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Effect of Direct Sun Heat Exposure on Creatinine & Creatine Kinase Level

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ABSTRACT

Illnesses associated with high environmental temperatures include; heatstroke (hyperthermia), heat exhaustion, heat syncope (fainting), and heat cramps, transient heat fatigue. The objective of this study was to estimate the levels of creatinine and creatine kinase (CK) in people who work under direct sun heat exposure, and assess the changes that can be caused. A descriptive, case-control study was conducted in Sudan, Khartoum State, during the period of May to August 2013. A total of 81 males – both case and control subjects – were studied, in which 50 males (61.7%) were the test subjects, which were bankers, and working under cold, air conditioned environment, thus there were not exposed to sun heat. Blood samples from each subject were taken and analyzed for creatinine concentrations and CK activities using spectrophotometeric method. In the test group, the mean ± S.E of creatinine and CK were 0.95 ± 0.13 mg/dl and 201±22 U/L respectively. The mean ± S.E of creatinine and CK in control group were 0.86±0.02 mg/dl, 92±12 U/L respectively. There was significant difference between the means of serum creatinine(*p* value of 0.004)and CK(0.00) levels, among the test group compared to the control group. This study concludes that, there is an effect of heat exposure on serum creatinine and serum CK levels causing an appropriate elevation, due to a mild injury to the body, caused by the heat stress. Further studies should be conducted for assessment of the heat stress effect on the body's systems.

Key words: Sun heat – Creatinine – Creatine kinase – Sudanese.

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INTRODUCTION

Environmental factors in work place will affect the body's ability to probably maintain itself. A humid environment, without air movement will slow heat loss from the body by reducing evaporation. A Mild form of heat stress may cause irritability, decreased morale, increased anxiety and inability to concentrate[1]. Heat is a physical hazard that can pose a problem in almost any work place especially during the warm months[2, 3]. Working in hot environments without being adequately acclimated or cooled increases a worker's heat load and thermal stress [(4)]. When this happens, the buildup of heat can impair worker performance, increase accident risk and cause illness or even death[1]. Health effects associated with exposure to extreme and prolonged heat appear to be related to environmental temperatures above those to which the population is accustomed[5]. Environmental heat exposure can cause illness, injury, and death[6]. Transient heat fatigue refers to the temporary state of discomfort and mental or psychological strain arising from prolonged heat exposure. Workers unaccustomed to the heat are particularly susceptible and can suffer to varying degrees. For instance they can suffer a declined task performance, or incoordination, decreased alertness, and low vigilance. The severity of transient heat fatigue will be lessened by a period of gradual adjustment to the hot environment (heat acclimatization)[7, 8]. Creatinine is the cyclic anhydride of creatine that is produced as a final product of decomposition of phosphocreatine. It is excreted in the urine; measurements of excretion rates are used as diagnostic indicators of kidney function[9]. Creatine kinase (CK), also known as phosphocreatine kinase or creatine phosphokinase (CPK) in an enzyme (E C 2.7.3.2) expressed by various tissue types[9, 10]. It is a dimeric enzyme with a molecular weight of 82 kDa [(9, 11)]; CK activity is greatest in striated and heart tissue, which contain some 2500 and 550 U/g of protein, respectively. Other tissues, such as brain, gastrointestinal tract, and urinary bladder, contain significantly less activity, and the liver and erythrocytes are essentially devoid of activity[9]. The objective of this study was to estimate the levels of creatinine and creatine kinase in people who work under direct sun heat exposure, and assess the changes that can be caused.

MATERIALS AND METHODS

The present study is a descriptive, case-control study design, to examine the relationship between the levels of creatinine and CK kinase and the exposure to sun heat along with the environmental hyperthermia that can be caused. The study was conducted in Khartoum State, Sudan, during May to August 2013. People who work under direct sun heat were the test subjects of the study. Two typical groups were chosen randomly, one which was traffic policemen [n=29 (58%)], and the other was constructors [n=21 (42%)], a total of 50, all of them are categorized as subjects exposed to sun heat. The other group was chosen as a

control group (n=31), almost having the same characteristics of the test group, but they only differ in the work environment. The control group subjects work under good ventilated, cool environment, and were categorized as non-exposed to sun heat.

