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Dietary and serum lipids in individuals with spinal cord injury living in the community

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Abstract—A cross-sectional study of 189 community-dwelling persons with spinal cord injury (SCI) (a) assessed levels of dietary and serum lipids, (b) determined the proportion of persons whose levels were out of the recommended/desired range, and (c) identified predictors of dietary and serum lipids. Lipid levels were out of range for a substantial proportion of the sample. Older persons were likely to have higher serum cholesterol and higher triglyceride levels than younger persons. Men tended to have higher intake of dietary cholesterol and lower levels of HDL than women. Caucasians and Hispanic-Americans tended to have higher triglycerides than African-Americans. Persons who had lived with SCI less time tended to have higher saturated fat intake and higher triglycerides than those who had lived with it longer. Greater saturated fat intake was associated with higher serum cholesterol after controlling for age. Studies are needed that test the effectiveness of various interventions on controlling dietary and serum lipids for persons with SCI.

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INTRODUCTION

There is convincing evidence that decreased levels of high-density lipoprotein cholesterol (HDL) and elevated levels of low-density lipoprotein cholesterol (LDL) in serum are associated with coronary heart disease (CHD) and myocardial infarction in the general population (1–4).

Diet, saturated fat intake, in particular, appears to play a central role in determining serum total cholesterol, HDL, and LDL (5–8). Keys (9) has shown that reducing intake of cholesterol by half has a minimal effect (7.6 mg/dl) on serum cholesterol. However, decreasing both saturated fat and cholesterol intake by half led to about a 30 mg/dl decrease in serum cholesterol. Stone (10) reviewed the central role of diet in the control of serum total cholesterol, LDL, and HDL and their connection to CHD. He concluded that dietary cholesterol and saturated fat are among the factors elevating serum cholesterol and LDL. Hegsted and colleagues (11) reviewed the published data on the effects of dietary cholesterol and fat on the serum levels of cholesterol and lipoproteins. They concluded that saturated fatty acids are among the primary determinants of serum cholesterol and that polyunsaturated fatty acids play a major role in lowering serum cholesterol.

A number of studies have shown that persons with spinal cord injury (SCI) are susceptible to the same diseases that affect the aging population, including CHD (12–18). As is the case for the general population, low HDL and high LDL are considered risk factors for CHD in persons with SCI (19–21). Some investigators have found that mean serum HDL levels were significantly reduced in men with SCI compared with age-matched controls (22–25). There is convincing evidence that depressed levels of HDL in persons with SCI, particularly those with tetraplegia, may be caused by a high fat diet (15,23,24,26,27). Levine and colleagues (28) reported that persons with SCI had high fat and limited carbohydrate intake. This combination can lead to abnormal metabolism, both at rest and during physical activity.

Little is known about dietary and serum lipids in persons with SCI living in the community. This report presents data from a cross-sectional study concerning the dietary intake of cholesterol, total fat, and saturated fat, and serum levels of total cholesterol, HDL, LDL and triglycerides in community-dwelling adults with SCI.

The purpose of this study was to measure the cholesterol and fat in the diet and blood of persons with spinal cord injury and to compare the results with the recommended/desired range. *Subjects/procedures.* Participants were 189 adults with SCI. Dietary fat and cholesterol were assessed by 3-day food diary. Blood samples were obtained after an overnight fast. *Results.* Intake of fat was above the recommended levels for 80 percent of the participants, and many had high cholesterol intake, particularly men. Over 40 percent had high cholesterol levels in their blood. Older persons had higher cholesterol and triglycerides. Caucasians and Hispanic-Americans tended to have higher triglycerides than African-Americans. *Relevance to Veterans.* These results suggest that a large proportion of persons with SCI may be at risk for coronary heart disease. Long-term studies are needed to determine the relationship between fats in the blood and onset of heart disease in persons with SCI.

