SHORT COMMUNICATION

Calcium and vitamin D plasma concentration and nutritional intake status in patients with chronic spinal cord injury: A referral center report

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Background: Nutritional status influences bone health spinal cord injury (SCI). This study evaluates serum levels of 25-hydroxy-vitamin-D and calcium along with dietary intakes in patients with chronic SCI. **Materials and Methods:** Total of 160 patients participated in this investigation. Dietary intakes were assessed by semi-quantitative food-frequency questionnaire. Serum calcium, phosphorus and 25(OH)-vitamin-D level were measured. **Results:** Mean of serum calcium and 25(OH)-vitamin-D were 9.54 ± 0.64 mg/dl (standard error of the mean [SE]: 0.05) and 13.6 ± 10.99 μg/dl (SE: 0.9), respectively. Dairy intake was below recommended amount (1.8 ± 0.74 per serving (SE: 0.06), recommended: 4). A high prevalence (53.1%) of Vitamin D deficiency (25(OH) Vitamin D <13 ng/ml) was found. **Conclusion:** This study shows below adequate intake of calcium and Vitamin D in Iranian patients with SCI. These results insist on the importance of dietary modifications among these patients.

Key words: Calcium, diet, spinal cord injury, vitamin D

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INTRODUCTION

Spinal cord injury (SCI) is a major ethology of reduced bone mineral density. Nutrition is an important factor which influences bone health. The two necessary nutrients for bone health are calcium and Vitamin D.[1] The role of Vitamin D deficiency in the development of osteoporosis is conclusively established.[1-4]

For humans, the essential source of Vitamin D is ultraviolet-irradiated skin with a little amount of dietary contribution.[5] The serum level of 25-(OH)-vitamin-D is the most useful index of the Vitamin D status.[6] Recommendations from the Institute of Medicine for adequate daily intake of Vitamin D is 200 IU for children and for adults up to 50 years of age, 400 IU for adults 51-70 years of age, and 600 IU for adults 71 years of age or older. Recommended dietary allowance for Vitamin D intake by 31-50 years old is 600 IU (15 μg) per day.[7] Oleson *et al*. has reported the existence of inadequate levels of Vitamin D among patients with SCI regardless of the season, ethnicity, or chronicity. Preserving sufficient Vitamin D levels prevents progression of osteoporosis and may result in less fracture.[8]

The important role of consumption of dairy products in increasing calcium and Vitamin D intake in healthy adolescents and young adults have been reported.[9,10] This is the first study assessing the relationship between dietary intakes of calcium and Vitamin D with their plasma concentrations in immobile patients. To our knowledge this is the first study reporting the plasma level of calcium and Vitamin D in Iranian patients with SCI and evaluates whether the present dietary intakes are adequate.

MATERIALS AND METHODS

Patients with chronic, traumatic SCI (>1 year since the injury) who were referred to Brain and Spinal Injury Research Center were invited to participate in this cross-sectional study during May 2008 to June 2009. Exclusion criteria were pregnancy, lactation, amputation, nontraumatic SCI, active decubitus ulcer, thyroid, hepatic, renal and neurological disorders. Informed consents were obtained after explaining adequate information to the patients. Participation in this study was voluntarily. The study protocol was ethically approved by Tehran University of Medical Sciences (Grant number: 7538/5/2008).

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A checklist was used for data collection and filled at each visit. Contents of checklist were patients' profiles (age, sex, educational level), information on medications, marital status, duration of injury, and location and completeness of injury. The level and completeness of lesion were classified according to proposed international standards for neurological classification of SCI.[11] Completeness of injury is determined according to American Spinal cord Injury Association impairment scale (ASIA)[12] in which only ASIA A represents complete injury.

A food-frequency questionnaire was also used to evaluate the consumption of Vitamin D and calcium rich foods intake.[13] The intakes of calcium and Vitamin D data were analyzed using Nutritionist IV 3.5.3. (N-Squared Computing, Salem, OR, USA) modified for Iranian foods. Serum calcium and phosphorus were analyzed using Pars Azmoon kits (Pars Azmoon Co., Iran) by the enzymatic colorimetric estimation with o-cresolphthalein complexone method.

The normal ranges of calcium and phosphorus were 8.5-10.5 mg/dl and 2.5-4.5 mg/dl respectively.[14] Serum 25(OH)-vitamin-D was measured by radioimmunoassay (RIA, IDS Ltd., Kit; UK). Intra-assay and inter-assay coefficient of variation for 25(OH)-vitamin-D was 6.8% and 8% respectively.

Vitamin-D deficiency was defined as follows: Deficiency (<13 ng/ml), insufficiently (13-20 ng/ml), and sub-therapeutic (20-32 ng/ml).[8]

Statistical analysis

All data were collected and analyzed by SPSS software (SPSS 18 Inc., Chicago, IL, USA). The differences of dietary intake between those with paraplegia, tetraplegia and those with complete and incomplete injuries, and female and male, were determined by independent *t*-test. Chi-square or Fisher exact test for two qualitative variables were used as appropriate. Spearman correlation analyses were performed to test the relationship of the quantitative variables. Quantitative variables are presented as mean ± standard deviation. Significant value was considered at $P \leq 0.05$.

