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Character of ocular changes in a zone polluted by heavy metals

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The environment is polluted by heavy metals which may exert a significant influence on the eyes of people. Early diagnosis of the disorders could contribute to the prevention of progression of severe eye diseases. We investigated the eyes of people in surroundings contaminated with some heavy metals (lead, cadmium, chromium, manganese, zinc, mercury, copper). We have investigated 971 persons exposed to some heavy metals at their workplace and 706 persons not exposed to these heavy metals. Our results indicate changes of conjunctival vessels, tissue allergic-inflamed microsoft changes of lens, iris and optic nerve in persons exposed to heavy metals. The results prove a possible harmful effect of these heavy metals on the eyes.

Key words: environment, ocular changes, heavy metals, ophthalmological examination

INTRODUCTION

The environment is polluted by heavy metals in the zone of influence of many industrial enterprises and traffic intensity, and this can have a significant influence on the health of people (Shimada, Bare et al., 1997; Stohs, Bagchi et al., 2000; Waalkes, Rehm et al., 1997). All heavy metals can disturb the harmony of the body, causing disharmony and disease. Heavy metals can cause our mental functions, energy, nervous system, kidneys, lungs and other organ functions to decline (Ehle, McKee, 1990; Lauwerys et al., 1990; Schwartz, 1991; Shimada et al., 1997; Waalkes et al., 1997). Symptoms of chronic toxicity are often similar to many common conditions and may not be readily recognized. Routes of exposure include inhalation, skin or eye contact and ingestion. Young organisms are particularly vulnerable to the effect of heavy metals. Learning where these metals can be found and decreasing one's exposure is vital to staying healthy. Adults in general and workers in particular seem to develop their own system of adaptation. Nevertheless, despite the absence of clinical symptoms they should also be given regular check-ups. It has been stated that all chronic and serious illnesses could be prevented if we were able to eliminate the most dangerous environmental toxins.

Environmental contamination with harmful agents exerts a negative impact on the eye and not seldom may become a cause of occupational illnesses. Heavy metals at high concentrations become toxic to the functions of the eye. The symptoms of their impact are diversified, however, most of the authors agree that the eye vascular system, optic nerve, flow of aqueous are most liable to distortions caused by contamination. Early diagnosis of the disorders could contribute to prevention of progression of severe diseases of the eye. The most common and dangerous forms of eye intoxication are caused by lead, additionally reinforced by cadmium. Several studies note a negative effect on ocular changes and organism of lead, cadmium and chromium (Ehle, McKee, 1990; Imbrasiene et al., 2004; Imbrasiene et al., 1999; Mulak, 1998; Schubert et al., 1988; Schwartz, 1991). In various cases some changes in the eye may be also induced by manganese. Our results obtained by examining representatives of the Jiesia Artistic Ceramics Factory proved the possible harmful effect of manganese on the eyes. We found a statistically reliable link between the increase in the manganese level

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in the hair and all the conjunctival changes, conjunctival vessel changes, conjunctival allergic changes, corneal epithelial dystrophies, changes in the optic nerve disc (Imbrasiene et al., 2002; Imbrasiene et al., 1999). The harmful effects of various heavy metals on ocular conjunctiva, cornea, iris, lens, vitreous, fundus, and optic nerve disc have not been studied.

Objectives

The purpose of this study was to examine and classify eye changes among the people in the zone of influence of some heavy metals (lead, cadmium, zinc, chromium, manganese, mercury, copper, lithium, nickel) and to compare eye changes of persons exposed to some heavy metals in the zone of influence and persons not exposed to these heavy metals at their workplace.

METHODS

The research was carried out at the Laboratory of Ophthalmology of Institute for Biomedical Research of Kaunas University of Medicine. Periodical check-up of the eye was done in persons exposed to some heavy metals in the zone of influence (at their workplace) and in persons who were not in the zone of influence of heavy metals (control group). Factories were chosen where the production of ceramics, batteries and building materials involves the use of heavy metals (lead, chromium, cadmium, manganese, zinc, mercury, copper, lithium, nickel). The interview helped to ascertain if the persons of the control group were exposed to contaminated surroundings at their workplace. All persons from the control group claimed not to have any direct contact with heavy metals at their workplace. The ophthalmological examination included visual acuity testing, biomicroscopy of the conjunctiva, cornea, iris and lens, ophthalmoscopy. Tonometry was done for persons aged 40 and over. Eye changes were subjected to the International Classification of Diseases. The levels of heavy metals in the hair was determined at the Laboratory of Anthropogenic Factors Research by applying the method of electrothermographite nuclear absorption and the Zeeman effect.

The results were considered within the Student's and chi-square criterian (Pierson–Fisher criterion) by answering the question whether a person had disorders caused by heavy metals and eye disorders.

