Effect of traditional gold mining on the levels of calcium and phosphorus in Abuhamad, Sudan

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ABSTRACT

Mining activities in developing countries are often carried out at an artisanal level using a variety of extraction methods that generate and release toxic waste products, which have profound impacts on the environment and increased frequency of many health problems.

Objective of this study: The aim of this study was to assess the levels of calcium and phosphorous, and health risks due to the mining in traditional gold miners in Abuhamad area, River Nile State- Sudan.

Material and methods: Blood samples were collected from 83 Sudanese miners working in traditional mining sites in the River Nile State, their ages ranged from 18 -55 years**,** and 50 healthy volunteers match in age and sex from Khartoum State as control group. Serum calcium (Ca) and phosphorus (P) were measured using automated chemical analyzer.

Results: The mean ±SD of serum calcium in traditional gold miners was (9.4±0.5mg/dl); while it was (9.3±0.6mg/dl) in control group (*P*. value = 0.407). The mean ±SD of serum phosphorus in traditional gold miners was (4.2±0.8mg/dl); while it was (3.2±0.8mg/dl) among control group with significance difference (*P*. value = 0.000).

Conclusion: Traditional gold mining affects the phosphorous levels among Sudanese workers.

{**Citation:** Amel O Gundi, Eltayeb Tayrab, Abed Al Salam Aljahmany. Effect of traditional gold mining on the levels of calcium and phosphorus in Abuhamad, Sudan.

American Journal of Research Communication, 2019, 7(10): 22-31} www.usa-journals.com, ISSN: 2325-4076.

INTRODUCTION

Traditional mining in Sudan provides enormous social and economic benefits, although it has adverse effects in many aspects. Traditional mining contributes to land degradation and destruction of geological structures. Human safety is severely affected by land collapses, shortage of oxygen, air pollution by mercury, silica dust, and other heavy metals [1]. There are no reliable studies for figuring out the effect of the air pollution and mercury poisoning besides the overall environmental parameters of the traditional mining in the River Nile State [2]. Gold mining is often associated with positive economic benefits such as job creation and increased standard of living; however, mining activities may also have negative impacts on the environment and human health. Gold mining activities has led to the release of toxic contaminants into the environment, it also led to the generation of large quantities of heavy metal laden wastes which are released in an uncontrolled manner, causing widespread contamination of the ecosystem [3,4] . Gold ion is toxic, affects many of systems or organs, such as nervous system, hypothalamus gland, gold chloride is toxic to all body tissues [2]. The underground work in gold mining, leads to decreased life expectancy increased frequency of cancer of the trachea, bronchus, lung, stomach, and liver. These problems are briefly documented in gold miners from Australia, South America, and Africa [5]. Gold mining activities in Nigeria resulted in the death of many children, their death was associated with poisoning associated with artisanal gold mining [6]. Traditional gold mining, using metallic mercury (Hg0) affect human health due to mercury exposure are well known with renal and neurological effects[7,8]. The target organ for inhaled mercury vapor is primarily the brain, in addition to the brain; metallic mercury is also deposited in the thyroid and may associate with thyroid dysfunction [9]. Cyanide is the chemical of choice for mining companies to extract gold from crushed ore. Cyanide is an extremely toxic substance, exposure to high levels of cyanide damage the heart and brain and can lead to death[10]. Cancer risk and non-cancer risk (hazard index) assessment showed that arsenic poses a higher risk in adults and children compared to other metals through the dermal exposure route [11]. Metals such as lead (Pb), cadmium (Cd), mercury (Hg), zinc (Zn), and chromium (Cr) are known for their persistent behavior in the environment with consequent environmental, human and animal damage [12]. These metals are easily released into the environment via anthropogenic activities [13].