METHOD

Participants

This study was a component of the Rehabilitation Research and Training Center in Community Integration for Individuals with Spinal Cord Injury sponsored by the National Institute for Disability and Rehabilitation Research (1994–2001). To participate, individuals had to be at least 18 years of age and have sustained a traumatic SCI. Dietary (n = 181) and/or serum (n = 179) lipid data were provided by 189 individuals (**Table 1**). The sample consisted, in part, of 115 persons with chronic SCI (31 women, 84 men) originally recruited for an earlier study (1988–1993) of the life status of persons with SCI. All 31 women (31 of 40 in earlier study = 77.5 percent) and 64 of the men (64/100 = 64.0 percent) had been randomly selected from a sampling frame of 661 adults with traumatic SCI living within a 13-county area surrounding Houston and Galveston, Texas. Ten additional men (10 of 15 in earlier study = 66.7 percent) had been selected for the life status study because they had been injured a long time, and another 10 men (10 of 15 = 66.7 percent) had been selected because they had been injured over the age of 35 years.

An additional 25 persons (3 women, 22 men) who were injured more recently (2 to 7 years) and 15 persons (5 women, 10 men) from Hispanic backgrounds were recruited from an updated sampling frame (1994–1998) to supplement those persons with chronic SCI who were in the earlier study. Finally, 34 persons (5 women, 29 men) were recruited during their initial rehabilitation hospitalization (1994–1998) and followed longitudinally during their first two years postdischarge. Lipid data for these 34 persons were obtained between 6 and 15 months postdischarge. As can be seen in **Table 1**, there was a wide range of ages and times since injury. Nearly one-fourth of the participants were female and approximately 40 percent were from minority backgrounds.

Dietary Lipid Intake

Dietary intake was assessed by 3-day self-reports on a form given to each subject. The form was accompanied by a booklet that contained life-size drawings of various glasses and measuring cups marked in ounces, circles marked in sectors to simulate wedges of pizzas, pies, or cakes, and rectangles to measure portions of meats or pats of butter. The booklet was part of the software package that was used to analyze the food intake. The program was developed at the School of Public Health of the University of Texas (29). The portions depicted in the

Table 1.
Characteristics of the sample

	N = 189 Mean	SD	Range	
Age (years)	43.07	13.32	19.16 - 81.89	
Time since injury (years)	12.46	10.43	0.46 - 46.97	
			Number	**Percent**
Gender				
Women			44	23.3
Men			145	76.7
Race/ethnicity				
Caucasian			112	59.3
African-American			42	22.2
Hispanic-American			33	17.5
Other			2	1.1
Level and completeness of SCI*				
Tetraplegia (A, B or C)			78	41.3
Paraplegia (A, B or C)			74	39.2
Tetraplegia or paraplegia (D)			37	19.6

* Based on American Spinal Injury Association Impairment Scale.

booklet were labeled with numbers and letters that the subjects used to indicate the size of the portions of each food they had eaten. The form had separate columns in which to indicate whether the subject was reporting on what they had eaten at breakfast, lunch, dinner, or as a snack. Within these categories, the subject listed all they had eaten plus the size of the portions of each dish. At the bottom of each page there was a reminder to include any food supplements, herbs, or vitamin and mineral pills. The participants were free to choose the days they were reporting. However, most of the participants reported on the days immediately preceding a home visit by a research nurse; therefore most of the days reported were weekdays. Those who had not completed the diet forms at the time of the home visit by the nurse, were called later by the research coordinator on 3 successive days and asked to report on their food intake. The coordinator recorded the information on the forms. The software program had standard recipes used to determine the amount of each nutrient ingested by the subject. The program also had the capability to accept the input of recipes of any unusual dishes that the subjects reported eating. The program reported absolute values of 25 individual nutrients including cholesterol, total fat, and saturated fat. It also reported total calories as well as the percent of calories contributed by each nutrient. After calculating each day's values separately, the program averaged the results for the 3 days. These average values were used in the analyses.

Serum Lipids

Following overnight fasting, blood was collected at the home of the participants and delivered in ice for biochemical assays. Serum levels of cholesterol, HDL, LDL, and triglyceride were measured using standard laboratory techniques (30).

Data Analysis

Descriptive statistics (means, standard deviations, ranges, skewness, kurtosis, numbers, percents) were obtained for all study variables including, for the lipid data, separate statistics for females, males, Caucasians, African-Americans, and Hispanic-Americans. A Chi-square analysis was performed to determine the relationship between gender and race/ethnicity in the sample. For each dietary and serum lipid variable, the percent of persons whose value was out of the range recommended/desired by the National Cholesterol Education Program (31, 32) was calculated for the entire sample and for each gender and racial/ethnic group. Spearman rho correlational analyses were performed to determine (a) the relationship of the dietary and serum lipid levels with age and time since injury and (b) the relationship of the dietary lipids with the serum lipids. Nonparametric analyses were used because several of the lipid variables did not have normal distributions (skewness >1.0 and/or kurtosis >1.0).

