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Cardiometabolic risk factors in Iranians with spinal cord injury: Analysis by injury-related variables

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Abstract—Persons with spinal cord injury (SCI) have a high prevalence of abnormalities in carbohydrate and lipid metabolism. These abnormalities cause adverse coronary heart disease (CHD) in patients with SCI. In this study, we performed a detailed analysis of the level-specific cardiometabolic risk factors in individuals with SCI and analyzed the association of injury level on these risk factors. This was a cross-sectional study of 162 patients with SCI, assessing the prevalence of diabetes mellitus, dyslipidemia, hypertension, obesity, and smoking. Fasting blood sugar (>100) was diagnosed in 27 patients (16.7%). Of the total patients, 36 (22.2%) had a total cholesterol (TC) level of >200. A triglyceride level of >150 was present in 56 patients (34.6%). Hypertension was present in 2.5% of the entire patient group. Body mass index (BMI), TC, and low-density lipoprotein cholesterol (LDL-C) were significantly higher in the paraplegia group than the tetraplegia group (24.44 +/– 4.23 vs 22.65 +/– 4.27, $p = 0.01$; 185.71 +/– 40.69 vs 163.28 +/– 37.92, $p < 0.001$; and 102.51 +/– 28.20 vs 89.15 +/– 22.35, $p = 0.01$, respectively). Patients with paraplegia may have increased hypertension, higher BMI, and increasing levels of serum LDL-C and TC than those with tetraplegia. Conventional risk factors for CHD should be identified and treated in individuals with SCI.

Key words: body mass index, cardiometabolic risk factors, cholesterol, coronary heart disease, fasting blood sugar, hypertension, lipid profile, paraplegia, spinal cord injury, tetraplegia.

INTRODUCTION

Spinal cord injury (SCI) predisposes an individual to medical complications such as obesity, lipid abnormalities, carbohydrate intolerance, and an atherogenic pattern for coronary heart disease (CHD) [1]. Cardiometabolic syndrome is defined through a clustering of cardiovascular risk factors, identified as overweight/obesity, dyslipidemia, hypertension, and insulin resistance [2–3]. It is also thought to better characterize cardiovascular disease (CVD) and endocrine risks [4].

Abbreviations: BASIR = Brain and Spinal Injury Research, BMI = body mass index, BP = blood pressure, CHD = coronary heart disease, CVD = cardiovascular disease, DM = diabetes mellitus, FBS = fasting blood sugar, HDL-C = high-density lipoprotein cholesterol, IGT = impaired glucose tolerance, LDL-C = low-density lipoprotein cholesterol, SBP = systolic blood pressure, SCI = spinal cord injury, TC = total cholesterol, TG = tryglyceride, WC = waist circumference.

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Because of their relative inactivity and adverse body composition changes [5–6], persons with SCI are predisposed to increased rates of impaired glucose tolerance (IGT), insulin resistance and diabetes mellitus (DM) [7], reduced high-density lipoprotein cholesterol (HDL-C) (20%–42% lower than in nondisabled persons) [8–9], high low-density lipoprotein cholesterol (LDL-C) [8–10], and increased serum triglyceride (TG) (6%–60% higher than in nondisabled persons) [6,8–9].

Increased mortality risk may be due to SCI-specific changes in body composition [6]. Persons with SCI have significantly less fat-free mass and greater fat mass than nondisabled persons [6]. Despite altered body composition, body mass index (BMI) has been a poor and inconsistent predictor of CHD in persons with SCI [11].

Although CVD is a leading cause of death in the population with SCI, an inverse relationship exists between the level of injury and CHD [12], possibly due to relative hypotension. To reduce cardiovascular-related morbidity and mortality, it is important to understand any possible differences in other cardiometabolic risk factors related to the level and completeness of injury. Also, Iranian patients with SCI have very low physical activity levels and poor dietary intake [13]. To our knowledge, a detailed analysis of all cardiometabolic risk factors that also examines the effects of level of injury has yet to be undertaken among patients with SCI. In this study, we analyzed cardiometabolic risk factors in individuals with SCI based on injury-related factors.

