Original Research Article

The Haematology and serum biochemistry of traditional textile dyers in Ntonso,Kumasi were affected by exposure to synthetic textile dyes

ABSTRACT

Aim: To study the effects of synthetic textile dyes on haematology and serum biochemistry of traditional textile industry practitioners at Ntonso in the Ashanti region of Ghana.

Study design: Case-control study

Place and Duration of Study: The study was carried out at Ntonso in the Ashanti region of Ghana and clinical analyses were carried out at the Clinical Analyses Laboratory at the Department of Biochemistry and Biotechnology, KNUST between October 2018 and February 2019.

Methodology: This study was conducted on 50 textile dyeing practitioners who have been using synthetic textile dyes for more than five yearsand 50 participants in the control group whose daily work does not expose them to any kind of synthetic textile dye.Participants over 70 years or less than 18 years, pregnant women and those with a medical history of kidney and liver diseases were excluded from the study. Haematological parameters such as White Blood Cell (WBC) counts, Red Blood Cell (RBC) counts, Platelet counts, Haemoglobin levels, etc. were measured. Liver function indicators such as Alanine transaminase (ALT), Protein, Aspartate aminotransferase (AST), Alkaline Phosphatase (ALP), Gamma-glutamyl transferase (GGT), Total Bilirubin (TBIL), and kidney function indicators such as Creatinine, urea, Na, K, Cl ion levels were assessed. Lipid profile parameters such as Total Cholesterol, Triglycerides, High-Density Lipoproteins, Low-Density Lipoproteins (LDL), and Very Low-Density Lipoproteins (VLDL) levelswere also assessed.

Results: There were statistical differences in both groups regarding key haematological and key serum biochemical parameters such as protein, globulin, ALP, GGT, creatinine, chloride, VLDL and Triglyceride.A significant correlation was observed between the metal ions and haematological parameters, biochemical parameters and quantity of dye used.

Conclusion:Heavy metals found in synthetic textile dyes altered lipid profile, haematological and biochemical parameters of the dye practitioners.

Keywords: Synthetic textile dyes,heavy metals;haematology, serum biochemistry.

INTRODUCTION

There is growing interest and competition from foreign textile producers that challenges local textile manufacturers to incorporate new decorative patterns and colours into their textile cloth products. Traditionally, dyes from plants were employed in colouring silk, wool and cotton fibers.However, cheaper synthetic dyes have been used as alternatives over the years.Dye is defined as a substance that after its application on a substrate produces a colour by a process that changes the crystal structures of the coloured substances [1].Thesesynthetic textile dyes and finishers are made up of toxic heavy metals, carcinogenic amides, pentachlorophenol and free formaldehyde [2]. Heavy metals are metallic ions that possess an atomic number greater than 23, a density greater than 5 g/cm^3 and generally have an effect on the environment and living organisms [3]. Heavy metals have the propensity to cause health problems in exposed individuals and the quantity of the metal ions in addition to the nature of the metal ingested play an important role in its effect [4]. Biological processes that are responsible for cell adhesion, intra- and intercellular signaling, protein folding, maturation, apoptosis, ionic transportation, enzyme regulation, and release of neurotransmitters are significantly disturbed because of lead toxicity [5].[6] observed thatiron that are in free circulation in the blood can cause lipid peroxidation that is responsible for the damage caused to mitochondria, microsomes and other cellular organelles.Chronic Cadmium intoxication results mainly in renal disease [7] but acute Cd exposure primarily results in liver accumulation and hepatocellular damage.[8] reported that the toxicity associated with aluminium is due to the interaction between the metal ion and plasma membrane. In humans, intercellular communication, cellular growth, and secretory functions are disturbed in humans because Al^{3+} replaces the legitimate binding sites for Mg^{2+} and Fe^{3+}.Chronic effects of zinc toxicity include anaemia, damage to the pancreas, lowering HDL cholesterol

levels and raising LDL cholesterol levels and possibly enhancing the symptoms of Alzheimer's disease [9].

Haematological and biochemical parameterscan be used to predict diseases as a result of their deviation from the normal range values [10]. The liverand kidney are particularlyimportant organs involved in several biochemical functions and deviations in metabolitelevels could be used to predict the health state of the individual.

The aim of the current study was the assess the effect of continued practice of using synthetic dyes on traditional textile dying practitioners at Ntonso in the Asante region of Ghana with emphasis on haematological and biochemical parameters.

