

**Original article:**

## **Serum Iron, Total Iron Binding Capacity and Electrolytes Levels in Sudanese smokers**

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### **Abstract**

**Background:** The effects of smoking on human health are serious.

**Material and Methods:** Data was collected in Khartoum area during March-June 2015, to evaluate serum iron, total iron binding capacity and electrolytes levels in smokers. Seventy cigarette smokers' aged  $37 \pm 15$  and fifty apparently healthy non-smokers  $36 \pm 53$  years were recruited in this study. Targeted parameters were estimated in blood specimen using auto analyzer (Cobas).

**Results:** Smokers showed high significant differences  $P \leq 0.05$  in Serum iron ( $162.2 \pm 54.6$ ,  $108.4 \pm 36.8$ )  $\mu\text{g/dl}$ , Sodium ( $140 \pm 3.7$ ,  $137 \pm 2.4$ )  $\text{mmol/l}$  Potassium ( $4.1 \pm 0.42$ ,  $3.7 \pm 0.23$ )  $\text{mmol/l}$ , calcium ( $9.9 \pm 0.75$ ,  $9.5 \pm 0.65$ )  $\text{mg/dl}$ , and phosphate ( $3.9 \pm 0.62$ ,  $3.2 \pm 0.46$ )  $\text{mg/dl}$ . Whilst, Total iron binding capacity was ( $254.3 \pm 53.9$ ,  $329.2 \pm 66.3$ )  $\mu\text{g/dl}$  compared to non-smoker. A scatter plot showed a significant positive correlation between serum iron level and the number of cigarettes consumed per day (p. value=0.000,  $r=0.604$ ) and duration of smoking per years (p. value=0.000,  $r=0.797$ ). Between the number of cigarette with sodium (P.value 0.000,  $r=0.506$ ) , potassium (P.value 0.000,  $r=0.385$ ), calcium (P.value 0.007,  $r=0.318$ ) and phosphate (P.value 0.002,  $r=0.36$ ), the duration of smoking with sodium (P.value 0.000,  $r=0.552$ ) and potassium (P.value 0.000,  $r=0.459$ ). While significant negative correlation found between total iron binding capacity and number of cigarettes consumed per day (P. value=0.000,  $r= - 0.499$ ) and duration of smoking per year (P. value=0.000,  $r= - 0.410$ ).

**Conclusion:** Smoking increases serum calcium, phosphate, sodium, potassium and iron concentrations while attenuating total binding capacity. These increments' are positively associated with number of cigarettes consumed per day and the duration of smoking.

**Key words:** smoking, electrolytes, serum iron, total binding capacity

## **Introduction**

There are many trace elements that directly or indirectly participate in metabolism. In addition to, more than 25% of the enzymes require metals for activation and to function properly (1). Electrolytes are essential in different contractility process, regulation of somatic blood pressure, myocardial rhythm and of adenosine triphosphate (Atpase), acid base balance and blood coagulation (2). Minerals disturbances may lead to severe and even life threatening metabolic abnormalities such as coronary heart disease, liver disease, lung infection, kidney failure, and disorders of endocrine system (3). Iron aids in the delivery of oxygen within the body through interaction with hemoglobin and myoglobin. Iron is also the main component of cytochrome C which is responsible for electron transfer within the mitochondria. Directly or indirectly, the iron status can have an effect on the ability of a cell to execute adenosine triphosphate (ATP) production and on the oxidation of glucose and other carbohydrates (4). Without iron, this oxidation is hindered, leading to the production of inactive cells. When this happens to brain cells and the nervous system, cognitive function is affected (5).

Cigarette smoking causes minerals disturbances which lead to serious consequences, like tissue hypoxia, in inadequate oxygenation of blood circulation, erythropoiesis, consequent increased production of erythropoietin (6), red cell mass above normal level (7) and the number of destroyed red cells in the normal turnover process which subsequently increases iron overload and hepatocellular damage (5). Chronic oxidative stress may modulate iron uptake and storage, leading to a self-sustained and ever increasing spiral of cytotoxic and mutagenic events (8). Smoking causes magnesium deficiency due to decreased supply (lesser appetite) and reduced absorption caused by disturbances in the digestive system functions (9).

