Original Article

Comparison of Dietary Macro and Micro Nutrient Intake between Iranian Patients with Long-term Complications of Sulphur Mustard Poisoning and Healthy Subjects

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Abstract

Background: **Patients with long-term complications of sulfur mustard (SM) poisoning are often less able to undertake optimum levels of physical activity and adequately control their dietary intake. The aim of present study was to investigate the dietary intake of patients with SM poisoning in comparison to a control group.**

Methods: **The study was undertaken on 55 Iranian male veterans, who had > 25% disabilities due to long-term complications of SM poisoning and 55 men age-matched healthy subjects. A previously validated food frequency questionnaire (FFQ) was used for measuring dietary macro/micro nutrient intake for both groups; and the results were analysed using Dietplan6 software.**

Results: **Analysis of macro/micro nutrients in dietary intakes of the patients versus the controls showed a significantly lower intake of several nutrients including selenium and carbohydrate. On the other hand, the dietary intake of trans-fatty acids and iodine were significantly higher in these patients.**

Conclusion: **Long-term complications of SM poisoning in the Iranian veterans induce both chemical and physical disabilities. Macro/micro nutrient intake in these patients was significantly different in comparison with matched, healthy subjects. Dietary advice for these patients should be strongly recommended to these patients in order to prevent other chronic diseases.**

Keywords: *diet, macronutrients, chemical warfare agents, sulfur mustard*

Introduction

Sulfur mustard (SM) or mustard gas is a Chemical Warfare Agents (CWA) which has been used on several occasions in the past, including in the Iraq – Iran war in 1983–1988 (1). The pharmacology, toxicology, and medical treatment and also the clinical toxicology of SM has been reviewed in detail previously (2,3). SM poisoning has chronic effects on several different organ systems, and these have been reported previously for severely affected Iranian veterans (4). Comparison of the early and late toxic effects of SM in Iranian veterans revealed

that the respiratory tract is the most commonly affected system either during the early phase or in the longer-term (5). Delayed complications of SM poisoning also include effects on the eyes, the skin and the immune system (6–9) and, head and neck malignancies (10).

Physical inactivity induces changes in body composition including progressive loss in bone and muscle mass as well as an increased proportion of fat mass. Due to its effects on the respiratory system, SM poisoning may therefore cause chronic secondary problems. These lead to a worsening of residual physical functional status, quality of life and increase the risk of co-morbidities (11).

Many studies show that the intake of different nutrients in physically disabled patients is often below the Recommended Dietary Allowance (RDA), thus, these patients are at risk of malnutrition (11). Miyahara et al., in 2008 founded that the intake of vitamin A and vitamin D in physically disabled patients within the age range of 17–56 years were lower than RDA (12).

In patients with spinal cord injury, the intake of vitamin A, vitamin C, B9, magnesium, zinc, B12, B1, B2, and B6 were lower than the RDA and consumption of fiber, vitamin D, Ca, K also were lower than the AI (adequate intake) (13). Inadequate intake of fiber, fruits, dairy foods, and calcium in men at age of 20–59 years with paraplegia have also been reported previously (14).

An inadequate and imbalanced dietary intake in physically disabled patients may have a negative influence on their mental and physical health (15). For example inadequate intake of vitamin B6 may lead to a reduced level of the neurotransmitter serotonin, that may cause a deterioration in the mental health of physically disabled patients. An inadequate intake of vitamin B6, B12, and B9 may lead to increase plasma concentrations of homocysteine, which along with decreased physical activity can causes increased risk of cardiovascular disease (15).

Tomey and co-workers (2005), have previously reported that the diet of men with paraplegia living in an urban community-setting, contained to much total and saturated fat, and inadequate fiber, calcium, fruit, and dairy foods (14). Bertoli and co-authors have reported that the biochemical profile of the disabled subjects was characterised by the presence of a number of risk factors for coronary heart disease (CHD) (11).

There is relatively little data available on the association between features of physically disabled patients and their dietary intake. There are even fewer reports on the dietary intake in patients with long-term complications of SM poisoning. Therefore, we aimed to compare the dietary intakes of macro/micro nutrients in Iranian veterans with SM poisoning with healthy subjects.