MATERIALS AND METHODS

Study population

The formula ($n = N/ 1+Ne^2$) was used to obtain the sample size from the study populationat Ntonso Craft Village in the Kwabre East District of Ashanti region of Ghana.This case-control study was conducted on 50 dye practitioners who have been using synthetic textile dyes for more than five yearsand 50 participants in the control group whose dailyworkdoes not expose them to any kind of synthetic textile dye.Relevant information including age, residence, type of work, duration of work, type and quantity of synthetic textile dyes, number of hours worked per day, socioeconomic status, level of education, previous history of exposure to hazardous chemicals and occurrence of chronic diseases were recorded. The participants were subjected to routine clinical examination and laboratory investigations into serum metal ions compositions, haematological and biochemical parameters. Participants over 70 years or less than 18 years,

pregnant womenand those withmedical history of kidney and liver disease were excluded from the study.

Sample collection and analyses

With the aid of pyrogen-free sterilize disposal syringes, 6 mL each of venous blood was collected from each participant. 2 mL was dispensed into a blood collection tube containing ethylenediaminetetraacetate (EDTA) as an anticoagulant for the measurement of haematological parameters. 4 mL of venous blood was dispensed into clot activator blood collection tubes and centrifuged for 15 minutes at 3,000 rpm and the resulting serum was used for biochemical analyses using the fully automated biochemistry analyzer (Selectra E, Vital Scientific, Japan) and reagents from ELITECH (France). Some parameters included Proteins (Albumin and globulin), alanine aminotransferase (ALT), aspartate amino transferase (AST), alkaline phosphatase (ALP), bilirubin (total, direct and indirect), lipid profile (total cholesterol, high density lipoproteins, low density lipoproteins and triglycerides), kidney function (urea and creatinine) and electrolytes (sodium, potassium and chloride)0.5 g of each serum sample was measured and wet digested for analysis by atomic absorption spectrometry using flame and graphite furnace atomization for cadmium, lead, Iron, Zinc and Aluminium.

Statistical Analysis

Data was assessed using SPSS (version 20) and data expressed as a mean ± SEM. Parametric data were analyzed using the student's t-test while non-parametric data were analyzed using the Mann-Whitney test. Pearson's correlation was used to determine the relationship between the measured parameters at 95% confidence level.

RESULTS

Age distribution of participants

Table 1 shows that the majority of the participants within the control group fallbetween 31-45 years while for the test group, most of the participants were between 45-70 years.

Table 1: Age Distribution of Participants

Participants	Age distribution of Participants	Control group	Test subjects	Total	p-value
		Frequency (%)	Frequency (%)		
Age category	18 - 30	23 (46%)	11 (22%)	34	<0.001
	31 - 45	21 (42%)	14 (28%)	35	
	46 - 70	6 (12%)	25 (50%)	31	
	Total	50 (100%)	50 (100%)	100	
	Min	18	20		<0.001
	Max	59	70		
	Mean (SD)	33.20±9.90	44.40±11.96		

Effect of textile dye usage on haematological parameters

Table 2 shows that the test group significantly had higher levels of WBC, MCH, MCHC and RDW-CV% than the control group. LYM% and MXD% and were reported to be higher in the test group as compared to the test group. There was no significant difference on the following parameters RBC, HGB, HCT, MCV, PLT, PCT, MPV, PDW, NEUT, and RDW-SD.

Table 2. Haematology Parameters of Study Participants

	Control (n = 50)	Test (n = 50)		
Haematology Parameters	**Mean ± SD**	**Mean ± SD**	**P-value**	**Normal Range**
WBC ($\times 10^3/\mu L$)	4.45 ±1.08	4.92 ±1.27	0.05	4.00 – 10.00
RBC ($\times 10^6/\mu L$)	4.83 ±0.76	4.77 ±2.61	0.67	3.90 – 6.50
HGB ((g/dL)	13.1 ±1.77	13.42 ±1.59	0.337	11.50 - 18.80
HCT (%)	44.59 ±5.16	42.47 ±8.74	0.144	36.00 – 54.00
MCV (fL)	91.78 ±6.59	92.38 ±7.67	0.58	79.00 – 96.00
MCH (pg)	26.57 ±3.19	28.96 ±4.71	0.004	27.00 – 32.00
MCHC (g/dL)	28.94 ±3.05	30.97 ±3.45	0.002	28.00 – 37.76
PLT $\times(10^3/\mu L)$	236.08 ±54.65	218.6 ±64.01	0.141	130.00 – 400.00
LYM (%)	61.71 ±18.94	54.24 ±17.27	0.042	20.00 – 50.00
MXD (%)	3.88 ±8.1	1.24 ±2.16	0.028	5.00 – 10.00
NEUT (%)	34.31 ±17.24	39.93 ±16.01	0.096	40.00 – 70.00
RDW-SD(fL)	48.89 ±4.04	48.45 ±4.22	0.603	36.00 – 77.00
RDW-CV (%)	14.29 ±4.96	19.32 ±13.72	0.017	11.50 – 14.50
PDW(fL)	15.91 ±3.34	16.29 ±4.14	0.611	8.30 – 25.0
MPV (fL)	11.92 ±1.45	11.67 ±1.25	0.358	8.60 – 15.50
PCT (%)	0.28 ±0.06	0.26 ±0.07	0.134	0.10 – 0.50

