

Elevated strontium concentration in the blood of automobile workers in Kolkata

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ABSTRACT

Introduction: Though the trace element strontium's (Sr) exact role in health remains unknown, at certain levels, it is toxic and, given the body's low threshold for Sr, has been cited to cause nervous disorders. At different stages of the life cycle, organisms vary in their ability to discriminate Sr and calcium, which can cause age-related differences in gastrointestinal absorption. Though data regarding the effects of such absorption remain limited, it can reportedly impact health, the immune system, and chromosomal aberration.

Purpose: To investigate and correlate levels of Sr concentration and any health problems at certain levels among automobile workers.

Materials and methods: The blood of 41 automobile

workers and 26 healthy controls of the Kolkata region was collected and whole blood Sr concentration estimated by the energy dispersive X-ray fluorescence (EDXRF) technique.

Results: Automobile workers showed significantly ($p < 0.001$) higher blood SR levels than controls from the same area, despite similar dietary habits and drinking-water quality.

Conclusions: Automobile workers are exposed to different pollutants that can harm their health, and a trace element imbalance of Sr and its elevated concentrations in the blood may cause different health complications.

Key words: Strontium; garage workers; blood; Energy Dispersive X-ray Fluorescence Technique.

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INTRODUCTION

Strontium (Sr) is a fairly reactive chemical element. Naturally-occurring Sr is a mixture of four stable (nonradioactive) isotopes—namely, ⁸⁴Sr, ⁸⁶Sr, ⁸⁷Sr, and ⁸⁸Sr, the last of which is the most abundant [1]. Stable metallic Sr is of relatively low toxicity, though Sr⁺⁺ plays no recognized essential biological role. Human exposure to Sr is primarily oral, via consumption of fruits, vegetables, and drinking water, though inhalation exposure is also possible [2]. As such, it is possible to find a detectable range of Sr in all humans [3]. Despite the limited number of case reports on the subject, studies have shown that high Sr⁺⁺ toxicity is responsible for different physiological and metabolic complications [4]. Sr can bind to proteins and, based on its similarity to calcium (Ca), likely form complexes with various inorganic anions (e.g., carbonate and phosphate) and carboxylic acids (e.g., citrate and lactate), as well as interact with various Ca-binding and Ca transport proteins [5]. The present study shows that, in central Kolkata, automobile workers have blood Sr concentrations significantly higher than those of the control population and a few times greater than the total allowable limit. Previous literature has shown that the typical body burden of Sr is about 0.3–0.8 g, with 99% occurring in the skeleton, and that humans absorb 11–30% of ingested Sr [6].

MATERIALS AND METHODS

The study was performed on 41 garage workers and 26 healthy male of Kolkata region. A thorough interview was carried out to find out their overall health problem, addiction history, mode of work, food intake habit during working hours, years of exposure in automobile repair shop, drug intake habit, any other relevant history of the male garage workers and healthy males of the control group. After ethical committee clearance (Ethical committee clearance certificate from Institute of Haematology and transfusion Medicine, Medical College, Kolkata) 5 ml of blood was drawn from each of male garage workers under proper medical supervision and care. The blood obtained were kept in a citrate (3.8%) container and stored at 4°C for further part of procedure. Similarly venous blood (5ml) was taken from 26 healthy males (living in the same area, in congested central Kolkata region) and this served as control. The blood samples (2ml) of male garage workers and healthy male controls were lyophilized at -80°C. The blood samples were dried and powdered using mortar and pestle. 150 mg portions of powdered sample was taken and compressed to form a pellet of

13mm diameter, with a table top pelletizer using 100 kg/cm² pressure. The pellets were subjected to energy dispersive X-ray fluorescence (EDXRF) technique [7]. The concentration of Sr in the blood samples was measured by EDXRF(Xenometrix former (Jordan Valley, Israel). Standard material for this said technique is Bovine liver (SRM 1577C) from National Institute of Standards and Technology (NIST). The certified value is 2.031mg/Kg or ppm and percentage of error are 2.2%. For statistical analysis student's t, test is used at 5% significance level and for the correlation coefficient, Pearson's correlation test is used, and correlation is significant at 0.01 level.

RESULTS

Forty-one garage workers in this study denied having any addiction and are working at the automobile shop for continuously for a minimum of last 1year and maximum occupational years are 22, and the average working year is 5.7 and average age is 25.36 (SD=4.8). It is found that only 8 auto mobile workers have Sr concentration below detection limit and rest all have far above the body permissible limit. Average Sr concentration in blood is 1.5±1.56 mgL⁻¹ (Table1).

Table 1. Difference of concentration of blood strontium between controls and worker group.

