁵⁸ blood sugar,⁵⁹ and in addition, is an excellent source of vitamin D. Dairy consumption may be especially important in the SCI population because of the higher prevalence of vitamin D deficiency, another CVD risk factor^{60–63} in persons with SCI.^{64–67} Previous studies have shown high fat and low fiber intakes among subjects with chronic SCI when their diets were compared with dietary recommendations of the American Heart Association (AHA) and the 2000 Dietary Guidelines for Americans,⁶⁸ the recommended Dietary Reference Intakes and the Acceptable Macronutrient Distribution Range,^{69,70} and the National Cholesterol Education Program recommendations.⁷¹ However, dietary intake of individuals with SCI has not been compared with a broadly representative, multicenter sample of matched able-bodied individuals or assessed for adherence to the 2010 Dietary Guidelines for Americans. Therefore, the purpose of this study was to compare the dietary intake, as well as adherence to the 2010 Dietary Guidelines for Americans, of individuals with SCI to age-, sex-, and race-matched black and white men and women enrolled in the Coronary Artery Risk Development in Young Adults (CARDIA) study.

Methods

Participants

Individuals with chronic SCI (>1 year) aged 38–55 years, presenting to a single site for dietary intake and CVD risk assessment were sex-, race-, and age-matched (± 5 years) to able-bodied individuals from the CARDIA study population. This age range was selected to overlap with CARDIA participants who attended a clinic visit in 2005–2006 when they were 38–50 years old; SCI participants were recruited to fall within this age range ± 5 years. In accordance with the CARDIA inclusion criteria for race and sex, all participants were composed of men and women of Caucasian or African-American race. Participants with SCI had sustained a non-vascular insult that caused an acute SCI (i.e. traumatic injury, transverse myelitis without a diagnosis of multiple sclerosis, surgical complication,

or benign neoplasm) at least one year prior to entering the study. They were American Spinal Injury Association (ASIA) A, B, or C and had adequate communication skills. Exclusion criteria included ASIA D, pregnancy, end-stage renal disease, treatment for cancer except for non-melanoma skin cancer within the past five years, and chronic, nontobacco substance abuse. Participants who had previously given consent to be in our SCI Registry were recruited with letters sent to their homes. Other participants were recruited with the assistance of their rehabilitation physician during visits to our outpatient clinic. All participants gave their informed written consent, and the local institutional review board approved the study.

There were 134 participants with SCI enrolled in the study. One participant with SCI was later excluded prior to collection of CVD risk factor measurements or dietary intake because he was Asian, and 33 other individuals with SCI withdrew from the study, leaving 100 participants with SCI in the analysis along with 100 age-, sex-, and race-matched CARDIA participants.

The CARDIA population

CARDIA is a multicenter, population-based, prospective study of CVD risk factor evolution in 5115 black and white, men and women ages 18–30 years at baseline (1985–1986) recruited from one of four field centers including Birmingham, AL, Chicago, IL, Minneapolis, MN, and Oakland, CA. Details of this study have been previously described.⁷² To date, there have been eight clinical examinations at years 0, 2, 5, 7, 10, 15, 20, and 25. For this study, data were obtained from 100 CARDIA participants that were matched based on age (± 5 years), sex, and race at the year 20 examination (2005–2006) when dietary intake was assessed.

Dietary intake

The CARDIA Dietary History, a comprehensive, quantitative food frequency assessment method⁷³ was used to assess dietary intake in both participants enrolled in CARDIA and those with SCI. This tool was developed to reflect the current food supply, frequently consumed foods of young adults, race-specific preferences, and certain regional foods. The CARDIA Dietary History was validated in adults who are similar to the CARDIA participants,⁷⁴ but not in individuals with SCI. One hundred open-ended questions comprising this interview were administered, and food models were used to facilitate portion size estimation. To ensure that all foods consumed were queried, the last question was an open-ended question regarding intake of any other foods not previously reported.

Table 1 Descriptive characteristics of spinal cord injury participants and CARDIA study participants

Characteristics	SCI	CARDIA
N	100	100
Mean age $\pm$ SD (year)	45.3 (5.1)	44.8 (4.4)
Sex		
Male, <i>n</i>	78	78
Race		
African-Americans	34	34
SCI		
Tetraplegia	57	
Paraplegia	43	NA
ASIA Classification		
A	66	NA
B	16	
C	18	
Time since injury $\pm$ SD (years)	15.1 (9.6)	NA

NA, not applicable.

Comparison to the 2010 Dietary Guidelines for Americans

Each participant was assessed for their adherence to the recommended daily minimum amounts for whole-grain foods (3.5 ounce equivalents), fruits and vegetables (5 cups), and low-fat dairy products (3 cups) for 31–50-year olds as defined by the 2010 Dietary Guidelines for Americans.³⁶ The total number of participants from each group who met the recommended daily minimum amount for each food group was reported.

