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HEXACHLOROBENZENE: PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM

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REDUCTION OF THE HUMAN BODY BURDENS OF HEXACHLOROBENZENE AND POLYCHLORINATED BIPHENYLS

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SUMMARY

Adipose-tissue concentrations of hexachlorobenzene (HCB), four other pesticides and 10 polychlorinated biphenyl congeners were significantly reduced by enhanced mobilization and excretion through the method developed by Hubbard. Electrical workers paired by age, sex and potential for polychlorinated biphenyl exposure were divided into treatment and control groups. Adipose-tissue concentrations were determined pre- and post-treatment, and 3 months post-treatment. Daily treatment was provided for 3 weeks, consisting of heat stress and niacin administration to enhance mobilization and polyunsaturated-oil administration to enhance excretion, with other components administered to provide protection from mobilized chemicals. Adjusted for re-exposure as represented in the control group, HCB body burdens were reduced by 30% at post-treatment and 28% 3 months post-treatment. Mean reduction of polychlorinated biphenyl congeners was 16% at post-treatment and 14% 3 months post-treatment. Analysis of variance indicates these reductions are statistically significant ($f < 0.001$). Enhanced excretion appeared to keep pace with mobilization, as blood-serum levels in the treatment group did not increase during treatment. Post-treatment remission of symptoms associated with chemical exposure has been summarized according to reports from related studies.

INTRODUCTION

Despite best efforts, large human populations are at times exposed to toxic chemicals. When these chemicals are lipid soluble and do not metabolize easily, they accumulate in the body and may present a health risk for the individual's entire life. Reduction of chemical body burdens is one goal of treatment for the chemically exposed. Other goals include remission of reversible physiological and behavioural effects associated with chemical exposure.

The purpose of this paper is 2-fold. We present the results of treatment in a controlled study of electrical workers with hexachlorobenzene (HCB) polychlorinated biphenyl and other chlorinated chemical body burdens. In addition, we summarize other research on body-burden reduction using the Hubbard (1980) method, with special attention on symptom remission and behavioural improvements.

Previous work (Schnare *et al.*, 1984) showed that persistent body burdens could be significantly reduced. However, little has been done to document body-burden reduction in a population with continuous chemical exposure. Further, no data are available on the blood levels of toxic chemicals during treatment. This study of electrical workers addressed both issues.

MATERIALS AND METHODS

Polychlorinated biphenyls have been widely used in electrical equipment because they are heat-resistant. Electrical workers are routinely exposed to these compounds as well as to other persistent chlorinated organic chemicals. Five treatment and five control participants, healthy male volunteers matched for age and occupational exposure, were selected from the International Brotherhood of Electrical Workers Local 18. All procedures followed were in accord with the Helsinki Declaration of 1975.

Samples of adipose tissue, blood and skin oil were taken from treatment subjects before treatment, immediately post-treatment and 3 months after treatment. Blood samples were also taken every 4 days during treatment, 1 day post-treatment and 10 days post-treatment. Samples of adipose tissue, blood and skin oil were similarly taken from the matched controls, except that blood samples were not taken every 4 days. A blood sample was taken from the control subjects 10 days after the treatment period ended.

Adipose tissue was obtained by subcutaneous needle aspiration (Daum *et al.*, 1978) and kept frozen until analysis. Chemical concentrations in adipose tissue were determined by the method of Smrek and Needham (1982), and blood concentrations according to Dale *et al.* (1966). The identity of specific chemicals and polychlorinated biphenyl congeners was confirmed by gas chromatography-mass spectrometry (Roboz *et al.*, 1982).

The treatment used to reduce the chemical body burden was originally developed by Hubbard (1980) to reduce body burdens of psycho-active chemicals. This treatment is currently in use in the USA for a variety of contamination incidents,

including treatment of policemen exposed during arrests to illicit psycho-active drugs (Warner, 1983). It is also used widely in Sweden and Italy during drug rehabilitation.

The treatment is a relatively complex 3-week regimen of aerobic exercise, polyunsaturated-oil supplements, heat stress (sauna at 60°–80 °C) and mineral and vitamin supplements. This regimen is vigorous, and requires adequate sleep, good nutrition and a well ordered daily schedule.