Control population, (all units in mgL ⁻¹)	Affected population, (all units in mgL ⁻¹)
Age (20-35); n = 26 Mean=0.215 (SD=0.26) Upper limit=0.75 Lower limit=0 Median=0.065	Age (20-35); n=41 Mean=1.5 (SD=1.54) Upper limit=4.68 Lower limit=0 Median=0.54
Age (27-35); n = 14 Mean = 0.27 (SD=0.305) Median=0.08	Age (27-35); n=18 Mean 3.12 (SD=0.78) Median=3.11
Age (20- 27); n = 12 Mean=0.2 (SD=0.24) Median = 0 .11	Age (20- 27); n=23 Mean=0.214(SD=0.28) Median=0.13

According to interview data, all automobile workers have different health problems and complications like muscle pain, frequent headache, fatigue and most of them (workers whose blood strontium concentration is above or equal to 1mg/L) presented same features like premature aging (Table 2). In contrast to the exposed workers, the concentration of Sr in the control population (whose age is also between 20-35 years) is 0.2154 ± 0.26

mgL⁻¹. Garage workers have about 86% elevated Sr concentration as compared to the control population which is statistically highly significant (p<0.001) (Table 1). Workers and the control populations are grouped into two groups according to their age, one <27 years and >27 years. In case of workers above 27 years all are working for constantly last 10 years, and they have significantly higher (p<0.001) Sr concentration in blood compared to the same aged control population. In case of workers aged below 27 years, all are working for 1-2 years, and blood Sr

level has no significant difference with the same aged control population. There is also significant (p<0.001) difference of blood Sr concentration between the young workers (<27yrs) and the elder workers (>27 yrs).

From Pearson's correlation study, it is clearly observed in case of the automobile workers that there is a significance correlation between the age, year of work i.e. working period and the blood strontium concentration (Table 3).

Table 2. Different health problems among automobile workers.

	0-0.25 mgL ⁻¹	>0.3-1 mgL ⁻¹	1-3 mgL ⁻¹	3-4 mgL ⁻¹
Symptoms/complains from workers	No such effective comments	Fatigue, headache, pain in hand muscles after short heavy work	Fatigue, headache, back bone pain, dull skin and appearance and age related wrinkles	Dizziness after heavy work, back bone pain ,lack of appetite and wrinkled, tired and dull face appearance

Table 3. Correlation results.

		VAR1 (age)	VAR2 (no of yr working)	VAR3 (concentration of blood strontium)
VAR1 (age)	Pearson Correlation	1	.948**	.973**
	Sig.		.000	.000
	N	41	41	41
VAR2 (no of year working)	Pearson Correlation	.948**	1	.943**
	Sig.	.000		.000
	N	41	41	41
VAR3 (concentration of blood strontium)	Pearson Correlation	.973**	.943**	1
	Sig.	.000	.000	
	N	41	41	41

** . Correlation is significant at the 0.01 level.

Table 4. 2x2 contingency table for correlation of Sr concentration and health problems.

		Strontium levels	
		≤ 30 mg/L Sr in blood	> 0.3 mg/L Sr in blood
Health Condition	No health problem	34	4
	No health problems	3	26

For the overall population, including the automobile workers as well as control workers, the 2X2 contingency table is shown in Table 4.

The coefficient of association is 0.973 (which is very close to 1). It indicates that higher levels of strontium are positively associated with health problems.

DISCUSSION

This study indicates that automobile workers are, by their occupation, exposed to Sr, which generally appears in car batteries, while Sr chromate is abundant in car spray paint [8]. Though stable Sr is nonradioactive, continuous exposure to and inhalation of stable Sr can be lethal to mammalian health, while Sr chromate can cause chromosomal aberrations [9]. Sr exposure can also cause irritation in the respiratory tract, changes in Ca-dependent enzyme activity, and

changes in the enzymes' kinetic parameters. Sr may also interact with secondary cell messengers and transporter systems that normally use Ca [10]. Furthermore, synaptic transmission may be variably affected by Sr, and consequently, at high Sr concentrations, differences in the chemical characteristics of Sr and Ca may prompt neurotoxic and neuromuscular perturbations associated with Sr toxicity [11]. All of these findings from the literature partly explain why garage workers face different muscle and health problems at very early stages of their career.

In the present study, though all exposed automobile workers were aged from 20–35 years, those with blood Sr concentrations equal to or greater than 1 mg/L clearly looked unhealthy and aged. Though Sr concentration in the control population of the Kolkata region was significantly lower than that of automobile workers, it was nevertheless, considerably higher than the total allowable body burden in the blood, likely due to lifestyle and diverse routes of contamination in the city [12]. Naturally occurring elevated Sr levels [13] in the population of the Kolkata region may stem from dietary habits that include the regular intake of Sr-rich grain and fish [14]. Additionally, according to previous studies, airborne Sr is high in cities due to industrialization [15], which may also explain the high blood Sr in region's population.

The elevation of Sr concentrations seems to be directly proportional to the exposure period (Table 3). Despite the high probability of exposure to heavy metals for automobile workers, such as exposure is not unusual for the control population, especially since it originated from an urban population. However, as our previous study observed, automobile workers also have low blood antioxidant levels [16]. The present study's control population showed no signs of premature aging and did not complain of pain in the muscles or elsewhere.

Nevertheless, further monitoring is essential to evaluate the data, for which more technical support and facilities are required and for which detailed health check-ups, and a longer follow-up period are essential. Ultimately, further studies should investigate the environmental and pathological mechanisms of Sr, since these the present study's results suggest health hazards due to Sr.

CONCLUSIONS

Automobile workers in Kolkata are exposed to different pollutants harmful to their health, among which Sr at elevated levels may primarily explain different health complications in the population.

Since workers who work over longer periods are at greater risk, they must receive special attention.

Conflicts of interest

There is no conflict of interest.

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