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HEAVY METALS (LEAD, CADMIUM AND ZINC) ANALYSIS IN THE URINARY SAMPLES OF ACTIVE AND PASSIVE CIGARETTE SMOKERS IN SOUTH WEST, NIGERIA

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ABSTRACT

Several heavy metals found in cigarette smoke accumulate in body tissues and fluids and are very harmful to both active and passive cigarette smokers. The aim of this study was to analyze cadmium, lead and zinc in the urine samples of active and passive cigarette smokers in South-West Nigeria. About 10 ml of freshly voided urine sample was collected into a sterile universal container from each of the 250 active cigarette smokers and 200 passive cigarette smokers that live in south-West, Nigeria. The urine specimens were processed to determine the levels of cadmium, lead and zinc metals using atomic absorption spectrophotometer. There was a significant increase in the levels of urinary cadmium, lead and zinc among active cigarette smokers when compared with passive cigarette smokers (P<0.001). Cadmium was significantly raised among male active cigarette smokers when compared with female active cigarette smokers (P = 0.03). The measured urinary zinc level of passive cigarette smokers was significantly raised in male when compared with their female counterpart in this study (P=0.003). Cigarette smoking has been seen to be one of the major sources of inhaling heavy metals which are toxic and capable of causing oxidative stress to both active and passive cigarette smokers. The accumulation of these toxic heavy metals over time, can cause DNA damage and consequently result to degenerative diseases.

Keywords: Cadmium, Lead, South-West, Zinc.

INTRODUCTION

Cigarette smoking is one of the most important causes of preventable morbidity and premature death worldwide (Hajek et al. 2014). It is widely acknowledged that cigarette smoke is also the most important risk factors for some cancers (Arcavi and Benowitz, 2014). Cigarettes are ignited and inhaled, usually through a cellulose acetate filter, into the mouth and lungs (Hajek et al. 2014). Smoking related diseases are ultimately the results of nicotine addiction which leads to the repeated inhalation of a variety of toxicants in cigarette smoke including nitrosamines, polycyclic aromatic hydrocarbons, volatile organic compounds and several other toxic heavy metals (Djordjevic and Doran, 2009). The most important identified chemicals causing cancer are those that produce DNA damage, since such damage appears to be the primary underlying cause of cancer (Travis et al. 2006). These cancer-causing chemicals include: acrolein, formaldehyde, acrylonitrile, 1,3-butadiene, acetaldehyde, lead, phenols, benzopyrenen nitric oxides, polonium, radium, thorium, isoprene, aromatic amines, arsenic, benzene, benzo(α) pyrene, beryllium, cadmium, chromium, ethylene oxide, nickel polonium-210, Polycyclic aromatic Hydrocarbons (PAHs) and tobacco-specific nitrosamines (Centers for Disease Control an Prevention (US), 2010). Heavy metals are the most common and hazardous environmental pollutants and they have relatively high densities of more than $5g/cm^3$ (Muhammad, 2012). To a small extent, heavy metals enter the body through food, drinking water and air (Muhammad, 2012). Some heavy metals are essential nutrients (typically iron, cobalt and zinc) or relatively harmless (such as ruthenium, silver and indium) (Muhammad, 2012). However, at higher concentration, this can lead to poisoning (Muhammad, 2012). Heavy metals like cadmium, mercury and lead are highly dangerous and poisonous because they tend to bio-accumulate (Patricia et al. 2009). Potential sources of heavy metal poisoning include mining, industrial wastes, occupational exposure, tobacco smoke and etc (Patricia et al. 2009). The presence of trace amounts of metals in tobacco smoke has been known for some time. Most commonly associated with health effects include arsenic (As), chromium (Cr), lead (Pb), nickel (Ni), cadmium (Cd) and all these metals are carcinogenic to humans by the International Agency for Research on Cancer (De-Sousa et al. 2011). The level of exposure to these heavy metals in a cigarette smoke is small and is likely not acutely toxic, but the toxicological effects depend on the number of cigarette sticks an individual can smoke per day and the number of months, years and decades an individual has been smoking (Dorne et al. 2011). Smoking is the main source of cadmium intake by humans (Rodgman and Perfetti, 2013). The cadmium concentration has an average of 1000 to 3000?µg/kg per cigarette base on different brands. When a cigarette is being smoked, cadmium is transformed to cadmium oxide, which is then inhaled (Rodgman and Perfetti, 2013). Approximately 10% of the cadmium is deposited in the lungs and 20-50% is transferred to the circulation (Rodgman and Perfetti, 2013). Cadmium does not only accumulate in the circulation but also in the kidneys, mainly in the kidney cortex where metallothioneins chelate cadmium and immobilize it (De-sousa et al. 2011). A number of studies have also shown that the accumulation of cadmium in kidneys can cause tubular dysfunction and renal end stage failure (De-sousa et al. 2011). Cadmium toxicity has been linked to the genesis of cancers of the breast, prostate, colon, rectum, kidney and the lung (De-sousa et al. 2011). Lead is a highly toxic metal and is capable of causing serious effects on the brain, nervous system and red blood cells (Galazyn-Sidorczuk et al. 2008). Though cigarette smoking is not the main source of lead uptake by humans but the contribution of smoking to the total lead load in humans have become increasingly relevant (Galazyn-Sidorczuk et al. 2008). The lead content of a cigarette is about 1.2µg and about 6% passes over to mainstream smoke which is inhaled by smokers (Galazyn-Sidorczuk et al. 2008).