To identify predictors (correlates) of lipid levels, separate stepwise multiple regression analyses were performed

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for the ranked data for each lipid variable. Criteria for entry were a probability for F to enter ≤ 0.050 and a probability for F to remove ≥.100. Ranked data for all continuous variables were utilized in these regression analyses because of the non-normal distributions of several of the variables. For dietary lipids, the potential predictors were gender, race, level and completeness of injury, rank of age, and rank of time since injury. Categorical variables were dummy coded for these analyses and omitted the two persons who were coded as "Other" for race/ethnicity.

For serum lipids, the potential predictors included those same demographic and injury-related variables as well as rank of dietary cholesterol, rank of amount of fat expressed as grams or as percent of total calories, and rank of amount of saturated fat expressed as grams or as percent of total calories. The regression analyses included only those persons for whom complete data were available for the particular analysis. For all analyses, the significance level was set at $p<0.05$.

RESULTS

Lipids

Mean dietary intake of cholesterol, total and saturated fat, and serum levels of cholesterol, HDL, LDL, and triglycerides are shown in **Table 2** for the total sample, females, males, Caucasians, African-Americans, and

Table 2.
Descriptive statistics for dietary and serum lipids

	N* = 189					
	Overall Mean (SD) range	**Female mean (SD) range**	**Male mean (SD) range**	**Caucasian mean (SD) range**	**African-American mean (SD) range**	**Hispanic-American mean (SD) range**
Dietary lipids						
Sample size	181	44	137	107	41	31
Cholesterol (mg)	273.28	244.92	282.40	245.86	314.99	308.12
	(154.78)	(163.01)	(151.53)	(131.58)	(174.91)	(187.39)
	21-728	69-695	21-728	61-711	69-694	21-728
Fat (g)	68.86	62.60	70.87	68.92	68.55	67.95
	(29.36)	(28.13)	(29.56)	(27.39)	(33.81)	(29.98)
	12-158	26-158	12-157	18-144	20-157	12-158
Fat (% of total calories)	36.67	36.47	36.74	36.18	38.78	35.76
	(7.58)	(9.32)	(6.97)	(7.55)	(6.70)	(8.63)
	12-60	12-60	15-53	12-55	25-53	19-60
Saturated fat (g)	23.40	20.82	24.22	23.20	23.76	23.17
	(10.72)	(9.10)	(11.09)	(10.25)	(12.42)	(9.59)
	4-56	9-50	4-56	6-55	7-56	4-50
Saturated fat (% of total calories)	12.44	12.26	12.50	12.11	13.40	12.40
Serum lipids						
Sample size	179	41	138	104	41	32
Cholesterol (mg/dl)	195.85	202.37	193.92	194.89	190.85	203.44
	(36.39)	(39.65)	(35.28)	(31.10)	(38.21)	(46.87)
	130-322	139-301	130-322	139-301	130-322	130-294
HDL (mg/dl)	46.21	54.21	43.74	45.86	47.49	45.69
	(11.71)	(13.33)	(9.97)	(12.44)	(10.25)	(11.59)
	22-91	31-91	22-68	22-91	23-70	25-72
LDL (mg/dl)	120.19	118.12	120.81	117.94	122.22	123.16
	(34.97)	(38.33)	(34.02)	(32.29)	(35.30)	(42.43)
	39-250	56-239	39-250	39-239	63-250	58-234
Triglycerides (mg/dl)	148.27	147.20	148.59	155.36	106.80	177.38
	(100.31)	(96.68)	(101.70)	(98.32)	(38.18)	(141.30)
	28-795	65-532	28-795	28-532	45-194	39-795

* Sample sizes vary because some participants ($n=8$) provided dietary information but their serum data were unavailable. For other participants ($n=10$), serum data were available but no dietary information was obtained. No LDL data were available for one Caucasian male. The percent of women across the racial/ethnic groups was not significantly different: Caucasian - 23.2%, African-American - 21.4%, and Hispanic-American - 27.3, Chi Square=0.366, p<.822.