MATERIALS AND METHODS

Study Population

In this cross-sectional study, we assessed 162 patients with SCI from May 2008 to June 2009. Data were collected from patients with SCI referred to the Brain and Spinal Injury Research (BASIR) Center at the Tehran University of Medical Sciences during a 1 h face-to-face interview. Individuals were included in the study according to the following criteria: motor complete injury between cervical level 5 and thoracic level 12, ≥18 yr old, and >1 yr postinjury. Exclusion criteria included pregnancy; lactation; amputation; nontraumatic SCI etiology; history of DM; active decubitus ulcer; thyroid, hepatic, or renal disorders; and neurological disorders other than SCI. The level and completeness of lesion were classified as proposed by Kirshblum et al. [14].

Anthropometric Measurements

Trained research assistants completed all anthropometric measurements. Each measurement was performed twice and averaged if the individual measurement differed by ≤5 percent. If the difference was >5 percent, a third measurement was performed and the two closest measures were averaged. Height and weight were measured, and BMI was calculated using body weight/height squared (kg/m^2). Waist circumference (WC) was measured at the level of the lowest rib and classified based on standard classification (male: >102 cm, female: >88 cm) [15]. Blood pressure (BP) was measured on the right arm in the sitting position after a 5 min rest by auscultation using a stethoscope twice (6 h interval), and the mean of these was used.

Assessment of Dietary Intake

A detailed description of the dietary intake assessment has been published in two previous research studies [13,16].

Laboratory Measurements

Antecubital venous blood samples were taken under antiseptic conditions in the postabsorptive state after an overnight (12 h) fast. Venous blood samples were collected in empty vacutainer tubes with the exception of those for glucose, which contained anticoagulant. All specimens were centrifuged within 30 to 45 min after collection at 3,000 rotations per minute. Glucose was measured using the glucose oxydase method using a Pars Azmoon kit (Teif Azmoon Pars Co; Tehran, Iran) [17]. Total cholesterol (TC) [15], HDL-C, and TG levels [18] were determined using an enzymatic colorimetric test (Pars Azmoon kit). LDL-C values were determined using the Friedewald equation [19].

Major risk factors for CHD were determined using the criteria established by the Executive Summary of the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) [20].

Statistical Analyses

The results are reported as mean ± standard deviation. The limits of statistical significance was $p < 0.05$. After evaluating the normality of data using a one-sample Kolmogorov-Smirnov test, numerical variables were compared with a Student *t*-test. Discrete values were compared with a chi-squared test. Correlations were computed between the duration of injury and individual CVD risk factors using Pearson and Spearman correlation coefficients for normally and non-normally distributed data, respectively. Linear regression analysis was performed for detecting predictor factors for serum profile. The statistical analysis was performed using SPSS for Windows version 16.0 (IBM Corporation; Armonk, New York).

RESULTS

A total of 162 patients with SCI participated in the study; **Table 1** shows their characteristics. **Table 2** presents anthropometric and biochemical data of the patients [21–24]. According to Laughton et al. [21], since a BMI score of >22 is overweight and >25 is obese, 62.96 (n = 102) and 32.71 (n = 53) percent of the patients in this study were classified as overweight and obese, respectively.

Table 3 compares mean ± standard deviation for cardiometabolic risk factors in tetraplegic and paraplegic and complete and incomplete groups. BMI, TC, and LDL-C were significantly higher in the paraplegia group than in the tetraplegia group (**Table 3**). Systolic BP (SBP) was significantly higher in the complete lesion group of patients (**Table 3**).

Time postinjury was correlated directly with WC (p = 0.04, r = 0.16). There was no correlation between time postinjury and other cardiometabolic risk factors.

Table 1.
Participant characteristics (n = 162).

Characteristic	n (%) or Mean ± SD
Sex	
Male	131 (80.9)
Female	31 (19.1)
Duration of SCI (yr)	8.03 ± 5.75
Level of SCI	
Paraplegia	68 (42.0)
Tetraplegia	94 (58.0)
Completeness of Lesion	
Complete	48 (29.6)
Incomplete	114 (70.4)
Age (yr)	34.17 ± 8.75
Weight (kg)	70.08 ± 13.40
Height (cm)	173.18 ± 9.14
Smoker	44 (27.2)

SCI = spinal cord injury, SD = standard deviation.