Materials and Methods

Subjects

This cross-sectional study was coordinated with support from the Veterans (Janbazan) Foundation of Khorassan Razavi. Approval was obtained from the Mashhad University of Medical Sciences Ethics Committee. Written informed consent was obtained from all participants (55 patients with complications of sulfur mustard poisoning and 55 apparently male healthy subjects without any physical disability and no history of chemical exposure and were nonsmokers) were studied. The non-smoker patients who were exposed to CWA during the Iraq – Iran war in 1983–1988 and had disabilities of > 25% due to long-term complications of SM poisoning were recruited (4). The exposure to SM had occurred 23–28 years previously.

A medical committee within the veterans (Janbazan) foundation assesses specific target organ complications of SM poisoning (mainly on the lungs, eyes and the skin) and based on their evaluations assigns a disability percentage to each veteran. According to their grading severity, a disability of < 25% was considered to be mild, 25–75% moderate and > 70% severe respectively. The veterans' health, particularly respiratory complications limit their physical activities. Demographic and clinical data as well as food frequency questionnaire were collected for all subjects as described below. We also used a questionnaire to assess the socio-economic status of our subjects.

Anthropometric measurements

All subjects were measured for height, waist, and hip circumference (in centimeters) and weighed in kilograms using a stand-on Bio Impedance Analyzer (BIA) (Tanita-418 body composition analyzer, Tania Corp., Tokyo, Japan). The latter was also used to estimate percent body fat. Body mass index (BMI) was calculated by the formula: BMI=weight (kg)/height (m2). The precision of this BIA was good (the coefficient of variation < 1%) , but because it may be sensitive to physiological factors, such as exercise and food intake with an effect of up to 2.6% on the % body fat estimate. Therefore, the BIA was used under

standard conditions; in the fasted state, before exercise and the same device was used in all subjects.

Clinical examinations

Clinical examinations of the patients and the healthy subjects were carried out by the first author and were recorded on pre-designed forms. Biochemical measurements

Blood samples were collected from the brachial veins of the patients and healthy subjects after 12 hours fasting. The blood samples were placed into plain glass tubes and biochemical parameters including low-density lipoprotein (LDL), high density lipoprotein (HDL), triglyceride (TG), and fasting blood glucose (FBG) were measured using routine procedures.

Dietary evaluation and analysis

Assessments of dietary intake in subjects were undertaken using a food frequency questionnaire and analysis of nutrient intake with Diet Plane version 6 software (West Sussex UK).

Statistics Analysis

We imported our data into SPSS 11.5 software (SPSS Science, Apache Software Foundation, Chicago, IL) and the descriptive statistic for the baseline characteristic of our subjects was compared using the independent sample *t* test for comparison of dietary intake of macro/micro nutrients between physically disabled and control groups. A *P* value of < 0.05 was considered significant.

Results

Comparison of anthropometric measurements and socio-economic status between patients with physical disabilities and healthy subjects:

There were no significant difference between patients with long-term complications of sulfur mustard poisoning and healthy subjects with respect to anthropometric measurements (including age, obesity indices and middle arm circumference) and socio-economic status. (Table 1, $P > 0.050$).

Table 1: Comparison of anthropometric measurements between 55 patients with long term complications of sulfur mustard poisoning and 55 healthy subjects

Group	Patients Mean (SD)	Healthy subjects Mean (SD)	*P* value
Number	55	55	–
Age (year)	44.25 (9.46)	44.18 (9.32)	0.962
Weight (kg)	75.25 (1.29)	74.32 (1.20)	0.960
Height (cm)	171 (.60)	170 (.50)	0.153
BMI (kg/m^2)	25.59 (4.21)	26.07 (3.70)	0.155
Body fat %	23.68 (1.28)	23.61 (4.32)	0.960
Waist circumference (cm)	96.46 (11.6)	93.18 (7.9)	0.092
Hip circumference (cm)	102.65 (7.28)	101.58 (5.24)	0.376
W/H Ratio	0.93 (0.06)	0.91 (0.05)	0.070
MAC (cm)	30.40 (3.55)	30.76 (2.66)	0.545

Values are expressed as mean (SD). Statistical test was Independent sample *t* test. There was no significant difference between the patients and healthy subjects.
Abbreviations: BMI = Body mass index; MAC = Middle arm circumference; W = Waist circumference; H = Hip circumference.

