Determination of fingernail chromium, cadmium, and lead in tannery workers

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Abstract

Purpose: To determine whether chromium, cadmium, and lead levels in human fingernails reflected the exposure to workplace contamination in tanneries.

Approach: 49 exposed tanning workers and 33 controls were monitored for fingernail levels of chromium, cadmium, and lead by graphite furnace and hydride atomic absorption spectroscopy.

Results: The mean levels of fingernail chromium, cadmium, and lead in the exposed workers were significantly higher than those in the controls. In regression models for the tannery workers, the significant risk factor that affected the fingernail chromium, Cadmium, and lead level were occupational exposure, respectively. Current smoker it showed a significant change in trend of increased fingernail cadmium levels.

Conclusion: These findings indicate that chromium, cadmium, and lead absorbed from. Leather tanning compounds result in raised levels of chromium, cadmium, and lead in fingernails and that improvement of the industrial health should be more practiced in the tanneries in Taiwan.

Keywords: Tannery; Fingernails; Chromium; Cadmium; Lead.

1. Introduction

Leather tanning is a traditional and polluted industry. Leather manufacturing consists of four steps: pre-tanning and tanning, wet finishing, dry finishing, and packing (Gupta 1990). Heavy metals, including Cr, Cd, and Pb are generally used in the tanning and dyeing procedures that are known not essential for plants or animals and can be toxic to both (Haroun et al. 2007). For the reason, tannery workers may thus be exposed to undue amounts of these metals.

Biological monitoring of Cr levels by analysis of hair, blood, and urine in tannery workers had been documented (Saner et al. 1984, Randall & Gibson 1987, Randall & Gibson 1989). The use of fingernails to monitor industrial exposure to Cr, Cd, and Pb is well invested in many sectors and environments (Sukumar & Subramanian 1992, Sukumar & Subramanian 1992, Mehra & Juneja 2005, Sukumar & Subramanian 2007). Nevertheless, the levels of fingernail Cr, Cd, and Pb in tannery workers are still not known. Human nails as well as hair are non-invasive and biological samples for monitoring body burden of elements (Hopps 1976, Sukumar & Subramanian 2007)... The fingernail's Cr, Cd, and Pb levels of tannery workers were determined in an attempt to establish whether they may reflect workplace contamination in tanneries.

2. Methods

2.1. Study subjects

We studied subjects from three tanneries in southern Taiwan. The study population consisted of 49 tannery workers. They were classified into three exposure categories based on their operational department, chemical use, and references (Saner et al. 1984, Ory et al. 1997): 1) 16 pre-tanning and tanning; 2) 18 wet finishing and dry finishing, and 3) 15 supervisor, plant services, and guards. The controls consisted of 33 persons who were not employed in industrial sectors. Each participant included in the study population completed a questionnaire, including information about age, cigarette smoking, working years, job histories, and operational department. The study subjects and controls had no overt signs of clinical disease. The study was approved by the Institutional Review Board of Kaohsiung Medical University. All participants were informed and signed consent forms.

2.2. Biological monitoring

Fingernails were scraped with clean stainless-steel clippers. A total of 3 grams of fingernails was sealed in the plastic cover till it was washed. All the fingernail clippings were stored in polyethylene tubes before washing. The samples were washed with nonionic detergent (Triton X-100) following a standardized washing procedure (Gammelgaard et al. 1991). The fingernails were soaked in acetone three times to remove external contamination and then rinsing them one time with deionized water, dried in an oven and stored in a desiccator (Sukumar & Subramanian 2007).

Microwave dissolution technique was used to digest fingernail samples by a Model-MDS-2000 CEM remote microwave system (CEM, Matthews, NC). A fingernail sample (100 mg) and 10 ml of the Bi-acid solution (three ml 65 % HNO3 + 1 ml 30 % H2O2)
were transferred into a 80-ml pressure-resistant polytetrafluoroethylene bottle. The sample was digested by seven steps to remove the interfering matrix (S1: 10 W, 5 minutes; S2: 0 W, 30 minutes; S3: 25 W, 15 minutes; S4: 40 W, 20 minutes; S5: 50 W, 10 minutes; S6: 10 W, 5 minutes; S7: 60 W, 15 minutes). Digested solution was evaporated completely to remove excess acid and then diluted with deionized water to 10 ml for metal analysis. The levels of the metals were assayed by using GBC AAS model 906 plus with graphite 3000 after microwave dissolution. The optimal experimental conditions are given in Table 1.