Samples collection

This research project has received an ethical clearance from the Sudan federal ministry of health, health research ethics committee. The prospective participants were interviewed and their willingness to participate in this research project was discussed in a simple language. Signed consents were obtained from the participants. Samples were collected from the three groups (2 test group and a control group) using a tourniquet, and applying local antiseptic for the skin (70% ethanol), a venous sample from each volunteer was collected (5 ml) from the forearm directly into a test tube for clot formation. Serum was separated after clot retraction by centrifugation for 5 min. at 3000 rpm, then collected by means of micropipette in a tightly sealed container and stored at -20^{o} c. Assays for serum creatinine and serum CK were performed in batches within one month using methods indicated in the following sections.

Data collection

Clinical data were obtained from the history and recorded on a questionnaire sheet explaining the personal information, duration of exposure to sun heat or good ventilation and other medical and clinical histories, considering the absence of any predisposing factors. The serum creatinine and creatine kinase were measured using spectrophotomeric method. This method used is based primarily on the reaction with alkaline picrate that was first described by Jaffe in 1886[9, 11].

Statistical analysis

An appropriate descriptive and analytical procedure was followed using SPSS package (version 11.5). Independent t-test was applied to compare the mean level of creatinine and creatine kinase between test group who are exposed to sun heat, and control group who are not exposed to sun heat. ANOVA test was applied to compare the mean level of creatinine and creatine kinase between the constructors, police control policemen and the bankers (the control group). The level of significance was expressed as p value of < 0.05 for significant, and p value of < 0.01 for highly significant when using t-test and ANOVA tests.

RESULTS AND DISCUSSIONS

The age of the individuals in the study group was between 19-56 years, with an average of 29 ± 7.7 years. The age of the individual in the control group was between 21-43 years, with an average of 31± 4.6 years. The results obtained were statistically analyzed, using the t-independent test and ANOVA test. The level of significance was expressed as p value of $<$ 0.05 for significant, and p value of < 0.01 for highly significant. Figures (1) and (2) illustrate

the means of serum creatinine and CK respectively, among the three groups, traffic policemen, constructors, and bankers. The mean values for creatinine concentration were 0.99 mg/dL for the traffic policemen, 0.89 mg/dL for the constructors, and 0.86 for the bankers. While the mean values for the CK activity was 131 U/L for the traffic policemen, 297 U/L for the constructors, and 92 U/L for the bankers. Table (1) shows the means of serum creatinine, the standard error of mean (S.E), of the test group and control group, and the p values, indicating the difference between the means among the two groups. Table (2) shows the means of serum CK, the standard error of mean, of the test group and control group, and the p values, indicating the difference between the means among the two groups. Table (3) shows the means, and standard error of mean of serum creatinine, and the p values among the three groups, traffic control policemen, constructors, and bankers. Table (4) shows the means, and standard error of mean of serum CK and the p values among the three groups, traffic control policemen, constructors, and bankers.

Table 1: Comparison of means of serum creatinine between test and control groups

Variable	Test group (exposed) n=50	Control group (non-exposed)) n= 31	P value
Serum creatinine level mg/dL	0.95± 0.02 (0.93-0.97)	0.86±0.02 (0.84-0.0.88)	0.004

*The mean difference is significant at the 0.05 level.

The table shows the mean ± S.E, range in brackets ( ) and probability (p) value.

Table 2: Comparison of means of serum CK between test and control groups.

Variable	Test group (exposed) n=50	Control group (non-exposed)) n= 31	P value
Serum Creatine Kinase Level U/L	201±22 (179-223)	92±12 (80-104)	0.00

*The mean difference is significant at the 0.05 level

The table shows the mean ± S.E, range in brackets ( ) and probability (P) value.

Table3: Multiple Comparison (ANOVA) of serum creatinine means between the traffic control policemen, constructors, and control groups.