Heavy metal concentrations of sera of participants

Table 3 indicates elevated mean values of lead, iron, cadmium and aluminium in the test group were 40.14 mg/kg, 82.67 mg/kg, 11.73 mg/kg and 426.86 mg/kg as compared to the control group with 36.34 mg/kg, 72.12mg/kg, 8.30mg/kg and 371.62 mg/kg respectively. On the contrary, the mean concentration value of zinc (7.42 mg/kg) was high in the control group as compared to (4.79 mg/kg) in the

test group. The levels of Al, Cd and Pb were all above WHO acceptable limit in both groups.

Table 3: Mean values of the elemental compositions in blood serum of participants

	Control (n=50)	Test (n=50)		
Metal	**Mean ±SD (mg/kg)**	**Mean ±SD (mg/kg)**	**P-value**	**FAO/WHO Maximum permissible values (mg/kg)**
Zn	7.42 ±2.43	4.79 ±2.01	<0.001	99.4
Pb	36.34 ±6.92	40.14 ±1.92	<0.001	0.3
Fe	72.12 ±7.64	82.67 ±5.60	<0.001	425.5
Cd	8.30 ±10.55	11.73 ±4.03	0.034	0.2
Al	371.62 ±80.78	426.86 ±21.44	<0.001	5 – 10

Biochemical parameters of participants

Table 4 indicates the mean concentrations of protein and globulin were significantly higher in the control group as compared to the test group. There were elevated values in VLDL, Triglyceride, ALP and GGT ($p<0.05$) in the test group than the control group. The mean values of creatinine and chloride were significantly lower in the test group as compared to the control group.

Table 4: Biochemical Parameters of Participants

Parameter	**Test (n=50)**	**Control (n=50)**	**p-value**	**Reference range**
	Mean ±SD	**Mean ±SD**		
Liver Function				
Protein (mmol/L)	68.90 ±7.40	76.24 ±7.75	<0.001	60 – 88
Albumin (mmol/L)	38.18 ±5.28	38.74 ±6.07	0.625	31.6 – 52
Globulin (mmol/L)	29.95 ±6.73	41.62 ±6.30	<0.001	23 – 35
ALT (U/L)	17.11 ±26.63	18.86 ±24.07	0.731	10.0 – 40.0
AST (U/L)	24.01 ±37.99	26.22 ±57.88	0.772	5.0 – 40.0
ALP (U/L)	140.64 ±64.19	114.84 ±47.07	0.024	53 – 240
GGT (U/L)	60.42 ±58.64	40.46 ±32.94	0.038	5.0 - 55.0
T. Bilirubin (mmol/L)	10.45 ±10.72	10.55 ±9.20	0.960	5.4 - 22.0
D. Bilirubin (mmol/L)	6.20 ±7.96	5.96 ±5.74	0.866	0.0 – 9.40
I. Bilirubin (mmol/L)	4.85 ±6.44	4.67 ±4.07	0.866	1.5- 17.5
Lipid Profile				
T. Chol (mmol/L)	4.49 ±0.98	4.28 ±0.91	0.274	3.6 – 6.10
LDL Chol (mmol/L)	2.81 ±0.84	2.67 ±0.77	0.386	2.6 – 4.90

HDL Chol (mmol/L)	1.26 ±0.36	1.26 ±0.35	0.911	1.0 – 3.50
VLDL Chol (mmol/L)	1.40 ±0.15	0.33614 ±0.13	<0.001	0.0 – 1.10
TRIG (mmol/L)	2.02 ±0.79	1.68 ±0.66	0.022	0.3 – 1.70
Kidney Function				
Creatinine (µmol/L)	111.03 ±57.17	134.95 ±44.32	0.021	53 – 125
Urea (mmol/L)	5.12 ±1.83	5.28 ±3.11	0.794	2.50 – 8.70
Na (mmol/L)	133.79 ±4.09	134.14 ±4.53	0.684	134 – 149
K (mmol/L)	4.19 ±1.04	4.12 ±0.98	0.722	3.6 – 5.5
Cl (mmol/L)	94.75 ±8.83	120.43±43.41	<0.001	94 – 112