Zinc is an essential heavy metal in the human body and its homeostasis reflects a balance between absorption of dietary zinc and loss of zinc from the body (Murgia et al. 2006). Zinc is highly needed for the functional integrity of many organ systems, as well as for growth development and tissue repair (Murgia et al. 2006). On the other hand, excessive exposure to zinc can be harmful and can have pathological consequences (Murgia et al. 2006). Due to the heavy metals present as part of the constituents of a cigarette stick, there is need to know their effects on the urinary cells of active and passive cigarette smokers in south-western Nigeria. The aim of this study was to analyze cadmium, lead and zinc in the urine samples of active and passive cigarette smokers in South-West Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted in south-west states in Nigeria namely: - Ondo, Ekiti, Osun, Oyo, Ogun and Lagos States. South Western States are known to be the Yoruba speaking region but with different Yoruba dialects.

Study Population

Subjects recruited for this study were 250 active cigarette smokers and 200 passive cigarette smokers from South-Western States in Nigeria. The 250 active cigarette smokers were recruited from various parks and joints in the 6 states of south-west Nigeria. The 200 passive cigarette smokers were apparently healthy age matched males and females who are non-tobacco smokers and users, and have no history of renal diseases were recruited from schools and offices. Participants for this study included both males and females between the ages of 25 years to 65 years and above. Subjects that refused consent and those that are less than 5 years in cigarette smoking were excluded from this study.

A well-structured questionnaire bothering on bio-data and socio demographic characteristics was administered to every subject prior to specimen collection. The protocol for this study was approved by the Ethics and Research Committees of Ministry of Health, Ado Ekiti; Osogbo, Osun State; Ibadan, Oyo State and Akure, Ondo State with the approval no MOH/EKHREC/EA/P/11; OSHREC/PRS

/569T/181; AD13/479/4046B and OW/380/VOL.CX/150 respectively.

Specimen Collection and Processing

Freshly voided urine sample of 10ml was collected from every active and passive cigarette smokers at early hour of the day into sterile universal bottles, transported to the Department of Medical Laboratory Science, Afe Babalola University, Ado Ekiti, where the samples were analyzed for heavy metals (lead, cadmium and zinc) using an Atomic Absorption Spectrophotometer. The analytical method used for the analysis of heavy metal concentration was spectrometry and the equipment used was atomic absorption spectrophotometer (AAS) (Buck Scientific Model 210 VGP) using the calibration plot method. Three processes were involved; standard preparation, equipment calibration and sample analysis. For each element, the instrument was auto-zeroed using the blank (distilled water) after which the standard was aspirated into the flame from the lowest to the highest concentration. The corresponding absorbance was obtained by the instrument and the graph of absorbance against concentration was plotted. The samples were analyzed with the concentration of the metals present being displayed in parts per million (ppm) after extrapolation from the standard curve (Cerulli et al. 2006).

