Research article

Dietary pattern as identified by factorial analysis and its association with lipid profile and fasting plasma glucose among Iranian individuals with spinal cord injury

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Objectives: Plasma lipids (triglyceride (TG), total cholesterol (TC), high-density lipoprotein (HDL-C) and low-density lipoprotein (LDL-C)) may be associated with dietary intakes. The purpose of this study was to identify the most common food patterns among Iranian persons with spinal cord injury (SCI) and investigate their associations with lipid profile.

Design: Cross-sectional.

Setting: Tertiary rehabilitation center.

Participants: Referred individuals to Brain and Spinal Injury Research Center (BASIR) from 2011 to 2014.

Outcome Measures: Dietary intakes were assessed by 24-hour dietary recall interviews in three non-consecutive days. Principal component analysis (PCA) was used to identify dietary patterns.

Results: Total of 100 persons (83 male and 17 female) entered the study. Four food patterns were detected. The most common dietary pattern (Pattern 1) included processed meat, sweets desserts and soft drink and was similar to 'Western' food pattern described previously. Pattern 1 was related to higher levels of TC and LDL-C ($r = 0.09$; $P = 0.04$ and $r = 0.11$; $P = 0.03$ for TC and LDL-C, respectively) only in male participants. Pattern 2 which included tea, nuts, vegetable oil and sugars had a positive association with TC level ($r = 0.11$; $P = 0.02$) again in male participants. Pattern 3 which represented a healthy food pattern showed no significant influence on lipid profiles.

Conclusion: In this study, the four most common dietary patterns among Iranian individuals with SCI have been identified. Western food pattern was the most common diet and was associated with increased TC and LDL-C. The healthy food pattern, in which the major source of calories was protein, was not associated with variance in lipid profile.

Keywords: Lipid, Triglyceride, Cholesterol, Spinal cord injury, Nutrition, Factor analysis

Introduction

Spinal cord injury (SCI) is one of the most important etiologies of immobility. The incidence of traumatic SCI varies among different nations. It is estimated that the annual incidence of SCI is approximately 40 cases per million population in the U.S. or approximately 12 500 new cases each year.[1] Iran has one of the highest rates of road accidents among the countries of the world[2] and subsequently, there is a high rate of SCI occurrence. Dyslipidemia has been reported to be very common at all body mass index categories in persons with SCI.[3] However, it has been shown that lipid profile seems to stabilize in the years after SCI rehabilitation.[4] The role of nutrition in developing dyslipidemia is well-known.[5–7] Moreover, among persons with SCI, other injury-related factors may also influence lipid profile. Altered body composition[8] and also the effect of the level of injury on the distribution of visceral and subcutaneous adipose tissue have been demonstrated so far.[9] These findings suggest that the correlation between nutrition, lipid profile and amount of

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adipose tissue may vary among individuals with SCI compared with able-bodied populations.

Dietary patterns and their association with levels of serum lipids have not yet been described in Iranian individuals with SCI. Since nutrition influences body composition through synergic interactions between foods,[10,11] isolating the particular effect of a single food or nutrient on a chronic disease is a major methodological problem, so it is more reliable to assess the effect of nutritional patterns and obtain the totality of dietary experiences. Many investigations propose the dietary pattern approach instead of focusing on a single nutrient.[12,13]

Variables in describing dietary patterns are numerous. In this regard, factor analysis is a variable consolidation technique which reduces information on frequency of food intake into 3 or 4 variables.[14] In fact the numerous range of foods which are obtained by food frequency questionnaires can be reduced to few major variables which present the dietary pattern in a specific study population.

The purpose of this study was to evaluate the dietary pattern identified by principle components factor analysis among Iranian individuals with SCI between May 2011 and May 2014 and the relationship between these food patterns with lipid profiles and blood glucose level were assessed.

Materials and methods

Study design

This study is a cross-sectional investigation designed for obtaining the dietary pattern of Iranian persons with SCI. The study was approved by ethics committee of Tehran University of Medical Sciences. Data was collected within three years from May 2011 to May 2014.