Many people around the world die from diseases caused by smoking cigarette. Number of researches indicated that smoking has numerous immediate health effects on the liver, respiratory, cardiovascular, gastrointestinal, immune and metabolic system, lung cancer, other cancers, heart disease, and mineral disturbance (6). Nicotine make acidosis in the body (10). Only a single study was conducted in Sudanese smokers to evaluate serum iron (11) but no studies were found in evaluation of Sudanese smokers' total iron binding capacity, that's why we attempted to evaluate the levels of serum iron, total iron binding capacity and electrolytes in Sudanese smokers.

## **Materials and Methods**

During March to June 2015 one hundred and twenty adult males from Khartoum were invited to participate in this a descriptive analytical case study. Seventy cigarette smokers' aged  $37 \pm 15$  and fifty apparently healthy non-smokers aged  $36 \pm 53$  years recruited as control group. Venous blood samples were obtained to evaluate serum iron, total iron binding capacity, calcium, phosphate, sodium and potassium levels among smokers by using auto analyzer (Cobas). Correlations between estimated parameters were also calculated. Individuals with kidney diseases, anemia and iron overload, parathyroid gland disease, renal disease, acute pancreatitis, mal absorption, bone disease and liver disease had been excluded from this study.

## **Ethical consideration**

This study was conducted according to the guidelines laid down in the declaration of Helsinki and all procedures involving human subjects/patients.

Authors declare that there was not conflict of interest.

**Data analysis**

The data was analyzed by using Statistical Package for Social Sciences (SPSS), Windows version 20.

**Results**

Smokers showed high significant differences  $P \leq 0.05$  in Serum iron ( $162.2 \pm 54.6$ ,  $108.4 \pm 36.8$ )  $\mu\text{g/dl}$ , Sodium ( $140 \pm 3.7$ ,  $137 \pm 2.4$ )  $\text{mmol/l}$  Potassium ( $4.1 \pm 0.42$ ,  $3.7 \pm 0.23$ )  $\text{mmol/l}$ , calcium ( $9.9 \pm 0.75$ ,  $9.5 \pm 0.65$ )  $\text{mg/dl}$ , and phosphate ( $3.9 \pm 0.62$ ,  $3.2 \pm 0.46$ )  $\text{mg/dl}$ . Whilst, Total iron binding capacity was ( $254.3 \pm 53.9$ ,  $329.2 \pm 66.3$ )  $\mu\text{g/dl}$  compared to non-smoker. A scatter plot showed a significant positive correlation between serum iron level and the number of cigarettes consumed per day (p. value=0.000,  $r=0.604$ ) and duration of smoking per years (p. value=0.000,  $r=0.797$ ). Between the number of cigarette with sodium (P.value 0.000,  $r=0.506$ ) , potassium (P.value 0.000,  $r=0.385$ ), calcium (P.value 0.007,  $r=0.318$ ) and phosphate (P.value 0.002,  $r=0.36$ ), the duration of smoking with sodium (P.value 0.000,  $r=0.552$ ) and potassium (P.value 0.000,  $r=0.459$ ). While significant negative correlation found between total iron binding capacity and number of cigarettes consumed per day (P. value=0.000,  $r= - 0.499$ ) and duration of smoking per year (P. value=0.000,  $r= - 0.410$ ).

**Table 1 Comparison of estimate parameters between study participants**

Variable	Smokers N=(70)	Non smokers N=(50)	P.value
Serum iron( $\mu\text{g/dl}$ )	$162.2 \pm 54.6$	$108.4 \pm 36.8$	0.000
Total iron binding capacity( $\mu\text{g/dl}$ )	$254.3 \pm 53.9$	$329.2 \pm 66.3$	0.000
Sodium $\text{mmol/l}$	$140 \pm 3.7$	$137 \pm 2.4$	0.000
potassium $\text{mmol/l}$	$4.1 \pm 0.42$	$3.7 \pm 0.23$	0.000
calcium $\text{mg/dl}$	$9.9 \pm 0.75$	$9.5 \pm 0.65$	0.003
phosphate $\text{mg/dl}$	$3.9 \pm 0.62$	$3.2 \pm 0.46$	0.000