Hispanic-Americans. Fat and saturated fat intake values are presented both as grams and as a percent of total calories.

Comparison with Recommended/desired Values

The values recommended/desired by the National Cholesterol Education Program (31, 32) are displayed in **Table 3**. The percent of participants whose values were out of the recommended/desired range for each lipid variable are presented for the total sample, females, males, Caucasians, African-Americans, and Hispanic-Americans. Fat and saturated fat as a percent of total calories are out of range for approximately 80 percent of the sample, and this is true for both genders and all racial/ethnic groups. Over one-third of the participants were out of range for dietary cholesterol, serum cholesterol, and LDL.

Relationship of Lipids to Age and Time Since Injury

As shown in **Table 4**, the relationship of dietary and serum lipids with age and time since injury were relatively weak. However, age was significantly related to serum cholesterol and triglycerides ($p<0.01$) and time since injury was related to saturated fat intake expressed as either grams or percent of total calories. Older persons tended to have higher serum cholesterol and higher triglyceride levels. Persons with longer times since injury consumed less saturated fat.

Table 3.
Percent of participants out of recommended/desired range

	Recommended/ desired amount*	Overall	Women	Men	Caucasian	African-American	Hispanic-American
Dietary lipids							
Cholesterol (mg)	<300 mg	35.4	25.0	38.7	29.9	41.5	41.9
Fat (% of total calories)	<30% of daily calories	82.9	75.0	85.4	81.3	92.7	74.2
Saturated fat (% of total calories)	<10% of daily calories	79.0	77.3	79.6	78.5	85.4	74.2
Serum lipids							
Cholesterol (mg/dl)	195.85	202.37	193.92	194.89	190.85	203.44	203.44
HDL (mg/dl)	46.21	54.21	43.74	45.86	47.49	45.69	45.69
LDL (mg/dl)	120.19	118.12	120.81	117.94	122.22	123.16	123.16
Triglycerides (mg/dl)	148.27	147.20	148.59	155.36	106.80	177.38	123.16

* National Cholesterol Education Program (31.32).

Table 4.
Spearman Rho correlation coefficients of dietary and serum lipids with age and time since injury

	Age	Time since injury
Dietary lipids		
Cholesterol (mg)	-0.08	-0.08
Fat (g)	-0.12	-0.14
Fat (% of total calories)	-0.10	-0.09
Saturated fat (g)	-0.16*	-0.21**
Saturated fat (% of total calories)	-0.15*	-0.20**
Serum lipids		
Cholesterol (mg/dl)	0.23**	0.08
HDL (mg/dl)	0.02	0.07
LDL (mg/dl)	.010	0.03
Triglycerides (mg/dl)	0.24**	-0.01

*$p<.05$, **$p<.01$

Relationship of Dietary Lipids to Serum Lipids

Displayed in **Table 5** are the correlation coefficients for the relationship between dietary and serum lipids. The correlations are very low, and none was significant at the $p<0.01$ level. Only the relationship between fat as a percent of total calories and triglycerides was significant at the $p<0.05$ level.

Predictors of Dietary Lipids

The results of the stepwise multiple regression analyses predicting the dietary lipid variables are presented in **Table 6**. It is important to mention that since this is a cross-sectional study, causal associations cannot be determined. Gender was predictive of dietary cholesterol levels. Women had lower dietary cholesterol levels than did men. No other variables were predictive of this dietary lipid. There was no significant predictor for dietary fat, whether expressed as grams or as a percent of

Table 5.
Spearman Rho correlations of dietary lipids with serum lipids

	Serum cholesteral	Serum HDL	Serum LDL	Serum triglycerides
Dietary lipids				
Cholesterol (mg)	0.04	0.02	0.11	-0.08
Fat (g)	0.09	0.02	0.09	-0.04
Fat (% of total calories)	-0.04	0.06	-0.01	-0.17*
Saturated fat (g)	0.09	0.05	0.09	-0.04
Saturated fat (% of total calories)	-0.03	0.08	-0.01	-0.10

**p<.05

Table 6.
Stepwise Multiple Regression Models for dietary lipids predicted by demographic and injury-related variables.*