Study population

The initial participants of this study were persons with SCI who were referred to Brain and Spinal Injury Research Center (BASIR) from May 2011 to May 2014. Individuals with SCI were invited to participate in the investigation based on the following inclusion criteria: traumatic spinal cord injury and post injury duration longer than 1 year. We excluded those with time since injury of less than 1 year because of depressive mood-induced dietary changes which may occur mostly in the first year after injury.[15] Since depressive mood may influence nutritional intake and subsequently affect body composition, anthropometric measures and subsequently serum lipids and blood glucose, we evaluated only those who were medically stable after SCI. Exclusion criteria included pregnant or lactating women, amputation and non-traumatic SCI etiology. Individuals with a history of diabetes, cancer, endocrine disease, acute infection, use of special medications such as glucocorticoid, hormones, thyroid hormones, anticonvulsive drugs, heparin, aluminum containing antacids, lithium, blood glucose reducing agents, atorvastatin, Gemfibrozil (serum lipid reducing medications), omega-3 fatty acids or other nutrient supplements were also excluded. Those with a history of habitual smoking were excluded as well. After these exclusions, 100 persons remained in the analytic sample. A written consent in Farsi language was read and signed before enrollment in the study.

Dietary assessment

Dietary intakes were assessed by recording consumed foods in three non-consecutive days after enrollment.[16] Data was collected by 24-hour dietary recall interviews with participants and there was no regular time interval between these three days. This measurement tool has been validated, however it has been reported that the accuracy of dietary recall estimates may vary across subgroups of the population.[17] In this method, a list of foods are provided and participants indicate the number and size of food and beverage servings that they have consumed.[18,19] Daily intake of all food items was computed by Nutritionist IV 3.5.3. (N-Squared Computing, Salem, OR, USA) and then consumed foods were converted to grams using household measures.[20] These food items were collapsed into thirty-one pre-defined food groups based on the similarity of nutrients (see Supplementary Table available at http://dx.doi.org/10.1179/2045772314Y.0000000294).

Laboratory measurements

Blood samples were taken under antiseptic conditions from antecubital vein. Blood samples were collected and centrifuged at 3000 rpm for 10 minutes at 4 °C. Single session analysis was used to reduce inter-assay variation in serum samples. Samples were sent to the Endocrinology and Metabolism Research Center (EMRC) laboratory for analysis and were frozen immediately. Serum high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC) and total triglyceride (TG) were measured. Fasting plasma glucose (FPG) was measured as well. Body mass index (BMI) was calculated as body mass (in kilograms) divided by height (in meters) squared. Weight was measured using a digital wheelchair scale and body height was obtained by measuring the supine length. Systolic and diastolic blood pressures were measured by standard devices.

Neurological assessment

The level of spinal injury was determined by magnetic resonance imaging and neurologist confirmation. Completeness was classified as either complete (no preserved sensory or motor function) or incomplete (variable motor function preserved below the neurological level of injury).[21,22] Patients were classified according to American Spinal Cord Injury Association Scale (AIS)[23] in which AIS-A indicates complete injury with no preserved motor or sensory function below the neurological level. AIS-B describes incomplete injury in which only sensory function is preserved. AIS-C illustrates preserved motor function in which more than half of key muscles below the neurological level have a muscle grade <3. AIS-D indicates preserved motor function in which at least half of key muscles below the neurological level have a muscle grade of 3 or more.

Statistical analysis

Principal Component Analysis (PCA) with orthogonal transformation was used to identify major dietary patterns. PCA converts a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. This transformation is defined in such a way that the first principal component has the largest possible variance.[24] Labeling of derived factors was based on our interpretation of data. The factor score for each pattern was obtained by summing the intakes of food groups weighted by their factor loadings.[19,25] In fact factor scores were calculated by summing the frequency of consumption multiplied by factor loadings across all food items. All food quantities were converted to gram before factor analysis. Multivariate-adjusted means for primary outcome variables (serum lipid, glucose and blood pressure) were computed with adjustment for age. The comparison of means and percentages was performed using one-way analysis of variance (ANOVA) and χ^2 test, respectively. $P < 0.05$ was considered significant. All analysis was performed using SPSS Version 21 (IBM Corp. Armonk, NY, USA). PCA was performed with factor solution including food group components with eigenvalue higher than 2. The eigenvalue is the standardized variance associated with a particular factor. Eigenvalues measure the amount of variation in the total sample accounted for by each factor.[26] The factor score for each food pattern was found by summing intakes of food groups weighted by factor loading.[27] Varimax rotation with Kaiser Normalization was also performed. Factors were divided into five quintiles, in which the lowest and highest quintiles were presenting the lowest and the highest amount of consumption of that specific food pattern, respectively. The third quintile always contained the mean value of factor scores. After these classifications, ANOVA test could be performed to compare means of TG, TC, LDL-C, HDL-C, FBG, BP and weight between quintiles. Labeling of these food patterns was based on our own interpretation of data. A Scree test was performed to determine the number of factors retaining in a factor analysis. The Scree test involves plotting the eigenvalues in descending order of their magnitude. The break between the steep slope and a leveling off indicates the number of meaningful factors, different from random error.[28] Factors were divided in quintiles and were treated categorically. Multivariate analysis with general linear model with adjustment for age was performed to determine the relationship between derived factors (as categorical values) and quantitative variables (serum TG, TC, LDL-C, HDL-C, FPG, blood pressure, weight and BMI) and is presented for men and women separately. The interpretation of individual factor loadings was based on correlation coefficients in which the most positive values contribute most to the factor score, and the most negative values contribute least to the factor score. Factor scores were derived by Anderson-Rubin method. Anderson-Rubin factor scores are a modification of Bartlett scores to ensure orthogonality of the estimated factors. They have a mean of 0 and a standard deviation of 1.