**Table 2 Correlation between estimated parameters**

	Serum iron	Total Iron binding capacity	Sodium	Potassium	Calcium	Phosphate
Number of smoked cigarettes per day	R 0.604 P 0.000	R -0.499 P 0.000	R 0.506 P 0.000	R 0.385 P 0.000	R 0.318 P 0.007	R 0.360 P 0.002
Duration of smoking per years	R 0.797 P 0.000	R -0.410 P 0.000	R 0.552 P 0.000	R 0.459 P 0.000	R 0.406 P 0.000	R 0.532 P 0.000

### Discussion

Results revealed increases in serum iron and reduction in total iron binding capacity are proportionate positively or negatively with duration of smoking per years and number of cigarettes smoked per day. These can be due to hypoxia and increase red blood cell turn over and resynthesized of newly red blood cell as result of elevated erythropoietin. On the other hand the greater number of consumed cigarettes associated with long duration is the greater induced chemicals that make a lot of biological and physiological changes. These are similar to that obtained by (10) the smokers had significantly higher serum iron. Hypoxia represents stress that induced cell growth arrest and injury that lead to acidosis and electrolyte imbalance (12). Cigarette smoke consist of many chemical including nicotine and gaseous compound carbon mono oxide was accumulate in human body with repeated smoking (10) chronic exposure to low level of carbon mono oxide result hypoxia (13). Contrary (14) who cited no significant difference in total iron binding capacity level among smokers compared to non-smoker.

A significant increase in serum sodium, potassium, calcium and phosphate found among smokers. These electrolytes correlate positively with number of consumed cigarettes per day and the duration of smoking .While iron binding capacity correlate negatively with the same parameters. These could be to the direct effect of smoking on parathyroid gland resulting in its dysfunction hence disturbances of minerals metabolism. Para thyroid hormones (PTH) and Vitamin D are two major regulators of mineral metabolism (15). Serum calcium and phosphate are regulated mainly by two hormones; the parathyroid hormone and the active form of vitamin D3 [1, 25 (oH) 2 vitD3]. The active form of vitamin D3 increases absorption of both calcium and phosphate in the intestine and also increases their reabsorption in the renal tubules and hence, increases the level of serum calcium and phosphate in plasma (16). Therefore, any interference with the action of vitamin D may lead to abnormal level of both serum calcium and phosphate (17).A previous study had shown that smokers had on average a 9% decrease of serum levels of 25OHD, and 1,25(OH)2D corresponding to 0.3 SD, and a 22% decrease of serum PTH (18) .Considerable numbers of chemical in cigarette smoke may interfere with action of the PTH. This could be by inhibiting; it's release from the parathyroid gland, its action on bone or its action on the renal tubules (19). The parathyroid hormone causes mobilization of calcium and phosphate from bone to plasma, while its action on the

renal tubules is to enhance reabsorption of calcium and loss of phosphate. The overall action of PTH is to increase serum calcium and to reduce serum phosphate (10). According to the results in this study the most likely cause is inhibition of the action of parathyroid hormone on the renal tubules and therefore increasing both of serum calcium and phosphate which agreed with (18). Measuring the level of parathyroid hormone in cigarette smokers, in addition to, urinary excretion of calcium and phosphate may help to clarify the finding in our study. Our results concerning the levels of serum calcium and phosphate in cigarette smokers, partially concert with previous studies (20,21).

The decrease in plasma potassium level among smokers can be due to glycyrrhizin acid that mimics aldosterone action which increases urinary potassium excretion (22). However, this result is synergetic to a study (10), which found an elevated plasma potassium level in chronic smoker. The insignificant decrease in plasma potassium level among the smokers group in this study may be attributed to the continuous repletion of potassium ions from intracellular compartment which contributes to correction of plasma potassium level. Longstanding intracellular potassium depletion causes extracellular alkalosis. Prolonged potassium depletion impairs the renal concentrating mechanism and may cause polyuria with potassium depletion (23,24) .

#### **Conclusion**

The levels of serum iron, calcium, phosphate, sodium, potassium, were elevated in cigarette smokers. Their levels were positively correlated with duration and the number of cigarettes consumed per day while, total binding capacity was significantly reduced.

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