Dependent variable	Predictor variables	Multiple R	Multiple R^2	Changes in R^2	β	p	Adjusted R^2
Rank of dietary cholesteral	Gender	0.156	0.024	0.024	0.156	0.04	0.019
Rank of fat (g)	No significant predictors						
Rank of fat (g) (% of total calories)	No significant predictors						
Rank of saturated fat (g)	Rank of time since injury	0.201	0.040	0.040	-0.201	0.01	0.035
Rank of saturated fat (% of total calories)	Rank of time sinceinjury	0.188	0.035	0.035	-0.188	0.01	0.030

*Potential predictors: gender, race/ethnicity (dummy coded as African-American and Hispanic), level and completeness of injury (dummy coded as tetraplegia (A, B, or C) and paraplegia (A, B or C)), rank of age, and rank of time since injury. The two male participants with "other" race/ethnicity were excluded from these analyses.

total calories. Saturated fat in grams and as a percent of total calories was related only to rank of time since onset. As noted above, persons who had lived with their SCI longer tended to have lower saturated fat intake. Although there were significant relationships between the demographic and injury-related information and some dietary lipids, no more than four percent of the variance in any of the dependent variables was accounted for by the predictors. Race/ethnicity, level and completeness of injury, and rank of age were not related to any of the dietary lipid variables.

Predictors of Serum Lipids

Displayed in **Table 7** are the results of the stepwise multiple regression analyses predicting the serum lipid variables. Rank of age and rank of saturated fat in grams were both significant predictors of rank of serum cholesterol. Rank of age accounted for 6.1 percent of the variance, and rank of saturated fat accounted for an additional 2.4 percent. Thus, a total of 8.5 percent of the variance was accounted for. Older persons had higher serum cholesterol levels and, after controlling for age, persons eating more saturated fat had higher serum cholesterol levels.

Gender was the only significant predictor for rank of HDL and accounted for 11 percent of the variance. Males had lower HDL levels. There were no significant predictors for rank of LDL. Three variables were found to be significant predictors of the rank of triglycerides—rank of age, being African-American or not, and rank of time since injury. Rank of age accounted for nearly 7 percent of the variance, being African-American or not accounted for an additional 5 percent, and rank of time since injury accounted for another 3 percent. A total of 14.5 percent of the variance was accounted for by these three variables. Older individuals, non-African-Americans, and those with less time since injury were more likely to have high triglyceride

Table 7.
Stepwise Multiple Regression Models for serum lipids predicted by demographic, injury-related, and dietary lipid variables*

Dependent variable	Predictor variables	Multiple *R*	Multiple R^2	Changes in R^2	β	*p*	Adjusted R^2
Rank of serum cholesteral	Rank of age	0.246	0.061	0.061	0.273	0.001	0.055
	Rank of saturated fat (g)	0.291	0.085	0.024	0.158	0.04	0.074
Rank of HDL	Gender	0.332	0.110	0.110	-0.332	0.001	0.105
Rank of LDL	No significant predictors						
Rank of triglycerides	Rank of age	0.257	0.066	0.066	0.325	0.001	0.061
	African-American	0.339	0.115	0.049	-0.238	0.003	0.104
	Rank of time since injury	0.381	0.145	0.030	-0.196	0.02	0.130

*Potential predictors: gender, race/ethnicity (dummy coded as African-American and Hispanic), level and completeness of injury (dummy coded as tetraplegia (A, B, or C) and paraplegia (A, B, or C)), rank of age, and rank of time since injury, rank of dietary colesteral, rank of fat (g), and rank of saturated fat (g). Similar results were obtained when rank of fat (% of total calories) and rank of saturated fat (% of total calories) were substituted for rank of fat (g) and rank of saturated fat (g), except that rank of saturated fat (% of total calories) did not enter the equation predicting rank of serum colesteral. The two male participants with "other" race/ethnicity were excluded from these analyses. For the analysis in which LDL was the dependent variable, the sample size was 168.

levels than those who were younger, African-American, and/or had more time since injury. It is noteworthy that, no more than 14.5 percent of the variance was accounted for in any serum lipid. Level and completeness of injury, rank of dietary cholesterol, rank of fat expressed as grams or percent of total calories, and rank of saturated fat expressed as percent of total calories were not predictive of any of the serum lipid variables.

DISCUSSION

A cross-sectional study of individuals with SCI indicated levels and correlates of their dietary and serum lipids.