The measured daily intake of calorie was also compared with required amount of calorie for each individual. Previously, Cox *et al.*[29] demonstrated that quadriplegics required 22.7 kcal/kg/day, and paraplegics 27.9 kcal/kg/day. We used these values to calculate the amount of required daily calorie. We calculated the mean differences between required calorie and measured calorie intake and compared them between people with tetraplegia and paraplegia.

Results

A total of 100 individuals with SCI (83 males and 17 females) participated in this investigation. Mean age was 41.0 ± 13.4 years old among men and 36.6 ± 9.4 among women. Mean of the time since injury was 12 ± 6 years in male participants and 15 ± 9 in females. There was no significant difference in age and post injury duration between men and women ($P = 0.20$ and 0.12, respectively). Most participants had paraplegia (84% of men and 100% of women). The most common AIS score was A (73% in men and 88% in women) and the most frequent injury level was at thoracic sections. Table 1 illustrates the baseline characteristics of participants with SCI. There was no

Table 1 Baseline characteristics and values of serum triglyceride, cholesterol, low density lipoprotein, high density lipoprotein, fasting plasma glucose, weight, body mass index and blood pressure in men and women with spinal cord injury. Values have been rounded to the nearest integer

		Men (n: 83)		Women (n: 17)		
Category		Mean (SD)	Frequency (percentage)	Mean (SD)	Frequency (percentage)	P-value
Age (year)		41 (13)		37 (9)		0.20
Time since injury (year)		12 (6)		15 (9)		0.12
Injury level	Cervical	–	21 (25.5%)	–	1 (6%)	0.20
	Thoracic	–	49 (59%)	–	13 (76.5%)	
	Lumbar	–	13 (15.5%)	–	3 (17.5%)	
AIS score	A	–	61 (73%)	–	15 (88%)	0.59
	B	–	9 (11%)	–	1 (6%)	
	C	–	4 (5%)	–	1 (6%)	
	D	–	9 (11%)	–	0 (0%)	
Plegia type	Paraplegia	–	70 (84%)	–	17 (100%)	0.07
	Tetraplegia	–	13 (16%)	–	0 (0%)	
Completeness of the injury	Complete	–	63 (76%)	–	15 (88%)	0.21
	Incomplete	–	20 (24%)	–	2 (12%)	
Triglyceride (mg/dl)		156 (66)	–	97(30)	–	0.001**
Cholesterol (mg/dl)		180 (36)	–	178 (25)	–	0.92
Low density lipoprotein (mg/dl)		103 (26)	–	101 (20)	–	0.81
High density lipoprotein (mg/dl)		42 (9)	–	52 (13)	–	< 0.0001**
Fasting plasma glucose (mg/dl)		100 (24)	–	82 (9)	–	0.12
Systolic blood pressure (mmHg)		118 (11)	–	113 (7)	–	0.09
Diastolic blood pressure (mmHg)		79 (6)	–	75 (6)	–	0.05
Weight (kg)		70 (14)	–	62 (13)	–	0.03*
Height (m)		1.7 (0.07)	–	1.6 (0.06)	–	< 0.0001**
Body mass index (kg/m^2)		24 (4)	–	25 (6)	–	0.25
Calorie intake (kcal)		1826 (553)		1413 (350)		0.004**
Protein intake (gr)		81 (26)		63 (16)		0.008**
Fat intake (gr)		67 (29)		70 (47)		0.75
Carbohydrate intake (gr)		237 (74)		172 (48)		0.001**

*Significance at level of P < 0.05.
**Significance at level of P < 0.01.

significant difference in injury level, AIS score and completeness of the injury between two sexes (P = 0.20, 0.59 and 0.21, respectively).