Statistical Analysis

Statistical analysis for Social Sciences (SPSS) version 25 was the statistical package used in analyzing all data obtained in this study. Student T test, Pearson correlation and Chi-Square were used to compare the means of the different analyses at P<0.05 statistical significance.

RESULTS

Table 1.0: Relationship between cadmium, lead and zinc levels among active and passive cigarette smokers.

Parameters	Active Smokers (n=250)	Passive Smokers (200)	P value
Cadmium (Cd)	0.16± 0.11	0.06±0.02	0.0001
Lead (Pb)	0.23±0.12	0.13±0.10	0.0001
Zinc (Zn)	0.63±0.53	0.34±0.27	0.0001

*Significant at P < 0.0001

There was a significant increase in cadmium, lead and zinc levels in the urine of active cigarette smokers when compared with that of passive cigarette smokers (P < 0.0001) (Table 1.0).

Table 2.0: Comparison of some heavy metals levels with gender of active cigarette smokers.

Parameters	Male (n=223)	Female (n=27)	P value
Cadmium (Cd)	0.17±0.12	0.05±0.03	0.03
Lead (Pb)	0.23±0.12	0.22±0.10	0.95
Zinc (Zn)	0.64±0.55	0.56±0.29	0.51

*Significant at P < 0.05

Cadmium level was significantly raised among male active cigarette smokers when compared to female active cigarette smokers (P = 0.03). The levels of lead and zinc were slightly raised among male active cigarette smokers in comparison with female active cigarette smokers. However, this was not statistically significant (P>0.05) (Table 2.0).

Table 3.0: Comparison of some heavy metals parameters with gender of passive cigarette smokers.

Parameters	Male (n=162)	Female (n=38)	P value
Cadmium (Cd)	0.07±0.03	0.06±0.02	0.190
Lead (Pb)	0.14±0.10	0.11±0.07	0.181
Zinc (Zn)	0.37±0.29	0.22±0.11	0.003

Significant at P < 0.05

The urinary zinc level of passive cigarette smokers was significantly elevated among males when compared to their female counterparts (P=0.003). The levels of cadmium and lead were not significantly elevated among passive cigarette smokers in south-western states of Nigeria (P>0.05) (Table 3.0).

Table 4.0: Correlation between Cadmium, Lead and Zinc among active cigarette smokers.

Heavy metals parameters	Cadmium r (p)	Lead r (p)	Zinc r (p)
Cadmium	1	0.131 (0.04)	0.114 (0.07)
Lead	0.131 (0.04)	1	0.126 (0.05)
Zinc	0.114(0.07)	0.126 (0.05)	1

The level of lead in urine was significantly correlated with zinc (0.126, 0.05) and cadmium (0.131, 0.04) among active cigarette smokers in the south-western states, Nigeria. Zinc did not significantly correlate with cadmium (0.114, 0.07) among active cigarette smokers in south-western Nigeria (Table 4.0).

Table 5.0: Correlation between Cadmium, Lead and Zinc among passive cigarette smokers.

Biochemical parameters	Cadmium r (p)	Lead r (p)	Zinc r (p)
Cadmium		.024 (0.73)	.071 (0.32)
Lead	.024 (0.73)		.178(0.01)
Zinc	.071 (0.32)	.178 (0.01)	1

The Lead and zinc, cadmium vs lead levels in urine of passive cigarette smokers significantly correlated (0.178, 0.01; 0.136, 0.06 respectively) in this study. In contrary, zinc and cadmium (-0.071, 0.32) did not correlate strongly (Table 5.0).