RESULTS

The baseline characteristics of patients are presented in Table 1. Total of 160 patients (131 [81.9%] males and 29 [18.1%] females) entered this investigation. Among these patients, 59.4% (*n*: 95) had tetraplegia and 40.6% (*n*: 65) were paraplegic. The majority of patients had an incomplete injury (70%). Average daily calcium, phosphorus and number of dairy (per serving) intake were 811.95 ± 328 mg/day (standard error of the mean [SE]: 26.02), 1199 ± 491 mg/day (SE: 38.93) and 1.8 ± 0.74 (SE: 0.06), respectively.

Table 1: Baseline characteristics of subjects with spinal cord injury (*n*=160)

Characteristics	Values
Age (years), mean±SD (range)	34.17±8.75 (18-62)
Time since injury (years), mean±SD (range)	8.1±0.45 (2-40)
Gender (%)	
Male	131 (81.9)
Female	29 (18.1)
Education (%)	
Less than high school	92 (57.5)
Diploma	48 (30)
College graduate or higher	20 (12.5)
Married (%)	
Yes	86 (53.7)
No	74 (46.3)
Level of injury (%)	
Tetraplegia	95 (59.4)
Paraplegia	65 (40.6)
Completeness of spinal cord injury (%)	
Complete	48 (30)
Incomplete	112 (70)

SD=Standard deviation

No difference was seen in average dietary calcium, phosphorus, Vitamin D and dairy intake between tetraplegic and paraplegic patients (*P*: 0.84, 0.92, 0.86, and 0.63, respectively). The amounts of calcium, Vitamin D and dairy intake were below guideline reference.

An average serum calcium concentration of 9.54±0.64 mg/dl (SE: 0.05) was calculated for the whole study population. Table 2 shows that the average serum calcium did not differ between patients with tetraplegia and paraplegia (*P*: 0.53) and also those with complete or incomplete injury (*P*: 0.16).

Age was negatively correlated with serum total calcium level (*P*: 0.03, $r = -0.16$). There was no significant difference in serum total calcium between two genders (*P*: 0.12 and mean total calcium levels in men and women were 9.58 ± 0.64 mg/dl and 9.38 ± 0.59 mg/dl, respectively).

An average serum Vitamin D concentration of 13.6±10.99 ng/ml was measured in the whole study population. Age was not associated with concentration of 25-(OH)-vitamin D in plasma (*P*: 0.14) and similarly no difference in levels of Vitamin D could be detected between men and women (*P*: 0.45, mean of 25(OH) Vitamin D in males and females were 13.91 ± 11.4 μg/dl and 12.11 ± 8.78 μg/dl, respectively). The amount of calcium intake was similar between two genders (mean calcium intakes were 825.96 ± 340.4 mg/day in males and 749.14 ± 261.97 mg/day in females [*P*: 0.25]) and similarly no difference in the amount of phosphor intake could be detected among men and women (*P*: 0.32, 1218.2 ± 498.2 mg/day and 1118.5 ± 456.27 mg/day in males and females, respectively).

Table 2: Calcium, phosphorous, Vitamin D intake and serum calcium, 25 (OH) Vitamin D (mean±SD) in patients with spinal cord injury

	RDA† AIS§	Tetraplegia (*n*=95)	Paraplegia (*n*=65)	*P*	Complete (*n*=48)	Incomplete (*n*=112)	*P*
Calcium intake (mg/day)	1000§ 1000†	807.69±330 SE: 34.05	818.12±327 SE: 40.62	0.84	780.63±364 SE: 53.17	825.1±312 SE: 29.5	0.43
Vitamin D intake (IU/day or μg/day)	5§ 600†	1.67±1.09	1.69±0.9	0.86	1.90±0.86	1.54±1.1	0.38
Phosphorous intake (mg/day)	700†	1203±538 SE: 55.5	1195.5±416 SE: 51.65	0.92	1159.5±89.19 SE: 71.35	1216.95±493 SE: 46.57	0.50
Serum calcium (mg/dl)	8.5-10.1ß	9.46±0.63 SE: 0.06	9.66±0.64 SE: 0.08	0.53	9.65±0.60 SE: 0.08	9.50±0.65 SE: 0.06	0.16
Serum 25 (OH) Vitamin D (μg/dl)	9.2-45.2ß	12.9±11.67 SE: 1.26	14.54±9.99 SE: 1.26	0.37	14.73±12.87 SE: 1.94	13.11±10.11 SE: 0.99	0.41
Dairy intake (serving)	4£	1.79±0.76 SE: 0.07	1.85±0.74 SE: 0.09	0.63	1.77±0.78 SE: 0.11	1.83±0.75 SE: 0.07	0.69

†RDAs=Recommended dietary allowances; §AIS=Adequate intakes; SE=Standard error of the mean; SD=Standard deviation. £Number of serving; ßNormal range

The daily intake of Vitamin D was also similar between genders (1.84 ± 0.78 IU/day in males and 1.66 ± 0.58 IU/day in females, *P*: 0.24). Age was not correlated with calcium and dairy intake (*P*: 0.15 and 0.28, respectively).