Mean daily intake of calorie was 1753 ± 545 kcal (1826 ± 553 kcal and 1413 ± 350 kcal in men and women, respectively). As expected, the amount of calorie intake per day was significantly higher in men (P = 0.004). However, the amount of fat intake was relatively similar among men and women (67 ± 29 gr and 70 ± 47 gr in men and women, respectively, P = 0.14). Daily intake consisted of 17.3% protein, 32.2% fat and 50.5% carbohydrate in men and 15% protein, 41.2% fat and 43.8% carbohydrate in women. Men consumed significantly higher amounts of carbohydrate and protein (P = 0.001 and 0.008, respectively) which demonstrates that the source of higher calorie intake is mainly provided through higher consumption of carbohydrate and protein (Table 1).

The required daily calorie intake was 1554 ± 283kcal and 1926 ± 409kcal in people with tetraplegia and paraplegia, respectively. As expected, the required daily calorie intake was lower among people with tetraplegia (P = 0.002). The daily intake of calorie was 1911 ± 417 kcal and 1729 ± 561 among individuals with tetraplegia and paraplegia, respectively (P = 0.26). Mean difference of calorie intake and required calorie was −195.3 kcal and 357.2 among people with tetraplegia and paraplegia, respectively (P = 0.005). The negative value of mean difference among people with paraplegia shows lower intake of calorie than the required amount. However, weight and BMI did not differ between people with paraplegia and tetraplegia (P = 0.89 and 0.68 for weight and BMI, respectively). No significant difference in the levels of TC, TG, LDL-C, HDL-C and FPG could be detected between people with paraplegia and tetraplegia (P = 0.39, 0.95, 0.28, 0.51 and 0.33, respectively).

Factor analysis detected 12 components with eigenvalue > 1 which accounted for 67.14% of the variance in intake. Obtaining 12 patterns from 31 food groups is not a proper dimension reduction. In order to come to a higher level of reduction in factors' dimensions, we considered factors with eigenvalue >2. In this analysis, PCA derived four factors which accounted for 31% of variance in intake. The factor-loading matrix for these dietary patterns is shown in Table 2. The most

Table 2 Factor loading matrix for the major dietary patterns in patients with spinal cord injury (values < 0.15 were excluded for simplicity)

	Pattern 1 (Western dietary pattern)	Pattern 2	Pattern 3 (Healthy dietary pattern)	Pattern 4
Processed meats	0.23	0.25	–	–
Red meats	0.25	–	–	–
Organ meats	–	–	–	0.15
Fish	–	–	–	–
Poultry	–	–	0.23	–
Egg	0.18	0.15	–	–
Butter	–	–	–	–
Low fat dairy product	–	–	–	0.25
High fat dairy product	–	–	–	–
Tee	–	0.19	–	–
Fruit	–	–	–	0.19
Fruit juice	–	–	–	0.31
Yellow vegetable	–	–	–	–
Green leafy vegetables	0.17	–	0.17	–
Tomatoes	–	–	0.24	–
Other vegetables	–	–	0.21	–
Legumes	–	–	–	–
Potatoes	–	–	–	–
French fries	0.15	–	–	0.33
Whole grains	–	–	–	–
Refined grains	0.11	–	0.22	–
Nuts	–	0.20	–	–
Mayonnaise	0.17	–	–	–
Sweet desserts	0.22	–	–	–
Animal Fat	–	–	–	–
Vegetable oil	–	0.30	–	–
Sugars	–	0.27	–	–
Condiments	–	–	–	0.21
Soft drinks	0.24	–	–	–
Yoghurt drink (dough)	–	–	0.20	–
Broth	–	–	–	–

common dietary pattern was Pattern 1, which accounted for 8.7% of variance in intake. This pattern included mostly processed meat, red meat, sweet desserts and soft drink. This pattern was labeled as ‘Western’ dietary pattern based on our own interpretation and previous study by Hue *et al.*[30] Pattern 2 included tea, nuts, vegetable oil and sugars and accounted for 8.3% of variance in intake. Pattern 3 consisted of poultry, vegetables, refined grains and yoghurt drink and accounted for 7% of variance in intake. Pattern 4 included low fat dairy product, fruits, fruit juice, French fries and condiments and accounted for 6.7% of variance in intake. Among these four food patterns, only Pattern 3 was considered healthy food pattern. Altogether these four factors accounted for 31% of total variance in intake.