BMI was directly correlated with SBP (p < 0.001, r = 0.27), serum TG level (p < 0.001, r = 0.37), serum TC level (p < 0.001, r = 0.28), serum LDL-C level (p < 0.001, r = 0.29), and WC (p < 0.001, r = 0.68). BMI showed inverse correlation with HDL-C (p = 0.01, r = –0.24). LDL-C was correlated with SBP (p = 0.01, r = 0.19), and HDL-C showed inverse correlation with diastolic BP (p = 0.02, r = –0.17). The lipid profiles did not show any correlation with the neurological level of SCI and completeness of lesions. Fasting blood sugar (FBS) was directly correlated with education (p = 0.01, r = 0.23).

Hypertension was more frequent in the patients with paraplegia than in those with tetraplegia (4.4% vs 1.1%), and the percentage of patients ≥45 yr old was also greater in those with tetraplegia than those with paraplegia (16.9% vs 10.5%). Patients with tetraplegia smoked more (28 vs 16) and had lower HDL-C (67.0% vs 60.3%) than those with paraplegia, but the difference was not statistically significant. **Table 4** presents the correlation coefficients between dietary intake and lipid profile of patients with SCI.

DISCUSSION

IGT and DM occur more frequently in persons with SCI than in the nondisabled population [25–26]. Similar to our previous two studies, approximately 13.58 and 3.58 percent of our patients had DM and IGT, respectively [13,16]. Duckworth et al. reported a higher prevalence of DM and IGT (23% and 40%, respectively) [27]. Studies have shown that the prevalence of IGT and DM are higher in the United States than in countries such as Iran [28–29]; this can also be generalized to subgroups such as patients with SCI.

In our study, 32.7 percent of the patients with SCI were relatively obese. In Demirel et al., patients with SCI had a prevalence of 10 percent for obesity, described as a BMI score >30 [8]. Mean BMI values in the studies of persons with long-standing SCI ranged from 20 to 27 [6,8,30]. In another study performed at the BASIR Center [16], 20 percent of the patients with SCI had central obesity according to the World Health Organization, significantly in patients with higher age and more time postinjury. There was also a significant positive relationship between the level of injury and BMI, as well as between WC and age and time postinjury.

Table 2.
Cardiometabolic risk factors in patients with spinal cord injury.

Risk Factor and Defining Levels	Mean ± SD	Frequency (%)	Population Not Meeting Normal Defining Level (%)
Body Mass Index [21]	23.4 ± 4.3	—	—
<22 (overweight)	—	—	102 (62.9)
<25 (obese)	—	—	53 (32.7)
Waist Circumference (cm) [22]	86.5 ± 12.4	—	—
<102 (male)	—	—	16 (12.2)
<88 (female)	—	—	9 (29.0)
Systolic Blood Pressure (≤120 mm Hg) [22]	113.0 ± 9.4	—	20 (12.3)
Diastolic Blood Pressure (≤80 mm Hg) [22]	70.7 ± 7.6	—	—
Fasting Blood Sugar (mg/dL) [23]	92.6 ± 27.1	—	27 (16.7)
<100 (normal)	—	135 (83.3)	—
100–125 (impaired)	—	22 (13.6)	—
≥126 (diabetes mellitus)	—	5 (3.1)	—
Total Cholesterol (mg/dL) [24]	172.6 ± 40.5	—	36 (22.2)
<200 (desirable)	—	125 (77.2)	—
200–239 (borderline high)	—	29 (17.9)	—
≥240 (high)	—	8 (4.9)	—
Triglyceride (mg/dL) [24]	145.7 ± 90.4	—	56 (34.6)
<150 (normal)	—	106 (65.4)	—
150–199 (borderline high)	—	25 (15.4)	—
200–499 (high)	—	30 (18.5)	—
≥500 (very high)	—	1 (0.6)	—
HDL-C (mg/dL) [24]	36.7 ± 8.5	—	—
>40 (male)	—	—	94 (71.8)
>50 (female)	—	—	10 (32.3)
LDL-C (mg/dL) [24]	94.7 ± 25.7	—	65 (40.1)
<100 (optimal)	—	97 (59.9)	—
100–129 (near optimal)	—	53 (32.7)	—
130–159 (borderline high)	—	8 (4.9)	—
160–189 (high)	—	3 (1.9)	—
≥190 (very high)	—	1 (0.6)	—

HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, SD = standard deviation.