RESULTS

We investigated 971 persons exposed to some heavy metals (lead, cadmium, zinc, chromium, manganese, mercury) in the zone of influence. The investigation was carried out among the staff of an artistic ceramics factory, batteries factory and building materials factory; 220 (22.66%) persons worked at the batteries factory, 530 (54.58%) at the artistic ceramics factory and 221 (22.76%) at the building materials factory. The persons who worked at the batteries factory were exposed to such heavy metals as cadmium, copper, zinc, lead, mercury, manganese. Workers of the artistic ceramics factory generally were exposed to manganese, lead, cadmium, zinc, copper, mercury, chromium. Persons from the building materials factory were mostly exposed to lead, cadmium, manganese, mercury, zinc, copper and chromium. In the study group, there were 400 men (41.19%) and 571 women (58.8%).

The control group consisted of 706 persons not exposed to the influence of some heavy metals. The interview helped to ascertain if the persons of the control group were exposed to contaminated surroundings. The control group was chosen randomly, taking into consideration the age and sex.

The age distribution of persons exposed and not exposed to some heavy metals is shown in Table 1.

Ocular changes in persons exposed and not exposed to heavy metals are shown in Table 2. In the group of exposed persons to heavy metals (lead, zinc, chromium, cadmium and

Table 1. **Distribution of persons according to age**

Age	Study group		Control group	
	Number of persons	Percent of persons	Number of persons	Percent age
Under 30 years	162	16.68	85	12.04
30–39 years	224	23.07	150	21.25
40–49 years	253	26.06	164	23.23
50–59 years	264	27.19	163	23.09
60–69 years	68	7.0	144	20.4

Table 2. **Ocular changes in persons exposed to heavy metals and in persons of the control group**

Ocular changes	Study group		Control group		P	χ^2
	Number of persons	Percentage	Number of persons	Percentage		
Decreased visual acuity	572	58.91	302	42.78	<0.001	41.986
Conjunctival changes	780	80.33	273	38.67	<0.001	301.891
Corneal changes	161	16.58	31	4.39	<0.001	58.718
Lens changes	263	27.08	206	29.18	0.375	0.788
Vitreous opacities	46	4.74	41	5.81	0.388	0.746
Iris degenerations	194	19.98	90	12.75	<0.001	14.687
Retinal changes	156	16.07	140	19.83	0.053	3.730
Optic nerve disc changes	225	23.17	33	4.67	<0.001	106.031
Increased intraocular pressure	27	2.78	17	2.41	0.751	01.00

manganese) 572 persons (58.91%) had a decreased visual acuity and conjunctival changes were present in 780 persons (80.33%). Corneal disturbances were found in 161 (16.58%), lens changes in 263 (27.08%), vitreous opacities in 46 (4.74%), iris degeneration in 194 (19.98%) retinal changes in 156 (16.07%), changes of optic nerve disc in 225 persons (23.17%). In persons with a decreased visual acuity myopia prevailed, because these changes are prevalent in young persons.

In the control group, we found decreased visual acuity in 302 persons (42.78%) and conjunctival changes in 273 persons (38.67%). Corneal disturbances were found in 31 (4.39%), lens changes in 206 (29.18%), vitreous opacities in 41 (5.81%), iris degeneration in 90 (12.75%) and retinal changes in 140 (19.83%), changes of the optic nerve disc in 33 (4.67%), increased intraocular pressure in 17 (2.41%) persons. In persons with a decreased visual acuity from the control group hypermetropia and presbyopia dominated, because these changes prevail in persons aged 40 and over, i. e. those are normal physiological changes.

Conjunctival changes in persons exposed and not exposed to heavy metals are shown in Table 3. In persons exposed to heavy metals, conjunctival changes prevailed. Changes of the microcirculatory system (changes of the lumen, tortuosity, uneven blood flow, extravasal changes, aggregation of erythrocytes) were found in 544 (56.02%), conjunctival degeneration as pinguecula, pterygium in 315 persons (32.44%), microsoft tissue allergic-inflammatory changes (itching, tearing, redness of conjunctiva, chemosis) in 149 (15.34%).

Changes of the microcirculatory system (changes of the lumen, tortuosity, uneven blood flow, extravasal changes, aggregation of erythrocytes) were found in 147 (20.82%), conjunctival degeneration as pinguecula, pterygium in 137 (19.40%), microsoft tissue allergic-inflammatory changes (itching, tearing, redness of conjunctiva, chemosis) in 6 (0.85%) persons of the control group. Conjunctival changes among the persons of the control group proved to be directly dependent on the age.

So, the investigation indicated that in the group of the exposed persons conjunctival changes ($p < 0.001$, $\chi^2 = 301.891$), corneal disturbances ($p < 0.001$, $\chi^2 = 58.718$), iris ($p < 0.001$, $\chi^2 = 14.687$) and optic nerve disc changes ($p < 0.001$, $\chi^2 = 106.031$) prevailed in comparison with the control group. The study showed the possible harmful effect of heavy metals in causing all the conjunctival changes: conjunctival degenerations ($p < 0.001$, $\chi^2 = 34.623$), vascular changes ($p < 0.001$, $\chi^2 = 207.655$), allergic-inflammatory changes ($p < 0.001$, $\chi^2 = 100.669$). Some changes (e. g., visual, retinal, lens changes) might have been age-related.