Data analysis

SAS version 9.2 (SAS Institute, Cary, NC, USA) was used for all data analysis. Participant characteristics of each group were described using means (standard deviations: SD), and frequencies (%). General linear regression models (PROC GLM) evaluated the differences in dietary intake between participants with SCI and age-, sex-, and race-matched participants enrolled in CARDIA. We examined the proportion participants with SCI vs. those enrolled in CARDIA adhering to the 2010 Dietary Guidelines for Americans ($<$ or $\geq$ food guideline) using a generalized linear model, adjusting for energy intake (kcal).

Results

Characteristics of the study population are described in Table 1. Participants were middle-aged (by design) and predominantly men, in keeping with known sex differences in prevalence of SCI. As shown in Table 2, nutrient intake was similar between the two populations, except for significantly greater calcium and vitamin D among CARDIA participants when compared with participants with SCI. The participants with SCI consumed more meat, including more fish/seafood, but consumed significantly fewer servings of whole grain foods, fruit, and dairy products than age-, sex-, and race-matched

Table 2 Comparison of dietary intake between age-, sex-, and race-matched CARDIA participants and spinal cord injury participants

Dietary intake	SCI (<i>n</i> = 100)	CARDIA (<i>n</i> = 100)	<i>P</i> value
Mean (SD)			
<i>Nutrient intake</i>			
Energy, kcal	2600.9 (2005.9)	2963.3 (2223.6)	0.23
Total fat, gm	100.2 (87.2)	115.2 (96.3)	0.25
SFA, gm	32.7 (25.8)	38.1 (31.1)	0.18
Carbohydrate, gm	327.1 (274.1)	371.3 (267.0)	0.25
Protein, gm	100.3 (70.4)	111.3 (81.2)	0.3
Total fat, % kcal	34.2 (7.1)	33.9 (8.4)	0.74
SFA, % kcal	5.07 (1.27)	4.98 (1.54)	0.68
CHO, % kcal	49.9 (10.3)	52.8 (23.5)	0.27
Protein, % kcal	16.1 (4.7)	15.6 (4.1)	0.44
Calcium, mg	1048.9 (693.8)	1414.7 (1051.6)	0.004
Vitamin D, IU	223.3 (180.0)	314.5 (292.2)	0.009
Vitamin C, mg	178.7 (216.2)	184.6 (174.1)	0.83
Folate, μ g	535.9 (572.9)	630.7 (476.1)	0.21
<i>Food intake, servings/day</i>			
Dairy	2.10 (1.6)	4.79 (5.67)	<0.0001
Fruit	2.01 (3.15)	3.64 (3.99)	0.002
Vegetables	4.10 (6.18)	4.93 (4.23)	0.27
Whole grain	1.20 (1.40)	2.44 (4.36)	0.007
Refined grain	5.42 (3.45)	6.44 (6.45)	0.16
Meat	5.37 (3.97)	4.60 (3.95)	0.18
Fish/seafood	1.44 (3.50)	0.85 (0.98)	0.11
Sugar sweetened beverages	10.2 (12.7)	9.15 (4.55)	0.43
Diet beverages	1.29 (5.3)	0.41 (0.94)	0.1
Sugar	1.46 (3.04)	3.50 (5.86)	0.002

Table 3 Proportion (%) of spinal cord injury (SCI) participants and age-, sex-, and race-matched CARDIA participants adhering to the 2010 Dietary Guidelines for Americans for selected food groups adjusted by energy intake

Prudent food group	Recommended servings	SCI (<i>n</i> = 100)	CARDIA (<i>n</i> = 100)	<i>P</i> value
Dairy	≥3 cups	23.4 (4.35)	48.6 (4.35)	<0.001
Fruits and vegetables	≥5 cups	40.3 (4.55)	68.7 (4.55)	<0.001
Whole-grain	≥3 ounces	8.9 (3.4)	21.1 (3.38)	0.01

CARDIA participants. However, the CARDIA group reported greater consumption of high sugar condiments added to other foods including sugar, honey, syrup, and jam than participants with SCI. Both groups had relatively poor adherence to recommendations for whole-grain food intake (Table 3). Compared with CARDIA participants, fewer participants with SCI met the daily minimum recommendations for whole grain, fruits, and vegetables, and dairy. Only three participants with SCI met the recommendations for all three food groups.