Table 3.
Cardiometabolic risk factors (mean ± standard deviation) in tetraplegic and paraplegic and complete and incomplete groups of patients with spinal cord injury.

Risk Factor	Tetraplegic (*n* = 94)	Paraplegic (*n* = 68)	*p*-Value*	Complete (*n* = 48)	Incomplete (*n* = 114)	*p*-Value*
Age (yr)	34.35 ± 8.82	33.91 ± 8.71	0.75	33.21 ± 9.44	34.57 ± 8.46	0.36
SBP (mm Hg)	112.35 ± 8.90	114.06 ± 10.24	0.26	115.90 ± 10.29	111.88 ± 8.92	0.01
DBP (mm Hg)	70.53 ± 7.79	70.99 ± 7.60	0.71	71.67 ± 7.81	70.32 ± 7.64	0.31
BMI	22.65 ± 4.27	24.44 ± 4.23	0.01	24.33 ± 4.77	23.01 ± 4.09	0.07
WC (cm)	86.07 ± 13.78	87.10 ± 10.32	0.58	88.75 ± 13.81	85.56 ± 11.72	0.13
Biochemistry						
FBS (mg/dL)	92.05 ± 13.07	93.46 ± 39.19	0.74	96.90 ± 46.51	90.85 ± 11.88	0.37
TC (mg/dL)	163.28 ± 37.92	185.71 ± 40.69	<0.001	172.58 ± 43.68	172.74 ± 39.34	0.98
TG (mg/dL)	136.77 ± 76.22	158.15 ± 106.46	0.16	151.23 ± 83.76	143.43 ± 93.41	0.61
HDL-C (mg/dL)	36.19 ± 8.88	37.57 ± 8.18	0.31	37.69 ± 8.45	36.39 ± 8.66	0.38
LDL-C (mg/dL)	89.15 ± 22.35	102.51 ± 28.20	0.01	92.90 ± 20.47	95.54 ± 27.72	0.55

*Independent sample *t*-test.

BMI = body mass index, DBP = diastolic blood pressure, FBS = fasting blood sugar, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride, WC = waist circumference.

Table 4.
Correlation between dietary intake and lipid profile of patients with spinal cord injury.

Dietary Intake	LDL-C	HDL-C	TG	TC	FBS
Total Energy (kcal)	–0.007	0.027	0.065	0.143	0.133
Carbohydrate (g)	0.028	–0.008	0.091	0.148	0.094
Fat (g)	–0.084	0.058	0.021	0.061	0.134
Saturated Fat (g)	–0.013	0.078	0.016	0.061	0.176
Monounsaturated Fat (g)	–0.02	0.052	0.019	0.107	0.111
Polyunsaturated Fat (g)	–0.191	0.005	–0.001	–0.053	0.057
Cholesterol (mg)	0.163	0.114	0.007	0.200	0.300
Fiber (g)	0.127	0.070	0.083	0.154	0.049

FBS = fasting blood sugar, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, TC = total cholesterol, TG = triglyceride.

Elevation of LDL-C and depression of HDL-C are two important risk factors for CHD [31–32]. Approximately 10 percent of the U.S. population has an HDL-C value of <35 mg per 100 mL, whereas about 24 to 40 percent of those with chronic SCI have HDL-C levels below this value [32–33]. Men with SCI may have a greater risk because their HDL-C level is lower. The percentage of individuals with low serum HDL-C level (<40 mg/dL) is remarkable (71.8%). Of women, 32.3 percent have HDL-C levels of <50 mg/dL. In the Turkish Heart Study, 53 percent of Turkish men and 26 percent of Turkish women had HDL-C levels of <35 mg/dL [34].