DISCUSSION

The main goal of the present study was to estimate the amount of calcium, Vitamin D, phosphorus, and dairy intake in patients with SCI. The high prevalence of Vitamin D deficiency in tropical countries has been reported.[6,15-17] In the agreement with those studies, in sunny cities of Iran, 81.3% of inhabitants of Tehran and 70.4% of healthy inhabitants of Isfahan showed Vitamin D deficiency.[15,18] In the present study, 53% of patients with SCI showed Vitamin D deficiency (25-(OH)-D <13 ng/ml). However, in contrast to the results from Isfahan populations,[18] the prevalence of Vitamin D deficiency was not sex and age dependent. Similar to the present results, Bertoli *et al*. have noticed that Vitamin D and calcium intake in 76% physically disabled participants was below recommended levels.[19]

In the general population of Saudi, females had significantly higher level of 25-(OH)-vitamin D than males and elderly subjects had significantly lower level of Vitamin D.[6] Patients with SCI in our study had a comparable 25-(OH)-vitamin D level with Saudi general population (mean in male and female: 13.9 ± 11.4 and 19.6 ± 29.2, respectively). Although similarly women had a higher level of 25-(OH)-vitamin-D, this difference was not statistically significant, and no relationship with age could be determined as well.

Based on Hashemipour *et al*. report,[15] 9.5% of the general population in Tehran had severe Vitamin D deficiency. Here we have shown that the prevalence of severe Vitamin D deficiency is much higher among patients with SCI in comparison with general population of Tehran (53% vs. 9.5%). Moreover, Hashemipour showed that 25-(OH)-vitamin D in females was lower in elderly individuals whereas our results in patients with SCI illustrated no association between Vitamin D level and patients' age and sex. Inversely a significant (*P*: 0.03) age-related difference but not sex and disability related, has been detected for total serum calcium.

Vitamin D deficiency in patients with SCI is common and it may be due to an insufficient exposure to sunlight since they are not able to move. In Iran (Isfahan) the prevalence of Vitamin D deficiency has been reported among women and younger population because the type of clothing prevents absorption of Vitamin D from sun exposure.[18] In addition to the type of clothing, some other factors such as air pollution, skin pigmentation, insufficient Vitamin D intake and lack of food fortification with Vitamin D could be the reasons for Vitamin D deficiency in Iran.[10,15]

Type of plegia and completeness of injury was not related with serum level of 25(OH)-vitamin-D. Although it is assumed that patients with paraplegia and incomplete injury have higher ability and independence, it seems that the type of plegia and completeness of injury do not influence the level of 25(OH)-vitamin-D which is probably a result of similar dietary pattern and sun exposure duration among these patients.

It has been suggested that keeping the adequate Vitamin D levels can prevent the development of osteoporosis and may reduce the risk of fractures. Suggesting that adequate sunlight exposure plus supplementation, fortified dairy intake for long periods, correction of nutritional deficits, and nutritional education, together may prevent and cure Vitamin D and calcium insufficiency. Although calcium-vitamin supplements in persons with SCI has a very low risk of urinary lithiasis, it can prevent a large risk of bone loss. The results of this study reveals the below normal levels of calcium and Vitamin D among patients with SCI and a quick dietary intervention is essential in these patients.

CONCLUSIONS

This study reveals calcium, and Vitamin D insufficiency in Iranian patients with SCI and it insists on a quick dietary modification to correct the serum level of mentioned values. Nutritional intervention is essential to come to an acceptable measure of calcium and 25(OH)-vitamin-D in these patients.

AUTHOR'S CONTRIBUTION

ANJ contributed in the conception of the work and study design and agreed for all aspects of the work. HS contributed in the conception of the work, design of the work and the acquisition of data and agreed for all aspects of the work. SL contributed in the analysis and interpretation of data, revising the draft agreed for all aspects of the work. MRV contributed in the conception of the work, the acquisition of data, approval of the final version of the manuscript, and agreed for all aspects of the work. FS contributed in the conception of the work, the acquisition of data, approval of the final version of the manuscript, and agreed for all aspects of the work. ZK contributed in the conception of the work, analysis and interpretation of data for the work and agreed for all aspects of the work. FS contributed in acquisition of data for the work and agreed for all aspects of the work. AR contributed analysis, or interpretation of data for the work and agreed for all aspects of the work. HER contributed in the conception and design of the work, approval of the final version of the manuscript, and agreed for all aspects of the work.

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