The identified changes in visual acuity (hypermetropia and presbyopia), conjunctival changes, iris degenerations, lens changes, corneal changes, and changes of retina mostly age-dependent in the control group, because they dominated in the age group of 40 and over.

No relation was noted between the length of exposure to contaminated surroundings and the increase in the amount of ocular changes.

DISCUSSION

The ocular effects of intoxication by heavy metals (lead, zinc, chromium, cadmium and manganese) is presented. Several studies note a negative effect of lead, cadmium and chromium (Ehle, McKee, 1990; Lauwerys et al., 1990; Schwartz, 1991) on ocular changes and on the whole organism. Our results obtained by examining representatives of the Jiesia Artistic Ceramics Factory proved the possible harmful effect of manganese on the eyes. Statistically reliable was the link between the increase in the amount of manganese in the hair and all conjunctival changes, conjunctival vessel changes, conjunctival allergic changes, corneal epithelial dystrophies, changes in the optic nerve disc (Imbrasiene, 1999; Imbrasiene, Svediene et al., 2002). In the present study, the exposed persons were identified to have ocular changes more frequently than persons of the control group. The results obtained by examining persons exposed to heavy metals (lead, zinc, chromium, cadmium, manganese, mercury, copper) show a possible harmful effect of heavy metals on ocular changes. These results indicate the presence of conjunctival vessels, allergic-inflamed microsoft tissue, lens, iris and optic nerve disc changes in persons exposed to heavy metals. Our results complement the data of our other investigations (Imbrasiene, 1999; Imbrasiene et al., 2004) and particularly investigations of other researches (Lauwerys et al., 1990; Mulak, 1998; Schubert et al., 1988). The novelty of this article is that it generalizes the integrated influence of heavy metals on different ocular changes. Till now, the influence of individual metals on separate eye structures has been analysed. The investigations proved that the most common and dangerous forms of eye intoxication are caused by lead additionally reinforced by cadmium. In some cases, changes in the eye may be also induced by manganese (Imbrasiene et al., 2002; Imbrasiene et al., 1999; Mulak, 1998). These ocular changes were in young persons, so we think that persons exposed to heavy metals (lead, zinc, chromium, cadmium and manganese) and working with these metals might be given regular check-up to prevent the development of ocular changes at an early stage.

CONCLUSIONS

Our results indicate the presence of changes in conjunctival vessels, allergic-inflamed microsoft tissue, changes of the lens, iris and optic nerve in persons exposed to heavy metals. In persons exposed to some heavy metals we identified the presence of ocular changes more often than in the control group.

Table 3. **Conjunctival changes in persons exposed to heavy metals and in persons from the control group**

Conjunctival changes	Study group		Control group		P	χ^2
	Number of persons	Percentage	Number of persons	Percentage		
Degenerations	315	32.44	137	19.40	<0.001	34.623
Vascular changes	544	56.02	147	20.82	<0.001	207.655
Allergic-inflammatory changes	149	15.34	6	0.85	<0.001	100.669

1. Investigations at an artistic ceramics factory, battery-producing factory and a factory producing building materials, statistically reliable data were obtained on the development of all conjunctival changes, conjunctival vessel changes, conjunctival degenerations, conjunctival allergic changes, corneal epithelial dystrophies, changes in the optic nerve disc.

2. The results obtained by examining persons exposed to some heavy metals prove a possible harmful effect of these metals on ocular changes. Some changes (e. g., visual, retinal, lens changes) might have been age-related. The identified changes in visual acuity and conjunctival changes, iris degenerations, lens changes, corneal changes, changes of retina mostly depended on the age of the members of the control group, because they dominated in the age group of 40 and over.

3. We may conclude that persons exposed to heavy metals (lead, zinc, chromium, cadmium and manganese) and working with these metals should be given regular check-ups to prevent the development of ocular changes at early stages. Furthermore, these ocular changes were found in young persons.

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AKIŲ PAKITIMŲ POBŪDIS TARŠOS SUNKIAISIAIS METALAIS ZONOSE

S a n t r a u k a

Aplinkos tarša sunkiaisiais metalais neretai pažeidžia žmonių akis. Ankstyva akių pakitimų diagnostika gali apsaugoti žmones nuo sunkių akių ligų. Tyrėme žmones, esančius lokalios taršos kai kuriais sunkiaisiais metalais (švinu, kadmiu, chromu, manganu, cinku, gyvsidabriu ir variu) zonose. Iš viso ištyrėme 971 asmenį, kurie buvo lokalios taršos sunkiaisiais metalais zonose, ir 706 kontrolinės grupės asmenis, nesusijusius su tiriamaisiais sunkiaisiais metalais. Mūsų atliktų tyrimų rezultatai parodė galimą sunkiųjų metalų poveikį akių junginių kraujagyslių, junginių alerginių ir uždegiminių, lęšiukų, rainelių ir regos nervų pakitimams.

Raktažodžiai: aplinka, akių pakitimai, sunkieji metalai, oftalmologinis ištyrimas