Correlations of heavy metal content and some biochemical parameters

Table 5 reveals a significant negative correlation between albumin and lead (r = −0.332, *P*=.05), HDL and Fe (r = −0.358, *P*= .05), albumin and Fe (r = − 0.332, *P*= .05), and total protein and Fe (r = −0.353, *P*= .05). The table also shows positive correlation between albumin and Zn (r = 0.293, *P*=.05), GGT and Fe (r = 0.3.26, *P*= .05), ALP and Cd (r = 0.311, *P*= .05), total bilirubin and Fe (r = 0.307, *P*= .05) and direct bilirubin (r = 0.296, *P*= 0.05), Pb and Na (r = 0.313, *P*=.05).

Table 5: Correlation between Biochemical Parameters and Heavy Metals of The Test Subjects

Biochemical Parameters		**Heavy Metals**				
		Pb	**Zn**	**Fe**	**Cd**	**Al**
PROT	R	-0.179	0.171	-.353*	-0.029	-0.123
	p-value	0.212	0.235	0.012	0.844	0.394
ALB	R	-.332*	.293*	-.322*	-0.175	0.13
	p-value	0.018	0.039	0.023	0.224	0.369
GLOB	R	-0.03	0.131	-0.129	0.027	0.066
	p-value	0.837	0.364	0.374	0.854	0.648
GGT	R	0.068	-0.118	.326*	0.065	0.167
	p-value	0.639	0.416	0.021	0.655	0.246

ALT	R	0.102	-0.064	0.203	0.116	-0.135
	p-value	0.483	0.657	0.158	0.421	0.35
AST	R	0.03	-0.055	0.054	0.134	-0.144
	p-value	0.834	0.705	0.708	0.352	0.319
ALP	R	-0.129	-0.168	0.133	.311*	-0.253
	p-value	0.371	0.244	0.356	0.028	0.077
T.BIL	R	0.141	-0.07	.307*	-0.045	0.034
	p-value	0.328	0.63	0.03	0.755	0.814
D.BIL	R	0.154	-0.04	.296*	-0.084	-0.006
	p-value	0.286	0.781	0.037	0.56	0.964
IN.BIL	R	0.239	-0.172	0.265	-0.139	-0.14
	p-value	0.094	0.232	0.063	0.336	0.333
T.CHOL	R	-0.059	0.067	-0.229	-0.05	-0.091
	p-value	0.686	0.644	0.109	0.731	0.528
TRIG	R	-0.047	0.073	-0.035	-0.065	-0.077
	p-value	0.639	0.472	0.728	0.520	0.448
VLDL	R	0.036	0.037	-0.099	0.12	-0.227
	p-value	0.801	0.796	0.492	0.406	0.113
HDL	R	-0.062	0.17	-.358*	-0.072	0.075
	p-value	0.667	0.239	0.011	0.621	0.604
LDL	R	-0.069	0.021	-0.158	-0.066	-0.028
	p-value	0.633	0.886	0.272	0.651	0.849
UREA	R	-0.087	-0.049	0.143	0.207	0.225
	p-value	0.549	0.735	0.321	0.15	0.116
CREAT	R	0.01	-0.069	0.063	0.143	0.206
	p-value	0.946	0.634	0.662	0.322	0.15
Na	R	.313*	-0.025	0.056	0.063	-0.234
	p-value	0.027	0.864	0.7	0.664	0.102
K	R	-0.001	0.029	-0.187	0.047	0.08
	p-value	0.994	0.842	0.194	0.746	0.581
Cl	R	0.194	0.148	0.174	-0.017	0.275
	p-value	0.178	0.307	0.228	0.906	0.053

DISCUSSION

The current study assessed the effect of synthetictextile dye usage on the health (biochemical and haematological) of participants. Table 1 reveals majority of the participants in the test group were between the ages of 46−70 years.Age plays a

sensitive role in the accumulation of metal ions in the blood since heavy metal accumulation or uptake is associated with the duration of exposure [11].

Elevated levels of the WBC in the test group seen in Table 2 indicate the stimulation of the body to produce more WBC in response to the damages caused by the metal ions. This result is in line with a study that revealedthatafter an interaction between Pd and cytokine secretion, the levels of IL-4, IL-6 and IL-10 increased indicating the activation of T helper cell response and eosinophil production[12]. On the other hand, LYM% was observed to be lower in the test group as compared to the control group. Reduction in lymphocyte count (particularly T-helper cell and B-cell subpopulations) may be due to the activation of immunity and release of cytokines, such as tumournecrosis factor-1 [13].

