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THE EFFECT OF HIGH TEMPERATURE ON SERUM ELECTROLYTES AND TRACE ELEMENTS FOR EMPLOYEES OF FURNACE IN RAMADI GLASS FACTORY

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ABSTRACT

This study includes determination of the effect of high temperature on the serum electrolytes and trace elements in thirty workers of furnace in Ramadi glass factory (Anbar – Iraq). Thirty technicians and administrators for interior control and thirty volunteers as external control. From the results of this study we observed that: K and P decreased significantly ($P< 0.01$), Mg remained within the normal value,Fe increased significantly ($p<0.01$) and Cu decreased significantly ($P < 0.01$), Zn/Cu ratio increased significantly ($P < 0.01$) . In conclusion, this study indicates that: the exposure to high temperature causes changes in the compositions of some constituents of blood.

Introduction

The electrolytes of greatest importance to cellular functions are those that release ions of sodium, potassium, calcium, magnesium, chloride, sulphate, phosphate and bicarbonate. Certain concentrations of these ions, for example, are necessary for the conduction of nerve impulses, the contraction of muscle fibers, and the maintaining the normal permeability of cell membranes, thus it is vital that their concentrations be regulated. Potassium functions to help maintain the intercellular osmotic pressure and pH. The consequence of loss may include muscular weakness, cardiac abnormalities, and edema. Phosphorous is responsible for about 1% of the total body weight. It is serves as structural component and play important role in nearly all metabolic reactions. Magnesium functions in number of metabolic reactions including many that occur within mitochondria and associated with production of ATP[(1).]

It is important in providing energy for cellular processes, and in regulation the function of the heart[(2).]

Trace elements are essential minerals that occur in minutes amounts. They include iron, manganese, copper, iodine, cobalt, and zinc. Iron functions a part of hemoglobin molecule in red blood cells and is responsible for the ability of the molecules to carry oxygen and is incorporated into a number of enzymes.

Copper is essential for the synthesis of hemoglobin, the normal development of bone and production of myelin within nervous tissue. Zinc is constituent of large number of enzymes involved in digestion, respiration and liver metabolism.

Direct association of electrolytes and trace elements in relation to human disease has been observed in many research studies. Shieh et. al.[(3)] predicted that, the heat stroke caused a reduction in calcium level in an acute renal failure in hyperglycemic people,.Heat stroke caused a decrease in potassium level in the people in Mecka[(4)] and

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Spain[5]. A study about trace metabolism in blood samples from Basrah steel casting workers exposed to high temperature revealed an increase in the level of iron and zinc but the level of copper did not change [6]. The effect of heat stress on mineral status of new born calves revealed an increase in the level of phosphorous, potassium, calcium, manganese and zinc but the level of ferrous did not changed [7].

The aim of the present study is to investigate the effect of high temperature produced by the Ramadi Glass Factory furnaces on the levels of electrolytes and trace elements in the serum of workers.

Material and Methods

This study was conducted on a total of 90 people from Anbar province, west Iraq. The study group consisted of 30 workers exposed to high temperature of furnace in Ramadi Glass Factory. The internal (first) control group consisted of 30 healthy managers in the same factory. The external (second) control group consisted of 30 healthy volunteers from outdoor of the glass factory.

The electrolytes and trace elements were determined. Inorganic phosphate and potassium levels in the serum were analyzed pectrophotometrically [8,9]. Manganese, copper, ferrous and zinc were analyzed with flame atomic absorption spectrophotometry (model PU 9100x-philips). Samples response was compared with standard solution of these inorganic compounds. The results were analyzed statically using the statistical program SPPSS Version 8 to calculate mean, SE and F value at different level of probability.

Results

Potassium concentrations decreased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls (4.2, 4.0 meq/dl for internal and external controls respectively). The concentrations were 3.8, 2.6 and 2.7 meq/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (fig.1).

Phosphorous concentrations decreased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls (3.7, 3.3 meq/dl for internal and external controls respectively . The concentrations were 2.8, 2.5 and 1.9 meq/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (fig.1).

Iron concentrations increased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls(120, 80 µg /dl for internal and external controls respectively (The concentrations were 230, 215 and 225 ug/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (f.g.2).

Magnesium concentrations decreased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls (2.1, 2.7 meq/dl for internal and external controls respectively. The concentrations were 2.7, 2.9 and 2.6 meq/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (fig1).

Copper concentrations decreased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls (74, 100 µg /dl for internal and external controls respectively. The concentrations were 55, 53, and 52 meq/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (fig.2).

Zinc concentrations decreased significantly ($p<0.01$) in the serum of the workers exposed to temperature of furnace in comparison to internal and

external controls. (150, 180 µg /dl for internal and external controls respectively The concentrations were 100,102, and 93 ug/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively (fig.2).