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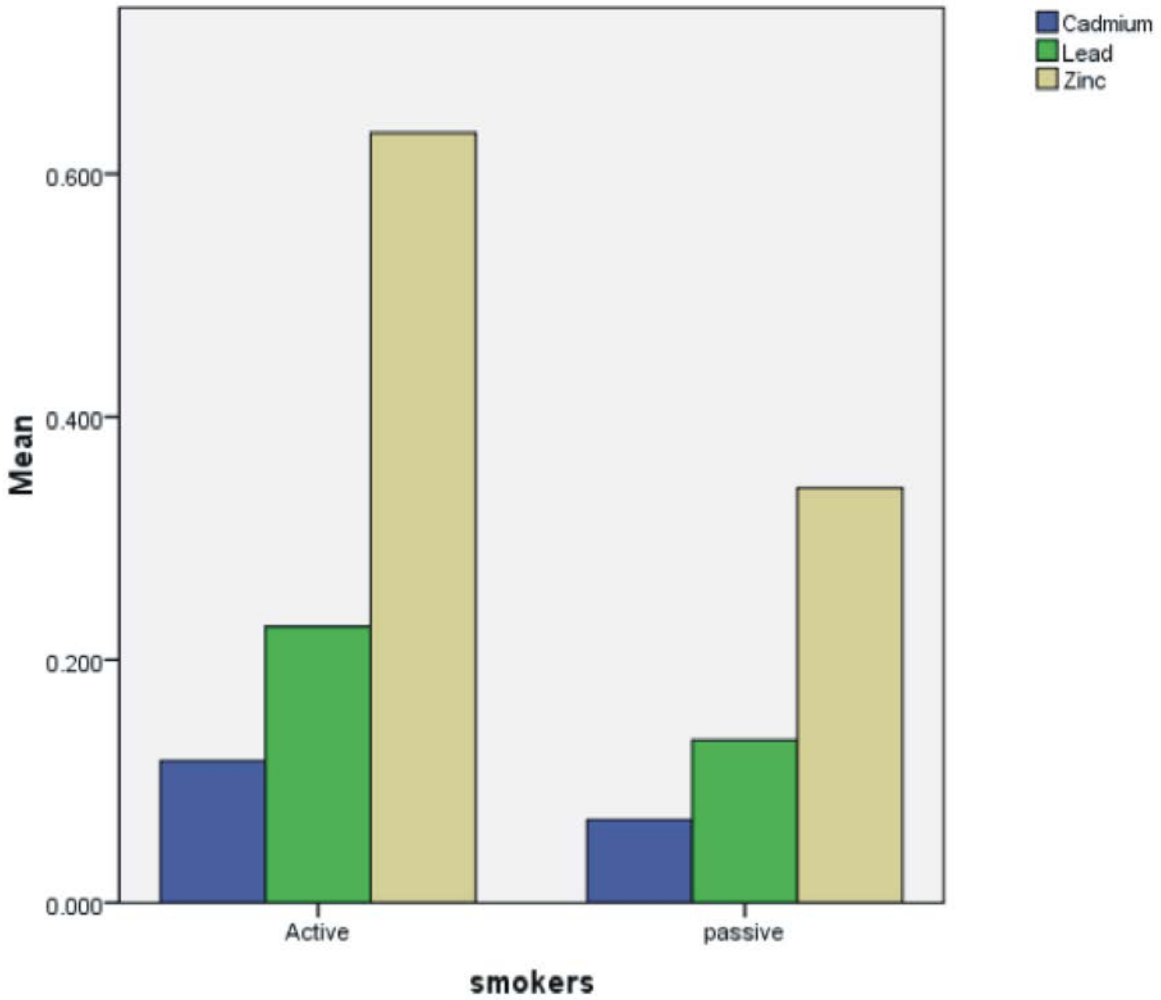

Figure 1.0: Comparison of the levels of some selected heavy metals between active and passive cigarette smokers.

DISCUSSION

Heavy metals present in cigarette smoke when inhaled are accumulated in body tissues and fluids and are of public health concern because of their potential toxicity and carcinogenicity (Wright, 2013). Lead and Cadmium are metallic chemical elements that have a relatively high density and are toxic to humans (Muhammad, 2012). Zinc being an essential trace element, plays an important role in normal metabolism, acts as anti-inflammatory factor and assists more than 200 enzymatic reactions. However, high intake of zinc over a long period can cause chronic zinc toxicity, suppress the immune system, making an individual more likely to develop ill health conditions(Muhammad, 2012).