Calcium (Ca) and phosphorus (P) are essential minerals found in the bone, blood and soft tissue of the body and have a role in numerous body functions. Ca binds with P and is deposited in the tissue buildup of these deposits causes calcification in the tissue, which can disrupt normal organ function [14]**.** Phosphorous level can affect Ca level in the body, and vice versa. A high P level may also result in a low Ca level [15]. Decreased ionized Ca concentrations in blood can cause neuromuscular irritability, and irregular muscle spasms, called tetany, and also impairs myocardial function [16]. Several chronic diseases are considered to be affected by high P intake, although mechanisms have not been well established [17]. Hyperphosphatemia is very common in chronic renal failure, severe infections and intravascular hemolysis[18]. Decreased intake of phosphate may cause hypophosphatemia, which increases in diabetic ketoacidosis, obstructive pulmonary disease, asthma, anorexia and alcoholism [19].

Micronutrients interact with toxic metals at several points in the body; absorption, transportation and excretion of toxic metals [20]. More lead is absorbed by people on a calcium-poor diet than by those on a calcium-rich diet [21]. Absorbed lead enters the blood and reaches the bones and soft tissues of the body, including the liver, from which it is gradually excreted [22].

The objective of this study was to measure the levels of serum calcium and serum phosphorous in traditional gold mining that may have an adverse effect on the health.

METHODS

The study site is located in the River Nile State; area of Abuhamad region as continuation of the study done by (Tayrab, 2016) [23]. This case control study was conducted among Sudanese miners working in traditional mining of gold. Eighty-three adult males who have been for more than 6 successive months in the mining area, were distributed in working areas; wells, stone mills, washing and molding. Fifty healthy individuals as control group from Khartoum state were included. An interview-administered questionnaire was completed for each of them; followed by clinical examination done by a physician. Blood samples were taken from cases and controls after administered consent form. The samples were stored in sealed polyethylene bags using labeled plain containers, then transported to the laboratory for analysis. All reagents and internal controls were obtained from Mindary & Biosystem Companies. Serum calcium and serum phosphorous were measured using automated chemical analyzer (Mindray BS-200 China). The demographics of the subjects and details of method seen in (Tayrab et al 2016) [23]. The study was approved by the Federal Ministry of Health and The National Ribat University ethical committee.

STATISTICAL ANALYSIS

Data was analyzed by computer software, by using IBM SPSS Statistics version 20. The mean and standard deviation was obtained, t test and the correlation were used for the comparison, and $p \leq 0.05$ was considered significant.

RESULTS

The study revealed that according to work position; the miners were distributed into four groups; 37 (44.6%) of miners represented wells, 27 (32.5%) represented mills, 14 (16.9%) represented washing and 5 (6%) represented molding. The study showed that, the (mean ±SD) of serum calcium in traditional gold miners was (9.4±0.5mg/dl); while it was (9.3±0.6mg/dl) among the control group with no significant difference (*P*. value = 0.407) as shown in (Table 1). The (mean ±SD) of serum phosphorous in traditional gold miners was (4.2±0.8mg/dl); while it was (3.2±0.8mg/dl) among control the group with highly significance difference (*P*. value = 0.000), as shown in (Table 1). No significant differences were seen in calcium: phosphorous ratio, (Table 2). From analysis of questionnaire the results of abnormal health signs among traditional gold miners were shown in (Table 3). Eleven abnormal clinical observations and complains were the most common as shown in (Table 2), especially cough (42.1%), headache and burning micturition (37.3%), putting in mind that a one person may complains for more than one disease or sign.

Table (1) Comparative study of calcium and phosphorous in traditional gold miners and their controls

Parameters	TGMs (N=83) (Mean ±Std)	Controls (N=30) (Mean ±Std)	P value
Calcium (mg/dl)	9.4±0.5	9.3±0.6	0.407
Phosphorous (mg/dl)	4.2±0.8	3.2±0.8	0.000

P value ≤ 0.05was considered significant

Table (2) Pearson Correlations between serum calcium and phosphorous in traditional gold miners and their controls

	Calcium/ Phosphorous	
	Exposed	non exposed
Pearson Correlation	0.022	0.139
Sig. (2-tailed)	0.846	0.337
N	83	50

Sig. (2-tailed) ≤ 0.05was considered significant.