Table 2: Frequency of delayed complications of sulfur mustard poisoning in different organs of 55 Iranian veterans in Mashhad 23–28 years after exposure

Organ system	Number of patients	Percentages
Respiratory tract	52	94.5
Peripheral neuromuscular	41	74.5
The skin	39	70.9
The eyes	37	67.2

Clinical findings

The common clinical findings of long-term complications of SM poisoning on different organ systems of the 55 Iranian male veterans in Mashhad are summarised in Table 2.

Comparison of Lipid Profile and FBS between patients with physical disabilities and healthy subjects

Data comparing the lipid profile and fasting blood glucose (FBG) between the SM patients and control subjects are in Table 3. Serum LDL cholesterol concentration (P = 0.020), TG (P = 0.042), and FBG (P < 0.001) were significantly higher in the SM patients compared to the healthy subjects.

Comparison of dietary intake of macronutrients between patients with physical disabilities and healthy subjects

Comparison of reported dietary intake of macronutrients comparing physically disabled patients and healthy subjects are shown in table 4. These data show that the macronutrient intake of starch, cholesterol, and carbohydrate intake were significantly different between patients and healthy subjects; dietary starch (P <0.001) and carbohydrate intake (P = 0.011) were significantly lower than healthy subjects and dietary cholesterol intake significantly higher than healthy subjects (P <0.001).

Table 3: Comparison of lipid profile and FBS between 55 patients with long term complications of sulfur mustard poisoning and 55healthy subjects

Group	Patients Mean (SD)	Healthy subjects Mean (SD)	*P* value
LDL (mg/dL)	165.84 (49.46)	119.06 (43.31)	0.020
HDL (mg/dL)	39.32 (7.32)	42.37 (11.30)	0.092
TG (mg/dL)	175.73 (120.93)	139.31 (74.20)	0.042
FBG (mg/dL)	110.06 (46.86)	88.78 (5.92)	< 0.001

Values are expressed as mean (SD). Statistical test was Independent sample *t* test. There were significant differences between the patients and healthy subjects in regards to level of LDL, TG and FBG.
Abbreviations: LDL = low density lipoprotein; HDL = high density lipoprotein; TG = triglyceride; FBG = fasting blood glucose.

Table 4: Comparison of dietary intake of macro nutrients between 55 patients with long term complications of sulfur mustard poisoning and 55healthy subjects

Group	Patients Mean (SD)	Healthy subjects Mean (SD)	*P* value
Energy (kcal)	2333.69 (873.06)	2585.49 (499.77)	0.060
CHO (g)	295.41 (1.15)	349.85 (1.04)	0.011
Starch (g)	178.85 (84.52)	233.74 (57.26)	< 0.001
Fiber (g)	20.82 (12.53)	19.55 (11.78)	0.582
Fat (g)	96.84 (4.98)	97.90 (2.30)	0.885
Polyunsat Fat (g)	34.05 (20.73)	39.08 (12.56)	0.129
Sat Fat (g)	26.69 (1.51)	23.54 (5.56)	0.150
Monounsat Fat (g)	26.30 (14.53)	24.81 (6.93)	0.493
Cholesterol (mg)	148 (271.31)	93 (179.51)	< 0.001
Trans fat (mg)	300.56 (1.06)	275.50 (.54)	0.560
Protein (g)	88.58 (4.45)	99.29 (2.27)	0.112

Values are expressed as mean (SD). Statistical test was Independent sample *t* test. There were significant differences between the patients and healthy subjects in regards to cholesterol, starch and carbohydrate intake.
Abbreviations: CHO = Carbohydrate; Polyunsat Fat = Poly unsaturated fatty acid; Sat Fat intake = saturated fatty acids; Monounsat Fat = mono unsaturated fatty acid.