Phosphorous concentrations (present study) decreased in the serum of the workers exposed to temperature comparison controls. The recommended daily adult intake of phosphates 800 mg, and since this mineral is abundant in foods (such as meats, poultry, fish, cheese, nuts, whole grain cereals, milk and legumes),diets adequate in phosphorous. The reduction of the phosphorous in the serum of workers of the Ramadi Glass Factory might be due to the deficiency in food contents of the workers, because of the application economic embargo against Iraq.

DISCUSSION

The exposure of the workers in Ramadi Glass Factory to high temperature caused a lost of water as a sweat. The sweat already contains considered quantities of electrolytes and trace elements. The present study revealed that, the potassium concentrations decreased in the serum of the workers exposed to temperature in comparison to controls. Many studies have shown that men working in the heat for 8 to 12 hours on successive days can secrete up to 12 liters of sweat per day [10]. The measurements of the potassium in sweat have shown values ranging between 8 and 10 mEq/liter [11].This implies that sweat losses alone explain the development of potassium deficiency during working in the heat. It has been established by a number of investigators that potentially serious potassium deficiencies can occur in soldiers under conditions of intense, prolonged training in hot weather. It was established that long term effect of heating microclimate causes a distinct reduction of K ions in the cardiomyocytes accompanied by essential changes of ultrastructure of ischemic character [12]. The reorganization of Wistar rat myocardium at 3 and 7 days after a single total overheating at a temperature of 43 degrees C was studied. At 7 day after exposure,a significant decrease of the heart weight as a result of atrophic changes in cardiomyocytes was recorded [13].

Magnesium concentrations decreased in the serum of the Glass Factory workers exposed to temperature of furnaces in comparison controls. These reductions can be attributed in part to an increased rate of magnesium loss via sweat, which could be significantly amplified in hot environments.The excessive sweating could result in a loss of magnesium from the body is consistent with the work of Consolazio et al. [14] who found that, under normal conditions, sweat loss accounted for over 12 percent of the total daily excretion of magnesium in men orking in temperatures of 49° to 50°C. It was reported that serum magnesium concentrations in marathon runners immediately following a race were significantly lower than preface values, a phenomenon that was attributed to sweat losses of the element during the run [15]. In addition to an

increased loss of magnesium via sweat, urinary magnesium loss increased after an intense exercise [16,17]. Although the reduction in plasma magnesium may be due in part to an increased rate of magnesium loss from the body, redistribution of magnesium from the plasma pool into other sites (as muscles) may also contribute to exercise-induced decreases in plasma magnesium [18]. Redistribution of serum magnesium into red blood cells [16] and into adipocytes [19] with exercise has also been observed.

Copper concentrations decreased in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls. Similar results was reported by Resina et al. (20), he found

that, plasma copper concentrations were lower in long-distance runners than in sedentary controls, and it was found that plasma copper concentrations and ceruloplasmin activity decreased in competitive swimmers over a 6-month period [21].

Uhari et al.[22] found that plasma copper concentrations decreased in male and female subjects following exposure to hot temperatures in a sauna bath. Consolazio et al. [23]) reported that the amount of copper lost via sweat can be considerable; men who were maintained at 37.8°C and 50 percent relative humidity lost as much as 1 mg per day in sweat. On the other hand it was found that the acute, strenuous exercise result in a marked increase in plasma copper concentrations, which has been attributed to an increase in plasma ceruloplasmin concentrations [24]. In contrast to reports of increased plasma copper concentrations, Anderson et al. [25] reported that plasma copper concentrations were similar in men prior to and after completing a 6-mile run; Lukaski et al. [26] reported no influence of training on plasma copper concentrations in elite swimmers, and Singh et al.[27] observed no change in plasma copper concentrations in men engaged in intense physical activity over a 5-day period.

Reasons for the above differences in reported effects of exercise on plasma copper concentrations are various, including differences in copper status of the subjects; type, intensity, and duration of the exercise; physical condition of the individual; and extent of exercise-induced tissue trauma. Presumably, increases in plasma copper occur primarily when there is tissue damage that triggers an acute-phase response. However, note that in the study by Singh et al. [27], despite evidence of significant tissue damage, plasma copper concentrations were not elevated.Additional studies are needed that define the mechanisms underlying exercise-induced increases in plasma copper concentrations.