This study revealed significant increase in the urinary cadmium, lead and zinc levels of active cigarette smokers when compared with that of passive cigarette smokers (P=0.0001). This observation is in tandem with the report of Patricia et al. (2009) that measured the urinary metals of tobacco (cigarette) smokers and that of non-smokers among some youths and Adult Population in the United States of America where a significant increase was revealed in the urine samples of cigarette smokers.

Studies have revealed that approximately 12% of the lead present as part of the constituents of a cigarette sticks enters the smoke and half of these are believed to enter the lungs of a cigarette smoker where it is absorbed into the blood stream. About 72% of zinc and cadmium present as part of the constituents of a cigarette are inhaled during cigarette smoking (Satarug et al. 2004; Bamgbose et al. 2007).

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Prolonged exposure to lead, zinc and cadmium are associated with multiple health hazards which may also lead to various metabolic and renal disorders. The increase in zinc, cadmium and lead level among active cigarette smokers carried out in this study is in agreement with the report of Hatem et al. (2013) that observed higher concentrations of lead and zinc among cigarette smokers than that of non-cigarette smokers.

Cadmium level in the urine of active cigarette smokers were significantly raised among male when compared to their female counterparts ($P<0.05$). Previous studies have revealed that good dietary habit like consumption of fruits and vegetables that are rich in antioxidant can lower the concentration of cadmium in the body tissues (Kim et al. 2010). The fibre inhibits the gastrointestinal absorption of cadmium, possibly due to the formation of insoluble complexes with phytates in the intestine (Singh et al. 2006). Studies have shown that female cigarette smokers tend to have better dietary habit than male cigarette smokers; this may be one of the reasons why cadmium level is raised among male active cigarette smokers than the female active cigarette smokers (Kim et al. 2010). Lead and Zinc were slightly raised among male active cigarette smokers when compared to their female counterparts. This can be attributed to the fact that majority of male active cigarette smokers take more cigarette sticks per day when compared with females active cigarette smokers (Bamgbose et al. 2007; Bernhard et al. 2006). Urinary Zinc level of passive cigarette smokers were significantly raised in male when compared to their female counterpart ($P=0.003$). This may be due to the fact that males generally are more exposed to secondhand smoke and to other environmental toxicants which could be responsible for the high level of this parameter.

The effects of heavy metals present in a cigarette smoke on the renal system of active cigarette smokers depends greatly on the number of years an individual has been smoking and the number of cigarette sticks an individual can smoke per day (Arcavi and Benowitz, 2014; Ajileye et al. 2016). The kind of vicinity an individual lives and works can determine the amount of heavy metals a second hand (passive) smoker can inhale and accumulate over time (Jong et al. 2019).

CONCLUSION

There was a significant increase in the urinary cadmium, lead and zinc levels among active cigarette smokers when compared with that of passive cigarette smokers. Urinary cadmium, lead and zinc level of male active cigarette smokers were slightly raised when compared to that of female active cigarette smokers.

Conflict of Interest: The authors declared that this manuscript was approved by all the authors in its form and that no competing interest exists.

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REFERENCES

Ajileye AB, Eze GI, Fasogbon SA. (2016). Cytology Analysis of Urine among cigarette smokers. American Journal of Biomedical Sciences. 8(1):56-67.

Arcavi L, Benowitz NL. (2014). Cigarette Smoking and Infection. *Archives of Internal Medicine.* **164**(20): 2206–2216.

Bamgbose O, Opeolu BO, Bamgbose JT. (2007). Levels of cadmium, lead and zinc in urine of randomly selected smokers and non-smokers residents of Abeokuta City, Nigeria Research Journal of Applied Sciences. 2 (2): 192-197.

Bernhard D, Rossmann A, Henderson B, Kind M, Seubert A, Wick G. (2006). Increased serum cadmium and strontium levels in young smokers: effects on arterial endothelial cell gene transcription. Arteriosclerosis, Thrombosis and Vascular Biology. 26: 833 – 848.

Cerulli N, Campanella L, Grossi R, Politi L, Scandurra R, Soda G, Gallo F, Damiani S, Alimonti A, Petrucci F, Caroli S. (2006). Determination of Cd, Cu, Pb and Zn in neoplastic kidneys and in renal tissue of foetuses, newborn and corpses. Journal of Trace Elements in Medicine and Biology. 20:171–179.