Discussion

Dietary patterns rich in whole grains, low-fat dairy, and fruits and vegetables have been associated with lower rates of CVD in the general population. The participants with SCI in our study were assessed for adherence to the 2010 Dietary Guidelines for Americans recommendations for these selected food groups, and they demonstrated poor diet quality with significantly lower adherence to these guidelines compared with a population-based control group. This finding was consistent with previous studies examining previous dietary guidelines in which participants with SCI were found to have poor diet quality consisting of excessive fat and low dietary fiber intakes.^{68,69,71,75} Both groups had low vitamin D intake compared with the RDA,⁷⁶ with the SCI group consuming significantly less vitamin D than the CARDIA participants. It is important to note that low vitamin D intake does not necessarily result in vitamin D deficiency and the only way to assess for vitamin D deficiency is by checking a serum vitamin D level. Reasons for the decreased intake of healthy food groups are unknown and warrant further study. Possibilities include convenience, costs, and education.

At 2600 kcal/day, adults with SCI consumed an excessive amount of calories given their decreased energy expenditure. Notably, dietary intake was self-reported, which is known to be an underestimate of caloric intake in overweight and obese individuals, while normal weight and underweight individuals over-report intake.⁷⁷ The SCI evidence-based nutrition practice guidelines recommend using indirect calorimetry to determine energy requirements if possible.⁷⁸ If

not, energy requirements for persons with SCI during acute rehabilitation can be calculated using 22.7 kcal/kg/day for tetraplegia and 27.9 kcal/kg/day for those with paraplegia based on ideal body weight.¹⁰ The practice guidelines recommend determining the ideal body weight for persons with SCI by reducing the baseline measure from the Metropolitan Life Insurance tables⁷⁹ by 10–15% for individuals with tetraplegia and 5–10% for those with paraplegia.⁷⁸

CVD prevention should be a comprehensive approach including an improvement in diet, physical activity, and smoking cessation.^{80,81} However, understanding dietary influences on risk of CVD in the SCI population is especially important because physical activity is limited at best. Many people with SCI may have limitations in increasing their physical activity because of the level of the SCI,⁸² the high potential for overuse injuries,^{83–85} and many other documented barriers to exercise.^{86,87} Therefore, dietary change, one modifiable lifestyle factor, likely provides the most realistic approach to CVD prevention in individuals with SCI.

Very few nutrition education studies have been conducted in the SCI population. A dietary intervention with recommendations based on the American Heart Association dietary guidelines on adults with chronic SCI and hypercholesterolemia showed a significant decrease in total cholesterol and LDL-C.⁸⁸ A pilot study of a 12-week weight loss program consisting of nutrition education and exercise for individuals with chronic SCI resulted in significant weight loss as well as an improvement in dietary behavior.⁸⁹ Nutrition education during acute rehabilitation has not been studied. Additional nutrition education during acute rehabilitation might improve diet quality in the chronic SCI population and reduce CVD morbidity. Improved dietary intake might also reduce the risk of other common complications in SCI, including pressure ulcers and infections^{90–94} and cancer.^{95–97}

Our study has several limitations. Participants with SCI were recruited from a convenience sample at a single site in the Southeastern United States. Therefore, our findings may not be representative of the population of people with chronic SCI in the US overall. This also resulted in a relatively small sample

size of 100 participants with SCI; thus, power to detect dietary differences was limited. Finally, self-reported dietary intake is likely under-estimated, although this reporting error is likely to be nondifferential between the two groups. Strength of this study is the comparison group of healthy, able-bodied adults matched for age, sex, and race to the SCI population. The rationale for using the CARDIA cohort is that it represents a generalizable comparison group; nevertheless geographic differences in dietary intake may be influencing our results.

Conclusions

Based on the 2010 Dietary Guidelines, participants with SCI consumed fewer than the recommended daily servings of fruit, dairy products, and whole grain foods, but similar energy intake compared with age-, race-, and sex-matched able-bodied adults. Future studies on increasing nutrition knowledge and physical activity in the SCI population are warranted as this intervention is likely to be the best approach to CVD prevention for the SCI population.

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Disclaimer statements

Contributors JL was a mentored principal investigator on the study and the primary author of the manuscript. DG was a research mentor on the study and a contributing author helping with the development and editing of the manuscript. FH was a research mentor on the study. As an author, she helped significantly with the editing process and her rehabilitation expertise was greatly appreciated. PS was the primary research mentor and a contributing author helping with the development of the project and throughout the editing process. She, along with LS, helped extensively on the dietary analysis and development of this part of the manuscript. JN helped with the data analysis and authorship of the data analysis section. MD was a research mentor and contributed to the editing of the final manuscript. XZ performed many of the data analysis and helped write the data analysis section. LS is the senior author and helped develop the project, manuscripts, and was involved throughout the editing process.

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Ethics approval This study was approved by the Carolinas Healthcare System Institutional Review Board, and was registered on Clinical trials.gov ID # NCT01025609.

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