Zinc concentrations decreased in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls. It has been reported that, reductions in plasma zinc concentrations were also observed in men who participated in a training course [27]. The authors attributed the reduction in plasma zinc primarily to a redistribution of plasma zinc into liver as a consequence of metallothionein synthesis, Lichton et al.[28] observed a reduction in plasma zinc concentrations in soldiers engaged in a 34-day field exercise at an elevation of 1800 m. Other investigators have been reported that, the exposure to high temperature can result in a stimulation of the changes in zinc metabolism [29]; sweat losses of zinc can range from 0.5 to 1 mg per liter [30]. Thus a synergistic effect of exposure to exercise and heat would be predicted. On the other hand, it was found that, the plasma zinc concentrations can increase during strenuous exercise [31]. Following the cessation of exercise, there is a rapid drop in plasma zinc levels back to preexercise concentrations . It is thought that this postexercise drop in plasma zinc is due to a urinary excretion of the element coupled with a shift in the distribution of the element from the plasma into the liver [32]. The shift of zinc from the plasma into the liver is thought to be in part of response to increase in liver metallothionein concentration, which can result in a sequestering of zinc in the liver [33].

Iron concentrations increased in the serum of the workers exposed to temperature of furnace in comparison to internal and external controls. The concentrations were 230, 215 and 225 ug/dl of serum of the workers of container furnace, plate furnace and bottle furnace respectively. The increase in the iron level in the serum may be due to the destruction of the

erythrocytes under effect of high temperature of furnace. It was reported that anemia can be associated with a diminished performance in maximal and submaximal physical exercise (32). On the other hand it has been suggested that high levels of physical activity to cause "sports anemia" (typically defined as a drop in hemoglobin concentration, hematocrit, and red blood cell count; (34). The phenomenon of sports anemia has been associated with increased erythrocyte destruction, depressed iron absorption, increased sweat loss of iron, and gastrointestinal blood loss (35).

In conclusion, the hot environment caused by furnaces was found to affect the electrolytes and trace elements in the serum of the workers in the Ramadi Glass Factory. Further investigations in different physiological aspects might be help in the understanding the requirements of the workers in hot environment. Example of these investigations, nutrition, fluid intake, specific vitamins, minerals, thermoregulation, metabolism and their related to the exposure to high temperatures emitted from the furnaces.

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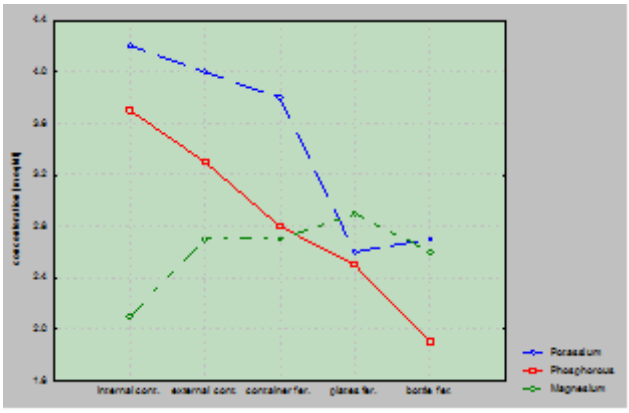

Fig. 1. Levels of electrolytes in the serum of the workers and controls.

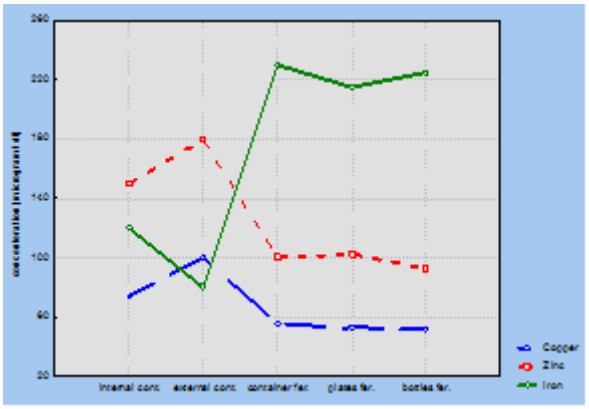

Fig. 2. Levels of trace elements in the serum of the workers and controls.

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تأثير ارتفاع درجات الحرارة على الشوارد والعناصر النادرة لمصل دم العاملين في أفران معمل زجاج الرمادي

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الخلاصة:

تَتضمّنُ هذه الدراسةِ تحديدَ تأثيرِ درجةِ الحرارة العاليةِ على العناصر النادرة والشوارد في مصل الدم في ثلاثين مِنْ عُمّالِ الأفران في معمل زجاج الرمادي – العراق وثلاثون فنيا للسيطرةِ الداخليةِ وثلاثون متطوّعاِ كسيطرة خارجية. مِنْ نَتائِجِ هذه الدراسةِ لاحظنَا: البوتاسيوم والفسفور نَقصَ بشكل ملحوظ (p <٠,٠١)، Mg بَقى ضمن القيمة الطبيعية، زادَ Fe بشكل ملحوظ (p<0.01) ونَقصَ Cu بشكل ملحوظ (p<٠,٠١)، زادتْ نسبةَ Zn /Cu بشكل ملحوظ (p <٠,٠١). هذه الدراسةِ تُشيرُ إلى ان التعرّض إلى درجةِ الحرارة العاليةِ يودي الى تغيير في تراكيبِ بَعْض مكونات الدمِّ.