The correlations between food pattern and lipid profile indices are presented for men and women separately and are adjusted for age as well. Total of 100 persons entered the investigation. Male participant were dominant (83%) and women consisted only 17% of participants (n: 17). Tables 3 and 4 present the values of TG, TC, LDL-C, HDL-C, FPG, weight and BMI in each factor quintile separately for men and women. Men had significantly higher TG level than women ($P = 0.001$) while cholesterol level did not show any significant difference between sexes. As expected, HDL-C was significantly higher among women ($P < 0.0001$) (Table 1). By considering these differences among sexes, we decided to present the data for men and women separately (Tables 3 and 4).

In male participants, Pattern 1 which included mostly processed meat, red meat, sweet desserts and soft drinks and also was the most common food pattern, had a significant positive relationship with TC and LDL-C level ($r = 0.09$; $P = 0.04$ and $r = 0.11$; $P = 0.03$ for TC and LDL-C, respectively) (Table 3). In fact, it seems that this food pattern can contribute to increase TC and LDL-C in male individuals. No such a relationship was observed among females ($P = 0.64$ and 0.63 for TC and LDL-C, respectively). Pattern 1 had a significant negative relationship with age ($r = -0.37$; $P = 0.001$) which shows that the consumption of mentioned food groups in pattern-1 decreases through time with increased age. Pattern 2 which included tea, nuts, vegetable oil and sugars had a positive association with TC level ($r = 0.11$; $P = 0.02$) only among males. Pattern 3 which was the only factor representing

Table 3 Relationship between quintiles of dietary pattern and serum triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HD), fasting plasma glucose (FPG), weight, body mass index (BMI) and blood pressure (BP) in male patients with spinal cord injury. Mean values ± standard deviations in each quintile have been illustrated. Values have been rounded to the nearest integer

Pattern		Age (Year)	TG (mg/dl)	Chol (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	FPG (mg/dl)	Systolic BP (mmHg)	Diastolic BP (mmHg)	Weight (kg)	BMI (kg/m^2)
Pattern 1	Q1	48 ± 11	180 ± 88	168 ± 32	39 ± 13	92 ± 22	92 ± 23	121 ± 10	81 ± 7	73 ± 17	25 ± 4
	Q3	44 ± 16	150 ± 60	175 ± 32	42 ± 10	100 ± 23	103 ± 46	115 ± 15	75 ± 6	70 ± 15	23 ± 4
	Q5	35 ± 11	140 ± 44	189 ± 37	44 ± 8	110 ± 26	85 ± 15	122 ± 10	82 ± 6	69 ± 14	22 ± 3
	P*	0.001	0.61	0.04	0.39	0.03	0.75	0.30	0.08	0.96	0.28
Pattern 2	Q1	40 ± 16	168 ± 82	168 ± 25	39 ± 9	94 ± 30	97 ± 43	121 ± 7	81 ± 7	68 ± 15	23 ± 4
	Q3	48 ± 12	144 ± 57	170 ± 42	46 ± 9	109 ± 28	89 ± 10	120 ± 11	79 ± 6	72 ± 16	24 ± 4
	Q5	38 ± 12	150 ± 61	191 ± 37	40 ± 8	97 ± 18	97 ± 24	120 ± 8	78 ± 5	97 ± 24	24 ± 3
	P*	0.89	0.56	0.02	0.11	0.07	0.54	0.28	0.76	0.96	0.35
Pattern 3	Q1	44 ± 12	157 ± 77	182 ± 37	42 ± 9	105 ± 27	98 ± 40	117 ± 12	80 ± 5	68 ± 9	23 ± 3
	Q3	45 ± 13	142 ± 53	187 ± 39	46 ± 8	105 ± 28	97 ± 22	117 ± 13	76 ± 6	67 ± 16	23 ± 4
	Q5	42 ± 14	187 ± 84	181 ± 34	39 ± 10	104 ± 25	90 ± 23	118 ± 11	78 ± 7	74 ± 16	25 ± 4
	P*	0.24	0.29	0.12	0.32	0.21	0.43	0.85	0.38	0.62	0.38
Pattern 4	Q1	36 ± 14	163 ± 85	174 ± 37	42 ± 12	98 ± 26	88 ± 10	118 ± 7	77 ± 5	66 ± 11	23 ± 3
	Q3	41 ± 15	181 ± 70	190 ± 38	42 ± 10	111 ± 28	95 ± 42	114 ± 13	79 ± 6	70 ± 13	23 ± 4
	Q5	39 ± 10	154 ± 61	170 ± 39	42 ± 10	94 ± 28	84 ± 7	117 ± 10	81 ± 6	69 ± 14	23 ± 4
	P*	0.25	0.43	0.06	0.82	0.06	0.74	0.29	0.56	0.39	0.52

*P-values stands for multivariate analysis with general linear model controlled for age. P-values of the relationships between age and derived factors are not adjusted.

r = −0.37.

r = 0.09.