De-Sousa GF, Garcia KS, Menezes-Filho JA. (2011). Assessment of carcinogenic heavy metal levels in Brazilian cigarettes. *Environmental Monitoring and Assessment*. 181, (1), 255–265.

Djordjevic, M. V. and Doran, K. A., (2009). Nicotine content and delivery across tobacco products. *Handbook of Experimental Pharmacology*. 192:61–82.

Dorne JL, Kass GE, Bordajandi LR, Amzal B, Bertelsen U, Castoldi AF, Heppner C, Eskola M, Fabiansson S, Ferrari P. (2011) Human risk assessment of heavy metals: Principles and applications. Met Ions Life Sci. 8:27–60.

Galazyn-Sidorczuk M, Brzóska MM, Moniuszko-Jakoniuk J. (2008). Estimation of Polish cigarettes contamination with cadmium and lead, and exposure to these metals via smoking. *Environmental Monitoring and Assessment*. 137(1): 481–493.

Hajek P, Etter JF, Benowitz N, Eissenberg T, McRobbie H. (2014). Electronic cigarettes: review of use, content, safety, effects on smokers and potential for harm and benefit. Addiction. **109** (11): 1801–1910.

Hatem AMA, Muhammad NJ, Jawaher SMA. (2013). Determination of Lead and Zinc in Urine in Saudi Population. IOSR Journal of Environmental Science, Toxicology and Food Technology. 6(5): 82 – 86.

Jong HJ, Young SJ, Youn KK, Su-Young J, Seohyun P, Chang-Yun Y, Seung HH, Tae-Hyun Y, Shin-Wook K, Jung TP. (2019). Secondhand Smoke and Chronic Kidney Disease. Clinical Journal of American Society of Nephrology. 14 (4) 515-522.

Kim H, Lee HJ, Hwang J, Ha E, Park H, Ha M, Kim JK, Hong Y, Chang N. (2010). Blood Cadmium Concentrations of Male Cigarette Smokers Are Inversely Associated with Fruit Consumption. *The Journal of Nutrition*. 140 (6): 1133–1138.

Muhammad WA. (2012). Levels of Heavy Metals in Popular Cigarette Brands and Exposure to These Metals via Smoking. The scientific world Journal. 1: 01-05.

Murgia C, Lang CJ, Truong-Tran AQ, Grosser D, Jayaram L, Ruffin RE, Perozzi G, Zalewski PD. (2006). Zinc and its specific transporters as potential targets in airway disease. Curr Drug Targets. 7: 607–627.

Patricia AR, Ellen EB, Jiantong W, Monica HS. (2009). Tobacco Smoke Exposure and Levels of Urinary Metals in the U.S. Youth and Adult Population. International Journal of Environmental Research and Public Health. 6(7): 1930 – 1946.

Rodgman A, Perfetti PT. (2013). The Chemical Components of Tobacco and Tobacco Smoke. 2nd ed. CRC Press; Boca Raton, FL, USA. Pp. 3091-3092.

Satarug S, Ujjin P, Vanavanitkun Y, Nishijo M, Baker JR, Moore MR. (2004). Effects of cigarette smoking and exposure to cadmium and lead on phenotypic variability of hepatic CYP2A6 and renal function biomarkers in men. Toxicology. 204: 161 – 173.

Singh S, Aepen S, D'souza SF. (2006). Cadmium accumulation and its influence on lipid peroxidation and antioxidative system in an aquatic plant. Chemosphere. 62: 233-246.

Travis LB, Rabkin CS, Brown LM. (2006). Cancer survivorship-genetic susceptibility and second primary cancers: Research Strategies and Recommendations. Journal of the National Cancer Institute. 98(1): 15-25.

Centers for Disease Control and Prevention (US) (2010). How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease: A Report of the Surgeon General. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; Atlanta, GA, USA. https://pubmed.ncbi.nlm.nih.gov/21452462/ (Accessed on 19 September, 2020)

Wright ME. (2013). Estimated urine pH and bladder cancer risk in a cohort of male smokers (Finland). *Cancer Causes Control*. 16: 1117 – 1123.