All reagents used were purchased from Merk (Germany) and were of Suprapur grade. To establish the validity of our results, we used the Trace Metals 7878 APG Setpoint TM QC Standard (Analytical Products Group, Belpre, OH, USA) as a reference. Table 2 shows the accuracy and precision of the Cr, Cd, and Pb analysis.

2.3. Statistical Methods

All results were presented as the value of mean ± SD. When two groups were compared, the Student’s t test (normalized transformation) or Chi-square test was employed. The one-way analysis of variance test (ANOVA) and post-hoc statistic were used to compare the significant differences of metal levels in fingernails among the three operational departments, and the controls. The Pearson’s correlation between each of measured Cr, Cd, and Pb levels in the various groups was calculated. The data were subjected to multiple linear regression models to examine the net effects and dose-response relation between exposure situation and fingernail metal concentrations. The limit of significance was set up at p<0.05. All analyses were performed with the SPSS program (SPSS Inc., Chicago, IL) for Windows.

3. Results

3.1. Distribution of demographic characteristic, and exposure biomarkers among the study subjects

The demographic, and levels of metals in human’s fingernails are showed in table 3.

Fingernail Cd levels were positively correlated (p < 0.05) with the fingernail Pb in the total subjects, in the total exposed group, and in the wet, finishing and dry finishing workers, respectively (table 4). There were no correlation between fingernail Cr and Cd, and Pb in the total subjects, in the total exposed group, and in the exposed subgroups, respectively.

3.3. Dose-response relation between biomarkers and risk factors

In stepwise regression models (table 5), we first used the controls as an external comparison group to examine fingernail Cr, Cd, and Pb levels. The regression coefficient (β) of exposure situation was 0.37 (p < 0.05) in fingernail Cr levels, 0.37 (p < 0.05) in fin-
Some studies suggested that cadmium levels observed high in fingernails were related to tobacco smoking (Sukumar & Subramanian 1992, Sukumar & Subramanian 2007). Their common suggestion is in agreement with our results. Age, and sex were not found influencing levels of metals in the fingernails. Similar observation has been made. For the studies of Sukumar & Subramanian, and Hayashi et al (Sukumar & Subramanian 1992, Hayashi et al 1993). Length of employment might reflect the accumulated levels of biological exposure markers. However, fingernail Cr, Cd, and Pb levels were not correlated with working years in our studies. It implied that fingernail levels may be similar to serum or urine as a biomarker of current metals exposure, and the mechanism of length of employment on fingernail metal should be further investigated.

There were very limited exposure studies that conducted with the levels of Cr, Cd, and Pb in the fingernails of normal humans. Fingernail Cr levels in the controls was between 0.36 μg/g and 1.24 μg/g, with a mean value of 0.82 ± 0.24 μg/g. This result is in good agreement with the values (0.9 μg/g) reported by Kasperek et al (Kasperek et al.1984), and Sukumar and Subramanian (0.9±0.1 μg/g) (Sukumar & Subramanian 1992). Fingernail Cd levels in the controls was between 0.54 μg/g and 1.90μg/g, with a mean value of 1.16 ± 0.38 μg/g. This result is in good agreement with the values (1.1±0.2 ) reported by Sukumar and Subramanian (Sukumar & Subramanian 1992), and Nowak and Chmielnicka (1.2±1.3 μg/g) (Nowak & Chmielniicka 2000).

Fingernail Pb levels in the controls was between 3.33 μg/g and 20.09 μg/g, with a mean value of 9.33 ± 4.59 μg/g. This result is in good agreement with the values (9.0±1.0 μg/g) reported by Sukumar and Subramanian (Sukumar & Subramanian 1992), and Wilhelm et al (8.5 μg/g) (Wilhelm et al.1991).The mean level of fingernail Cr (1.16 ± 0.02μg/g) was significantly higher in the group of supervisor, plant services, and guards than in the controls, as well as their fingernail Cr levels were higher by 62.1 % (p < 0.05) than those in the controls. Ory et al suggested that non-tanning workers, such as packers, and plants services often had chemicals of exposures as they move from one section to the other during their daily work (Ory et al. 1997). Based on the above results, we suggest that improvement of the workplace through adequate ventilation should be more practiced in the tannery.

The limitation of this study is its cross-sectional design. Because the biological limit value of fingernail Cr, Cd, and Pb are not well known, more work will be warranted to clarify the relationship of metals exposure and health effects.

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References