Table 3 shows the mean levels of Pb, Al, Cd and Fe in the test group were significantly higher than the control group. This may be due to the fact that the test group are constantly exposed to the synthetic textile dye and absorption of the metal ions occur through inhalation, ingestion and dermal contact.[14] established that the point of entry of the chemicals and metal ions include the skin through contact, nasal cavity through inhalation and buccal cavity through ingestion. The control group had significantly a higher concentration of Zinc than the test group. [15] established that the displacement of zinc by cadmium causes the disruption in zinc homeostasis and impaired zinc absorption. The mean concentrations for lead, cadmium, and aluminium were all above the permissible ranges given by WHO in both groups, however, the test subjects had higher concentrations of the metals than the control group.The high levels of metals in the control group could also be established that participants in the control group

consume contaminated farm produce from soils that have been exposed to pollutants in textile wastewater. This agrees withprevious findings[15,16,17]that have documented the absorption, accumulation and distribution of heavy metals in different food crops such as rice, wheat, barley, maize and potato, oil seed crops and forage crops. Again, contaminated plant parts that are used to feed livestock will result in the transfer of the metal ions to the animals and eventually into participants that consume these animal products. [18] concluded that quantities of heavy metals can be found in water, soil, livestock tissue and organs and in livestock products.

Table 4 shows statistically significant low protein levels in the test group.[19] observed the inhibition of protein synthesis in animals exposed to azo dyes. The table indicates a significant increase in alkaline phosphatase and Gamma-glutamyl1transpeptidase in the test group.[20] recorded a significant increase in serum ALP in rats administered with a green-colouring dye. According to [21] elevated levels of GGT have been established to cause cardiovascular disease with risk factors including diabetes mellitus, hypertension, dyslipidaemia and metabolic syndrome. The study also reveals high levels of triglycerides and VLDL in the test group. Triglyceride analysis helps in detecting hyperlipoproteinemia [18]. Hyperlipoproteinemia predisposes a person to atherosclerosis; elevated plasma triglycerides and VLDL are directly associated with the risk of atherosclerotic heart disease [22]. The table also reveals significantly low levels of creatinine and chloride in the test group. Poor liver or kidney function may reduce the production of creatinine which will lead to low levels of creatinine in the body [19]. The measurement of chloride was statistically lower in the test group as compared to the control group. Hypochloraemia helps to maintain the glomerular filtration rate (GFR)

by stimulating the release of renin and prostaglandins from the macula densa which widens the afferent arterioles and causes constriction to the efferent arterioles [20].

From Table 5, a significant negative correlation was observed between iron and total protein and albumin. Free radicals that are formed due to the inability of iron to bind albumin result in the reduction of albumin synthesis after damage caused by the free radicals to hepatocytes. The weak positive correlation between cadmium and ALP shows hepatobiliary damage due to cadmium-induced free radical generation. Chronic exposure to cadmium has been demonstrated to cause hepatobiliary damage [21]. There was a weak positive correlation between iron and serum bilirubin. Elevated level of serum bilirubin causes a decrease in C reactive protein that correlates with acute phase protein [23]. Therefore, an elevated level of bilirubin causes an increase in unbound iron circulating in the body as there is insufficient transferrin to bind iron. The table also shows a significant negative correlation between HDL and iron in the test group. Iron deficiency anaemia is reported to show HDL particles with altered composition and functionality [24]. A significant positive correlation was observed between cadmium and gamma glutamyl transpeptidase (GGT). This shows that an increase in blood cadmium level may produce lipid peroxidation (LPO) damage in the bile duct which results in an increase in GGT levels in the blood. Glutamyl transpeptidase (GGT) is now being considered as a biomarker of oxidative stress and is regarded as one of the most robust indicators of whole-body oxidative stress[25].

CONCLUSION

The exposure to synthetic textiledyes has adverse effects on the health of textile dyeing workers. This was evident by changes in the haematological and serum biochemical parameters of traditional textile dyers when compared to the control group.

ETHICAL APPROVAL

Ethical approval (Ref: CHRPE/RC/154/18)was sought from the Committee for Human Research Publications and Ethics (CHRPE) at the School of Medical Sciences (KNUST) and approved on10th October 2018. Informed consent was taken from all individuals who participated in the study.

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