Comparison of intake of micronutrients between patients with physical disabilities and healthy subjects

The estimated intake of micro nutrients between patient and healthy subjects are shown in table 5. Vitamin E ($P < 0.001$) and copper ($P = 0.010$) intakes in patients was significantly lower, and the dietary content of iodine ($P = 0.012$), carotene ($P < 0.01$), pantothenic acid ($P = 0.015$) and vitamin C ($P = 0.030$) intake in patients were significantly higher than for healthy subjects.

Discussion

Long-term complications of SM poisoning

The long-term clinical complications of SM poisoning on different organs of the 55 Iranian male veterans in Mashhad were similar to previous reports (3–9). They had both chemical and physical disabilities that may have affected their nutritional status.

Comparison of macronutrient intake between the patients and healthy subjects

In the present study, the reported starch and carbohydrate intake in the patients with long-term complications of sulfur mustard poisoning was significantly lower and the amount of dietary cholesterol was significantly higher the control group. However the total energy intake did not differ significantly between the two groups. Bertoli et al., previously reported that daily energy intake was lower in the disabled patients than in the controls (11). In their study, the patients were

Table 5: Comparison of intake of micro nutrients between 55 patients with long term complications of sulfur mustard poisoning and 55 healthy subjects

Group	Patients Mean (SD)	Healthy subjects Mean (SD)	*P* value
Potassium (mg)	3277.98 (1382.19)	3194.52 (821.36)	0.701
Calcium (mg)	922.38 (385.27)	988.65 (375.21)	0.360
Magnesium (mg)	295.82 (140.36)	302.43 (83.06)	0.762
Phosphorus (mg)	1508.36 (616.68)	1575.30 (313.03)	0.475
Copper (mg)	1.49 (0.74)	1.81 (0.55)	0.010
Zinc (mg)	11.84 (5.45)	12.66 (3.20)	0.332
Magnesium (mg)	3.45 (1.82)	3.82 (1.10)	0.769
Iodine (µg)	150.57 (9.21)	111.03 (6.90)	0.012
Iron (mg)	13.12 (8.50)	14.59 (8.38)	0.533
Retinol (µg)	268.16 (2.37)	211.99 (1.37)	0.130
Vitamin B1 (mg)	23.96 (1.01)	26.15 (0.43)	0.340
Riboflavin (mg)	1.55 (0.71)	1.53 (0.52)	0.899
Vitamin B6 (mg)	1.83 (0.95)	1.86 (0.67)	0.873
Vitamin B12 (µg)	3.87 (2.51)	3.28 (2.02)	0.590
Folate (µg)	295.78 (1.91)	250.36 (8.15)	0.462
Caroten (µg)	2508.67 (351.79)	2456.85 (4006.27)	< 0.001
Vitamin D (µg)	1.77 (1.86)	2.14 (3.15)	0.133
Vitamin E (mg)	23.96 (14.64)	26.15 (8.64)	< 0.001
Niacin (mg)	21.23 (15.22)	23.19 (10.73)	0.165
Pantothen (mg)	5.69 (2.87)	5.37 (1.80)	0.015
Biotin (µg)	27.87 (1.48)	27.78 (1.02)	0.960
Vitamin C (mg)	110.12 (98.91)	74.05 (73.81)	0.030

Values are expressed as mean (SD). Independent t test was used for comparing the dietary intakes of micro nutrients between the patients and healthy subjects. There were significant differences between the patients and healthy subjects in regards to iodine, copper, carotene, vitamin E, pantothen, and vitamin C intake.

two groups of mentally and physically disabled patients but the present study comprises a single group of patients. In the present study, the total energy consumption did not differ significantly between the two groups, although there was a lower mean energy intake that just failed to reach statistical significance.