β r = 0.11.

ββ r = 0.11.

healthy food pattern showed no association with levels of TG, TC, LDL-C, HDL-C ,FPG, blood pressure and weight (Tables 3 and 4). Although this food pattern was considered healthy, it seems it has insufficient effect on decreasing TG, TC, LDL-C and weight and also an inadequate effect in increasing HDL-C. Weight and BMI were not affected by any of the food patterns. No association between these four food patterns and blood pressure was detected either (P = 0.30, 0.76, 0.38 and 0.56 for the association between systolic BP and patterns 1,2,3 and 4 respectively in men and P = 0.51, 0.86, 0.27 and 0.39, respectively in

Table 4 Relationship between quintiles of dietary pattern and serum triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HD), fasting plasma glucose (FPG), weight, body mass index (BMI) and blood pressure (BP) in female patients with spinal cord injury. Mean values ± standard deviations in each quintile have been illustrated. Values have been rounded to the nearest integer

Pattern		Age (Year)	TG (mg/dl)	Chol (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	FPG (mg/dl)	Systolic BP (mmHg)	Diastolic BP (mmHg)	Weight (kg)	BMI (kg/m^2)
Pattern 1	Q1	38 ± 16	90 ± 15	188 ± 12	50 ± 12	106 ± 4	86 ± 6	116 ± 11	76 ± 5	59 ± 13	24 ± 5
	Q3	32 ± 5	87 ± 21	183 ± 42	57 ± 16	106 ± 34	80 ± 8	114 ± 5	78 ± 4	58 ± 11	23 ± 3
	Q5	40	77	152	54	74	81	110	70	69	28
	P*	0.46	0.72	0.64	0.98	0.63	0.14	0.51	0.57	0.55	0.34
Pattern 2	Q1	24	70	131	39	73	84	110	80	72	26
	Q3	38 ± 2	106 ± 52	178 ± 24	62 ± 8	93 ± 16	80 ± 7	113 ± 5	76 ± 5	60 ± 8	26 ± 2
	Q5	34 ± 2	112 ± 41	171 ± 15	47 ± 16	102 ± 12	84 ± 16	110 ± 14	75 ± 7	51 ± 6	21 ± 3
	P*	0.16	0.83	0.44	0.72	0.68	0.36	0.86	0.85	0.30	0.49
Pattern 3	Q1	46	86	185	59	98	78	116 ± 5	78 ± 4	64	27
	Q3	35 ± 3	112 ± 35	186 ± 26	48 ± 15	114 ± 24	81 ± 14	106 ± 5	73 ± 5	59 ± 26	25 ± 13
	Q5	45 ± 19	97 ± 28	165 ± 30	42 ± 4	94 ± 19	89 ± 8	116 ± 11	73 ± 11	73 ± 1	26 ± 2
	P*	0.10	0.72	0.25	0.45	0.59	0.05	0.27	0.59	0.61	0.87
Pattern 4	Q1	35 ± 5	112 ± 4	183 ± 30	52 ± 16	107 ± 15	80 ± 12	116 ± 5	78 ± 4	66 ± 17	27 ± 8
	Q3	31 ± 6	87 ± 25	181 ± 44	52 ± 12	107 ± 36	81 ± 8	110	80	55 ± 16	23 ± 5
	Q5	57	125	177	42	99	98	110	60	72	25
	P*	0.43	0.69	0.20	0.48	0.56	0.06	0.39	0.59	0.61	0.87

*P-values stands for multivariate analysis with general linear model controlled for age. P-values of the relationships between age and derived factors are not adjusted.