Table (3) Abnormal health symptoms among traditional gold miners [TGMs] (n=83)

Symptoms	Responses in cases	Percent
Palpitations	27	32.5%
Burning micturition	31	37.3%
Headache	31	37.3%
Shortness of breath	25	30.1%
Constipation	17	20.5%
Weight loss	22	26.5%
Chest Pain	26	31.3%
Wheeze	17	20.5%
Excess sputum	28	33.7%
Heampotesis	6	7.2%
Cough	35	42.1.2%

DISSCUSION

Traditional gold mining is a real problem to human health and environmental consequences. The present study was done to evaluate health impact concerning assessment of serum calcium and phosphorous levels in Sudanese traditional gold miners, as a continuation of our previous studies Tayrab et al (2016) [23] & Tayrab et al (2017) [24]. Occupational exposure to mercury in traditional gold mining may be associated with thyroid dysfunction especially hypothyroidism as reported by Robin (2012)[9] and Tayrab et al (2017) [24]. In the current study; the serum phosphorous levels among Sudanese traditional gold miners show significant increase comparing with control group (*P* value = 0.000), this finding is consistent with the results reported by Jingqiu et al (2016) [25], which showed that the phosphorous levels were increased among Japanese gold miners. In this study hyperphosphatemia may be due to recurrent infection found among the study group, a similar to study, found that hyperphosphatemia is very common in severe infections as reported by Petley. (1995) [18], or the raised phosphorus levels may be due to the exposure of large amounts of toxic substances being released into the environment from mining activities. The generation of large quantities of waste that produced during mining process of gold release over 99% of extracted ore as waste to the environment as reported by Adler et al (2007) [4].

In this project using the same cases and controls Tayrab et al (2017) [24] revealed that thyroid stimulating hormone and total thyroxine significantly increase; while total triiodothyronine, free triiodothyronine and free thyroxine significantly decrease. Another study done by Reuben et al (2015) [15], showed that high phosphorous levels stimulate the release of parathyroid hormone, which can cause complications when the normal mechanism for bone mineral management does not work correctly.

However, the levels of serum calcium were not significantly different in traditional gold miners comparing with their control group (*P* value = 0.4), this finding is in agreement with a study reported by Choudhury et al (2003)[26], who found that, the calcium level was normal among gold miners. Studies done on the effect of calcium intake, found that an adequate supply of calcium protects against symptoms of cadmium toxicity as found in Rimbach et al (1995) [27]. More lead is absorbed by people on a calcium-poor diet than by those on a calcium-rich diet as written by Bremner (1978) [21]. Metals like cadmium and lead are known to act as human mutagens and carcinogens and are associated with various human ailments such as cardiovascular, nervous system, blood and bone diseases, kidney failure, gingivitis, and tremors, among others as reported by (Sun et al., 2015) [28].

No significant differences were seen in calcium: phosphorous ratio, this disagrees with previous investigations generated evidence that a low Ca:P dietary ratio may have an adverse effect on the skeleton because a high phosphorous intake leads to a chronically elevated serum parathyroid hormone (PTH) concentration which presumably increases the loss of bone mineral content and density as written by Calvo et al (1990) [29] and Kemi et al (2010)[30]. Prolonged use of a low Ca:P diet has been considered as an important risk factor that contributes to skeletal fractures as reported by Anderson et al (2006) [31] & Kemi et al (2009) [32]. Low Ca:P ratio may contribute to higher levels of serum phosphate concentration, post-intake increases of PTH secretion, increased risks of vascular pathology, a decline in bone mass and strength, and increased mortality of both men and women, even among those who are generally considered healthy Reuben et al (2015)[14].

CONCLUSION

Traditional gold mining affects the phosphorous levels among Sudanese workers in Abuhamad. A major limitation of this study is that no causal effect of a low Ca:P ratio on adverse health effects can be established. More studies are needed to assess the effects of metal wastes generated from gold mining activities on the environment and human health in Sudan.

ACKNOWLEDGEMENTS

Our thanks go to all who were participated in data collection, traditional gold miners in River Nile State, lab work especially Mohammed Abdalla Mohammed, National Ribat University administration. We would like also to thanks Prof Omer Musa for his technical support.

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