Groups	Number	Mean	Standard Error	P value
Traffic Policemen	29	0.99	0.04	0.02
Constructors	31	0.89		
Traffic Policemen	29	0.99	0.03	0.00
Bankers	31	0.86		
Constructors	21	0.89	0.04	0.87
Bankers	31	0.86		

*The mean difference is significant at the 0.05 level.

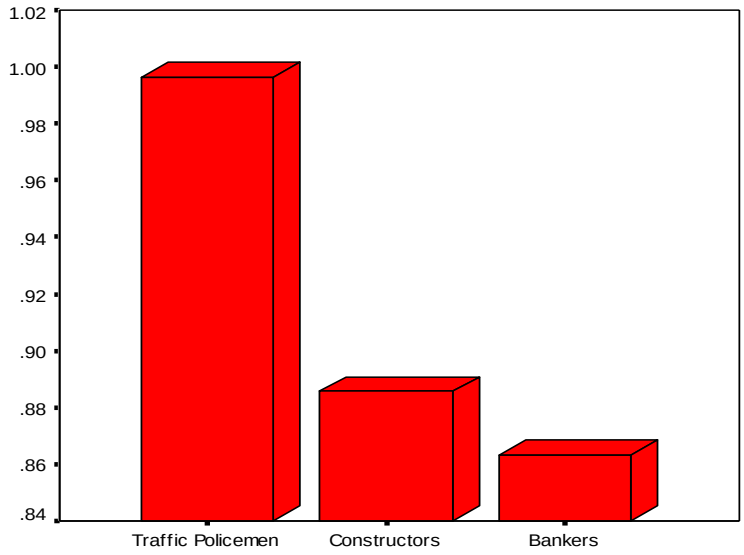

Figure 1: Mean concentrations of serum creatinine level among the traffic control policemen, constructors, and control groups.

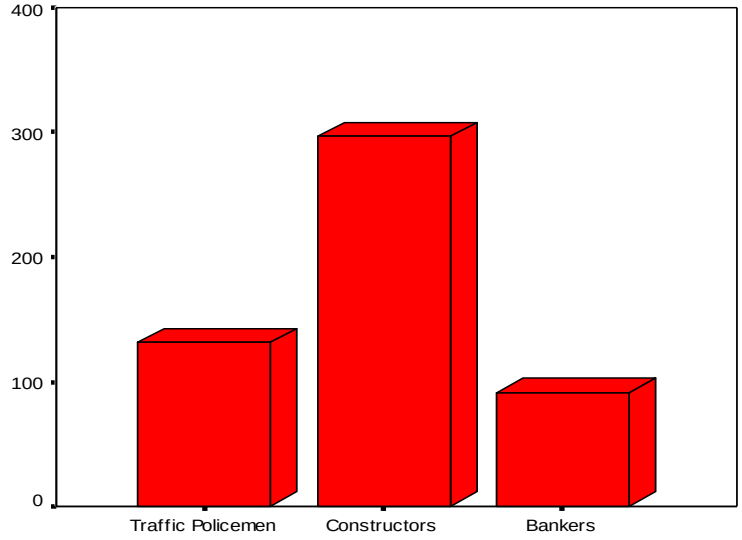

Figure 2: Mean concentrations of serum CK level among the traffic control policemen, constructors, and control groups.

Table 4: Multiple Comparison (ANOVA) of serum CK means between the traffic control policemen, constructors, and control groups.