Table 5 P-values of the relationships between dietary patterns and spinal cord injury characteristics and dietary components

Category	Pattern 1	Pattern 2	Pattern 3	Pattern 4
Injury duration	0.20	0.34	0.87	0.73
Injury level	0.82	0.07	0.69	0.39
AIS score	0.63	0.16	0.19	0.44
Completeness of the injury	0.42	0.11	0.61	0.28
Plegia type	0.06	0.10	0.21	0.84
Protein intake	0.005 ($r = 0.28$)**	0.06	0.008 ($r = 0.24$)**	0.02 ($r = 0.23$)*
Fat intake	< 0.0001 ($r = 0.37$)**	0.02 ($r = 0.22$)*	0.06	0.43
Carbohydrate intake	< 0.0001 ($r = 0.42$)**	0.32	0.18	< 0.0001 ($r = 37$)**

*Significance at level of $P < 0.05$.
**Significance at level of $P < 0.01$.

women). FPG was not also related to these four patterns ($P = 0.75$, 0.54, 0.43 ad 0.74 for patterns 1, 2, 3 and 4, respectively in men and $P = 0.14$, 0.36, 0.05 and 0.06, respectively in women). This analysis shows that current food patterns which can commonly be observed among persons with SCI had no effect in modulating serum lipids, glucose and body mass.

Calorie intake in Pattern 1 (Western pattern) was provided through consumption of all three components of protein, fat and carbohydrate ($r = 28$; $P = 0.005$, $r = 0.37$; $P < 0.0001$ and $r = 0.42$; $P < 0.0001$ for protein, fat and carbohydrate, respectively). However the main source of calories in Pattern 2 was fat ($r = 0.22$; $P = 0.02$) and in Pattern 3 (healthy pattern) was protein ($r = 0.26$; $P = 0.008$). The main source of calorie in Pattern 4 was protein and carbohydrate ($r = 0.23$; $P = 0.02$ and $r = 0.37$; $P < 0.0001$, respectively) (Table 5).

Injury level, AIS score, completeness of the injury and plegia type were not related to any of these dietary patterns (Table 5).

Discussion

Our analysis revealed four dietary patterns using principal component analysis among individuals with SCI. The most common food pattern mostly included processed meat, red meat, sweet desserts and soft drink and was associated with increased cholesterol and LDL-C among males with SCI. Unlike reports in other populations,[18,31] healthy food pattern (Pattern 3) had no effect on serum lipids, body mass, blood pressure and plasma glucose in persons with SCI.

Newby *et al.*[31] showed that healthy food pattern which is rich in low-fat dairy products, cereal, fruit, fruit juice, nuts and seeds, whole grains, and beans and legumes was inversely related with waist circumstances in healthy men and women and had a negative relationship with BMI changes only in females but our study showed that a healthy diet rich in poultry, vegetables, refined grains and yoghurt drink (Pattern 3 derived by factor analysis) had no effect on weight and BMI among persons with SCI. One of the most considerable differences between our study and Newby *et al.*[31] report is the difference in the investigated population. Since Newby *et al.* investigated healthy subjects who are known to have higher level of physical activity compared with people with SCI. In SCI, immobility restricts body movements significantly and physical activity may contribute to emergence of such differences between results among individuals with SCI and normal healthy subjects in Newby's report.

The healthy food pattern which was derived from our analysis has some differences from healthy food pattern described by Newby *et al.*,[31] because in our study, legumes, nuts, low-fat dairy products and fruit juices play a trivial role in construction of this food pattern. The healthy food pattern derived in the present study has some similarities with 'prudent' food pattern described by Slattery *et al.*,[32] which is rich in fiber and folate. In both patterns have high positive factor loading score for vegetables and poultry. The western dietary pattern described by Hu *et al.*[30] has similarity with food pattern 1 in our study and both patterns are rich in processed meat, red meat, French fries, refined grains, sweets and desserts. Hue *et al.*[30] showed that "Western" dietary pattern is associated with increased risk of coronary heart disease which is in line with our finding that shows the potential effect of this dietary pattern in increasing total cholesterol and LDL-C. Similarly, Fung *et al.* [33] showed that "prudent" dietary pattern in comparison with "Western" dietary pattern is associated with lower risk of coronary heart diseases in women. Although our study did not show the same results in females with SCI, western dietary pattern was associated with increased cholesterol and LDL-C in men. This finding shows that men are more susceptible to dietary-induced increased serum lipids than women. However, the low number of female participants with SCI in our study is a noticeable issue that should be considered and subsequently, results in females should be interpreted and compared cautiously.

Western dietary pattern in Esmaillzade's study[18] led to increased FPG among Iranian women but our investigation did not show such a relationship among Iranian individuals with SCI. The Western food pattern had no effect on body mass and levels of HDL-C, FPG and blood pressure as well.