Level of Dietary Lipids

Fat intake as a percent of total calories was about 37 percent compared to the recommended value of 30 percent. Similar results have been reported by Levine and colleagues for persons with SCI (28) and by Millen and colleagues for the general population (33). Intake of total and saturated fat were above the levels recommended by NCEP (31) for about 80 percent of participants. More than one-third of the participants had cholesterol intake above the recommended level of 300 mg. This was true for both genders and all racial/ethnic groups.

Predictors of Dietary Lipids

Women had lower dietary cholesterol than men. This is similar to the findings in the Framingham study of the general population (33). Persons with longer time since injury had lower saturated fat intake. To our knowledge, no previous studies have examined the relationship between time since onset of SCI and dietary lipid intake. The very small amount of variance accounted for in dietary lipids suggests that intake of lipids is related to several factors other than demographic and injury-related variables such as cultural differences in diet (34) and socio-economic factors (35).

Level of Serum Lipids

More than 40 percent of the participants were out of the desired range for serum cholesterol and over 30 percent for LDL (32). It is noteworthy that although mean serum levels of HDL were above the desired minimum of 35 mg/dl, 20 percent of the men with SCI in this study had a serum level of HDL below 35 mg/dl. This is twice the percentage (10 percent) of persons with low HDL in the general population (22). Depressed serum HDL in persons with SCI has been reported by previous investigators. In a study by Zlotolow and colleagues, approximately half of the veterans with paraplegia had values below 35mg/dl (24). Bauman et al. noted that about one-third of the persons with SCI in their study had serum HDL below 35mg/dl, compared to 12 percent for the aged-matched controls (22). This finding suggests that a larger proportion of men with SCI than those in the general population may be at risk for development of CHD due to reduced levels of HDL (22–25,32). In contrast, less than 5 percent of the women had an HDL level below the desired 35 mg/dl.

Only 7 percent of African-Americans with SCI had serum HDL below 35mg/dl compared to about 20 percent for Caucasians and Hispanic-Americans. Serum HDL levels have been reported in a number of studies to be higher in African-Americans than in other ethnic groups both in persons with SCI (22) and in the general population (36–38). Triglyceride levels were similar to the general population (33). Interestingly, in our study, no African-Americans had triglyceride levels above the desired range.

Predictors of Serum Lipids

Older persons and persons eating more saturated fat had higher serum cholesterol. Similar results have been reported for persons with SCI (39) and for the general population (5–8).

Triglyceride levels were predicted by age, race, and time since injury. Age was positively related to serum triglyceride levels. Matter, et al. (40) reported similar findings for adults in the general population. African-Americans had lower triglyceride levels in our sample, and this also was found by Bauman, et al. (22) for both SCI and age-matched controls. After controlling for age and race, persons with longer time since injury had lower triglyceride levels. As with saturated fat intake, to our knowledge, no other studies have reported the relationship between time since onset of SCI and triglycerides. Although, the percent of variance accounted for in three of the four serum lipids studied here was greater (8.5 percent to 14.5 percent) than the variance accounted for in dietary lipids, it was still relatively small. Other factors that may affect serum lipids may be genetic factors or activity levels (22,38, 41,42).

Limitations of this study include (a) food consumption diaries for 1 to 7 days, while frequently used (24, 28, 33), may not be the most accurate method of determining dietary intake, since they rely on self reports of, not only what was eaten, but also estimation of portion size; (b) a single measurement of serum lipids can provide reliable, but not optimal, results (43); and (c) all of the participants resided in a small geographic area in southeastern Texas, which may limit generalizability. However, financial and practical considerations made these choices the most viable for this study.

The implications of these findings include (a) there is a need for interventions to reduce the dietary and serum lipids of persons with SCI, particularly men; (b) studies are needed to determine what effect innovative nutritional education programs have on the lipid intake of persons with SCI; (c) studies are needed to determine what effect reduction of dietary lipids has on the serum lipids of persons with SCI; and (d) very long-term studies are needed to determine the relationship between serum lipids and later onset of CHD in persons with SCI .

Future studies should include age-matched controls, multiple blood samples for serum lipid measurement, cultural and socio-economic factors, genetic factors, activity levels, and medications. Interventional and longitudinal studies will be necessary to determine the complex role of dietary lipid intake and other factors in determining serum lipids in persons with SCI.

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