Estimated dietary starch and carbohydrate intake in patients was significantly lower than in the healthy subjects and the amount of cholesterol intake in patients was significantly higher than the healthy subjects. Since high dietary fat intake and blood concentration of cholesterol is a risk factor of cardiovascular disease, it may confirm the results of a study in 2006 by Bertoli and co-workers who reported that obesity, cardiovascular diseases, diabetes, and osteoporosis are frequent co-morbidities among physically disabled patients. Quantitative and qualitative inadequacy of diet, may lead to a sub-optimal nutritional status that could be one of the first steps in the development of co-morbidities in the physically disabled subjects (11). Thus, physically disabled patients, including those with long-term complications of sulfur mustard poisoning, need nutritional and social support and advice to help improve their quality of life.

Comparison of micronutrient intake between the patients and healthy subjects

In the present study the reported vitamin E and copper intake in the patients with long-term complications of sulfur mustard poisoning was significantly lower and the content of iodine, carotene, pantothenic acid, and vitamin C intake was significantly higher than healthy subjects. It has previously been shown that subjects with disabilities were six times as likely to be marginal or deficient in dietary intake of vitamin C; which is an important antioxidant (16). These authors suggest an inverse relationship between vitamin C intake and death from cardiovascular disease and mortality from all causes. The subjects of this study were diabetic patients who had paraplegia or hemiplegia for at least five years, resulting from cerebral palsy, spinal cord injury, or polio, but our patients were poisoned by the chemical warfare sulfur mustard > 25 years previously during the Iraq–Iran war. Results of the present study in relation to dietary vitamin E are in agreement with the results of a study in 2002. Burri and co-workers have previously shown that vitamin E intake in physically disabled patients is significantly lower than the healthy subjects (16).

Comparison of Lipid Profile and FBG between the patients and healthy subjects

We found that the serum concentrations of LDL, TG and FBG in the patients with long-term complications of sulfur mustard poisoning were significantly higher than for the healthy subjects. The higher level of LDL and TG in patients may be due to differences in reported consumption of foods with high cholesterol in his group. High levels of plasma LDL and TG are risk factors of CHD, and so these patients may be at higher risk for CHD. Nutritional education of this population would be important to modify this risk.

Conclusion

It appears that long-term complications of SM poisoning after a short-term exposure to SM remains several years after initial exposure, and these may include metabolic abnormalities.

The macro/micro nutrients intake in these patients was significantly different in comparison with the healthy subjects, which may cause some chronic health problems for them. These nutritional abnormalities may be associated with diseases such as cardiovascular and cancer. However, it is difficult to disentangle the effects of inadequate diet from those due to physical inactivity, which also induces changes in body composition including progressive loss in bone and muscle mass as well as an increased proportion of fat mass. These alterations worsen residual physical functional status, quality of life and increase the risk of co morbidities. Therefore, dietary advice and interventions including education, fortification or supplementation may be important for the prevention of the chronic diseases. To confirm these findings, a multicenter study with bigger sample size and both gender may be necessary. In the meantime, patients and their carers need to be provided with advice about their diet. Some recommendations for dietary changes of these subjects include:

a) Reducing their dietary saturated fat intake because of the higher levels of LDL cholesterol. Therefore, their intake of high fat dairy products such as butter, cream, fat meat, and liver should be reduced.

b) Increase the intake of polysaccharides, especially the whole grain and limit the intake of simple sugar (such as sugar, jam, honey, jelly) to reduce the FBG and TG.

c) Increase the physical activity as much as possible to reduce the levels of FBG, TG, and LDL, and to prevent obesity and overweight.

Limitations

The small sample size and the inclusion of only men subjects were two main limitations of our study. The use of a food diary rather than a food frequency questionnaire may also improve the reliability of the dietary intake estimates.

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Conflict of Interest

None.

Funds

None.

Authors' Contributions

Conception and design: MBM, MGM
Analysis and interpretation of the data, drafting of the article: MZ
Critical revision of the article for the important intellectual content: MZ, GF
Final approval of the article: MBM, MZ, MGM, GF
Provision of study materials or patient, statistical expertise, obtaining of funding: MSSA
Administrative, technical or logistic support: HMA
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