In the present study, none of the patients performed regular physical activity. The remarkable percentage of patients with low HDL-C in these patients may be explained by the lower physical activity levels in this group. Other causes of lower HDL-C, such as a high-fat diet [35–37], shown in our previous related study [13], may also contribute to low HDL-C in these patients.

In the general population, about 25 percent of individuals have elevated serum LDL-C levels (>130 mg per 100 mL) [1]. LDL-C levels of our patients with SCI was 40.1 percent; Bauman et al. reported a nearly similar value of LDL-C (44%) [36].

In our study, 22.2 percent of patients had a TC of >200 mg/dL, which is similar to the findings of other studies [27,35]. High TG levels, described as >150 mg/dL, were present in 34.6 percent of the patients with SCI. Consistent with our findings, Vichiansiri et al. reported high TG levels in 28.9 percent of patients with chronic SCI [37]. Groah et al., in a cross-sectional study of 121 subjects with chronic SCI, showed that 305 had high levels of TG [4].

In the present study, patients with paraplegia were shown to have higher BMI as well as increased levels of serum LDL-C and TC. In Duckworth et al., higher levels of HDL-C were detected in the paraplegia group [38]. In Groah et al., TG levels were similar between the tetraplegic and paraplegic groups [4]. In addition, TC, HDL-C, and LDL-C levels were all nonsignificantly higher in the persons with paraplegia.

Hypertension was present in 2.5 percent of our study population; it was more frequent in those with paraplegia than tetraplegia (4.4% vs 1.1%) but this difference was not statistically significant. However, in Bauman and Spungen, the prevalence of hypertension was 34 percent for both paraplegia and tetraplegia [39]. Increased prevalence of hypertension in persons with paraplegia was found in other studies as well [4,39]. BP was lower in persons with incomplete lesions than in those with complete lesions. Based on our research, there is no study available to compare BP in complete and incomplete patients. However, a possible reason for that is elevation due to autonomic dysreflexia at the time BP was recorded [11]. On the other hand, there remains a relationship between increased BMI levels and higher BP [11].

A total of 27.2 percent of the patients were current cigarette smokers, compared with 34 percent in Bauman and Spungen [39]. In Iran, there are poor options for transportation and sports facilities available for persons with SCI. Therefore, they have low activity levels, and perhaps this is the main reason for obesity and other abnormal cardiometabolic risk factors. With the improvement of transportation and sports facilities, persons with SCI would find more chances to increase their daily activity levels and reduce cardiometabolic risks.

We found no correlation between time postinjury and other cardiometabolic risk factors. Whereas in Demirel et al., the adverse risk profile of increased TC and the ratios of TC to HDL-C and LDL-C to HDL-C were more common with time postinjury >12 mo, and there was a negative correlation between HDL-C and time postinjury [8]. When HDL-C levels decrease, SBP rises, and when LDL-C levels rise, SBP also rises. Similar in Reaven [40], obesity was associated with hypertension and increased levels of TC, TG, and LDL-C levels in our study. HDL-C showed inverse correlation with the time postinjury, TG, and TC to HDL-C and LDL-C to HDL-C ratios in Demirel et al. [8]. Similar to another study [20], an inverse relationship was present between BMI and serum HDL-C levels and a direct relationship was noted between BMI and serum TG levels in this study. We found a positive correlation between saturated fat intake and FBS, and also between cholesterol intake and LDL-C. Relating to our previous study [13], the diets of individuals with SCI did not meet dietary guidelines [13], and the intakes of total fat and saturated fat (38% and 12.8%, respectively) were high. Therefore, the dietary intakes in patients with SCI were corrected and standard interventions were applied for reducing cardiometabolic risk factors.

CONCLUSIONS

Persons with paraplegia may have increased hypertension, higher BMI, and increased levels of serum LDL-C and TC levels. Of our patients with SCI, 13.58 percent had DM, 32.71 percent were obese, 71.8 percent had low HDL-C, 40.1 percent had high LDL-C, 34.6 percent had high TG, and 22.2 percent had high TC. Individuals with SCI must receive nutrition consultation and exercise encouragement to reduce cardiometabolic risk factors.

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