Groups	Number	Mean	Standard Error	P value
Traffic Policemen	29	131	43	0.002
Constructors	31	297		
Traffic Policemen	29	131	19	0.12
Bankers	31	92		
Constructors	21	297	42	0.00
Bankers	31	92		

*The mean difference is significant at the 0.05 level

The study was carried out in order to estimate the predictors of development of any heat related illness among people who work under direct exposure to sun heat, in this extremely hot climate. This prediction was believed to be achieved through the identification of direct sun heat exposure on creatinine level, which is a good indicator for renal impairment, as well as, the level enzyme creatine kinase which is an indicator for muscle damage and rhabdomyolysis that can leads to renal failure. The data and results obtained by applying the statistical comparison of the means of the two groups, using the t- independent test and ANOVA test. The t- independent test showed that, the mean concentration of serum creatinine was 0.95 ± 0.13 mg/dl for the test group, and 0.86 ± 0.11 mg/dl for the control group, with a p value of 0.004, indicating the significant difference between the groups. Therefore, there is a significant difference between the means of creatinine level of the test group compared to the control group. This is evidence that the heat exposure has a direct effect on the creatinine level causing an appropriate elevation which could be attributed to effect of dehydration caused by the exposure to heat. There is a significant elevation of the CK activity in the test group compared to the control group. The t- independent test also showed that, the mean level of serum CK was 201 ± 156 U/L for the test group, and 92 ± 65 U/L for the control group, with p value of 0.00. This may be because the prolonged heat exposure affected the muscles, causing muscle infarction as well as its fatigue. Another theory could be attributable to the elevation of CK level is that the elevated CK level can be caused by the ATP depletion that is caused by heat exposure. The heat exposure eventually causes the enzymes leakage from the cells due to their membranes damage. According to the ANOVA test results, the mean level of serum creatinine was 0.99 ± 0.11 for the traffic control policemen, 0.89 ± 0.13 for the constructors, and 0.86 ± 0.11 for the bankers. Therefore, there is a high significant difference among the traffic control policemen compared to bankers, where the p value was 0.00, as well as, the significant difference observed in the means among the traffic controller policemen compared to the constructors, where the p value was 0.02, which could most probably attributed to their longer duration of exposure to sun heat**.** There is no significant difference among the constructors compared to bankers. The ANOVA test results also showed that, the mean level of serum CK was 131 ± 80 for the traffic control policemen, 297 ± 183 for the constructors, and 92 ± 65 for the bankers. Therefore, there is a high significant difference have been observed in the means of the CK activity levels among the constructors, compared to the traffic control policemen, where the p value was 0.002, which is most probably attributed to the muscles injury caused by the high intensive activity performed by the constructors. There is also high significant

difference among the constructors compared to bankers, where the p value was 0.00 that is attributable to the heat exposure effect on the constructors, being discussed before. There was no significant difference between the traffic control policemen compared to bankers. In comparison to a previous study, which was conducted to describe the characteristics and outcomes of patients who were presented to the emergency department with presumed environmental hyperthermia, the results of the creatinine level were > 1.5 mg/dL in 40.4% of the patients, and the CK activity levels of more than 200 U/L in 67.3% of the patients [(92)], it seems that there is an agreement to an extent between the present study and the previous study in the CK levels only, but not in the creatinine level, another factor should be considered that, in the mentioned study the subjects were at the final stage of the hyperthermia, while in the present study they are not yet reached that stage , these conclude that there could be predictors of damages that could be imposed by the exposure to sun heat. There is a sort of agreement with other studies conducted on people exposed to heat stress and working with high intensive activity, where elevated values of creatinine was observed, as well as CK activities[12, 13, 14]. Therefore, evidences are increasing showing the effect of heat exposure on creatinine and CK levels, causes their elevation. Still more studies should be done for evaluation of the severity and the possibility of development of heat stroke which is the fatal stage in heat related illness. Hot summer weather cannot be prevented. However morbidity and mortality related to summer heat can be reduced by reducing heat stress effects and risk factors. One of the best ways to reduce heat stress is to minimize heat exposure in the workplace. However, there are some work environments where heat exposure is difficult to control as when the work place itself is outdoors and exposed to varying hot weather conditions. Community and government in Sudan must recognize the impending problem of the high ambient temperature during summer promptly. Moreover, there is increasing evidence shows that the global temperature is in a continuous increase.

CONCLUSION

This study concludes that, there is an occupational heat related conditions. For example impairments in the body's system causing an appropriate elevation in creatinine as well as CK levels. The risk of unintentional injuries increases substantially with exposure to heat stress.

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