Sex-dependent effects of food patterns on BMI has been previously reported.[34,35] However, our results did not reveal any association between common food patterns and body mass among Iranian men and women with SCI. In this regard, Newby *et al.*[31] and Foote *et al.*[36] suggested that a healthy food pattern is part of a general healthy life style (associated with many factors such as being non-smoker, taking supplements and etc.). In fact, there are many potential confounders (like socioeconomic factors and life style components) that affect the association between dietary patterns and BMI. Future studies with consideration of these factors can help to understand the association between common dietary patterns among Iranian individuals with SCI and changes in body mass more conclusively.

Previously, we investigated the calorie and macro nutrient intake in Iranian people with SCI.[16] according to our previous study, the percentages of total energy intake derived from macronutrients were 53% carbohydrate, 10% protein, and 37% fat for men and 52% carbohydrate, 11% protein, and 39% fat for women. The total intake of energy was reduced through time when age and time since injury increased which is in line with our present findings on the association between western food pattern (Pattern 1) and age. The Western food pattern contain high fat components like French fries, processed meats and mayonnaise and also includes considerable amount of sweet desserts and soft drink. Generally, this food pattern can present a high-calorie intake diet. We found an inverse relationship between age and western food pattern (high calorie intake) which is in consistency with our previous study.[16] Moreover, our present study shows that daily intake of calorie among people with tetraplegia is higher than the required amount. Although people with tetraplegia showed no difference in weight, BMI and lipid profile compared with people with paraplegia, this finding suggests that dietary modifications should be considered to balance the calorie intake of these individuals according to the required amount.

In this study, the exact amount of provided calorie by each dietary pattern could not be measured because these patterns are defined by factor scores which demonstrate the components that contribute the most in the content of a diet and therefore measurement of exact amount of calorie intake is not possible. However, a method similar to that found in Newby *et al.*[31] for the measurement of correlation coefficient between dietary patterns and food components can clarify the main contents of the pattern and subsequently, the main source of calorie. Our result showed that healthy pattern (Pattern 3), in which the main source of calorie was protein, could not have any noticeable effect on lipid profile and serum glucose. In Patterns 1 and 2 intake of fat was a major component in providing daily calorie (Table 5) and these two patterns were related to increased total cholesterol levels in male individuals with SCI. However their effect on TG was insignificant. In Pattern 4 in which major components were protein and carbohydrates, no significant effect on serum lipids and glucose could be detected. These data propose that consumption of foods rich in fat content tend to increase cholesterol more than foods rich in carbohydrate content. Moreover, a healthy dietary pattern rich in protein content seems to be inadequate for improvement of lipid profile and when decreasing serums lipids is a major clinical goal, dietary modifications should be accompanied with other alternative interventions.

Our investigation showed no association between dietary patterns and injury characteristics. One explanation can be that individuals with SCI, regardless of their injury level and dependence, eat mostly similarly with their family. Here we think that families' socioeconomic status and traditional cultures may play a more important role in the content of their diets rather than injury characteristics. Further investigations should be performed to clarify the factors that affect dietary patterns among people with SCI.

Study limitation

In this study, anthropometric characteristics such as circumstances of waist and hip, volume of abdominal subcutaneous fat tissue and body composition were not measured. Future studies should be designed to evaluate the effect of dietary patterns on anthropometric measures among individuals with SCI. Investigating life style and estimating the level of physical activity may enlighten the association between dietary patterns and anthropometric measures more precisely. Using 24-hour dietary recall interviews in three non-consecutive days is another limitation of this study since this method may overestimate the calorie intake. Further investigations by using 7-days dietary recalls are recommended. Moreover, the amount of total energy expenditure and basal metabolic expenditure are not measured in this study. Further investigation with measuring total energy expenditure are required to identify the exact needed amount of calorie intake for Iranian individuals with SCI and may help to modify dietary patterns of these people based on their requirements.

Conclusion

The present study investigated the common food patterns among Iranian individuals with SCI and its association with lipid profile and plasma glucose. Four food patterns were derived using principle component analysis. The Western food pattern (Pattern 1) which included mostly processed meat, French fries, sweet desserts and soft drinks was associated with increased levels in serum LDL-C in male participants. The healthy food pattern (Pattern 3) did not influence on serum lipids, FPG, blood pressure and body mass. No association between these four food patterns and BMI, blood pressure and FPG could be detected.

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