Results were analysed statistically, using the SPSS 2.1 software for personal computers. Analysis of variance was used to evaluate the hypothesis that chemical concentrations in treatment and in control adipose tissue and blood were the same over the period of the study.

RESULTS

All 16 target chemicals were found at quantifiable levels in adipose tissues of all participants. Levels varied from 0.002–6.3 ppm lipid weight and were generally at least 10 times the detection limit. Analysis of quality-control samples indicated analytical precision of 16%. Treatment and control populations did not significantly differ before treatment.

At post-treatment, all 16 chemicals were found at lower concentrations in the adipose tissues of the treatment group, but 11 were higher in the control group (Table

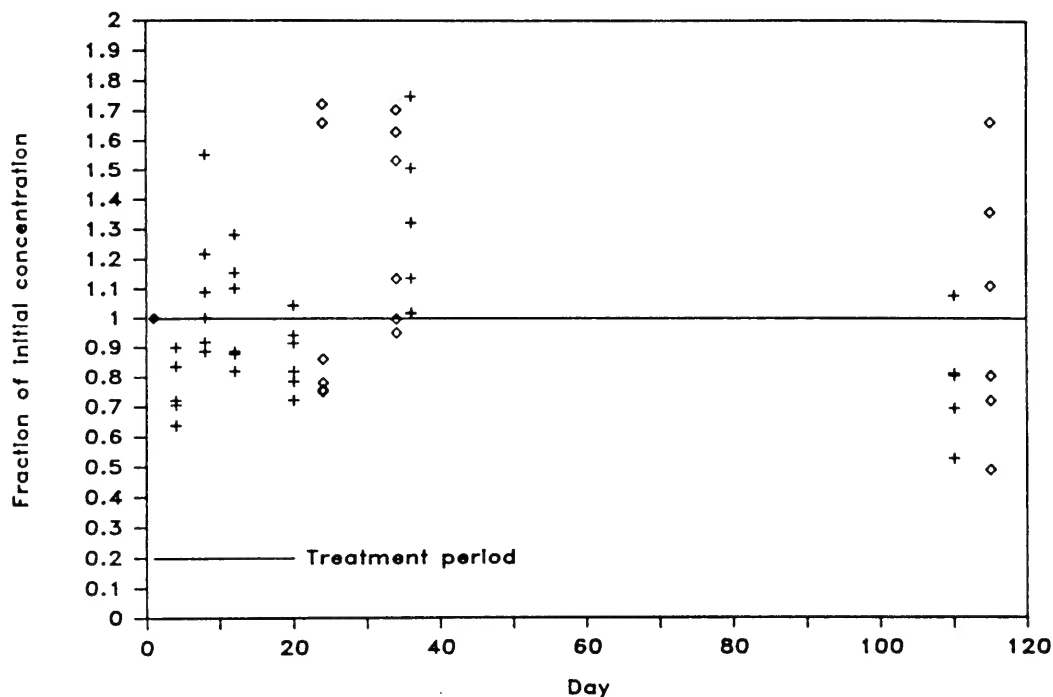
Table 1. Mean body-burden reductions^a

McCall numbers ^a	Chemical	Treatment (%)		Control (%)	
		Post-treatment	Follow-up	Post-treatment	Follow-up
Pesticides					
	Hexachlorobenzene	19	16	-11	-12
	Oxychlorodane	5	37	15	6
	Heptachlor epoxide	6	26	3	-5
	Dichlorodiphenyldichloroethylene	1	7	-8	-17
	Dieldrin	8	20	-3	7
	Mean	7.8	21.2	-0.8	-4.2
Polycholorinated biphenyls					
146	22'44'55'-Hexa	8	6	-10	-11
174	22'344'5-Hexa	5	4	-9	-10
203	Hexa	7	1	2	-1
244	233'44'5-Hexa	4	3	-7	-8
332	Hexa	8	-6	2	-8
360+372	Hepta	7	-2	-16	-18
448	Hepta	0	4	-53	-40
528	Hepta	3	-4	-5	-9
717	Hepta	2	2	-6	-11
	Mean	4.7	2.3	-10.8	-12.4

^a Differences in body-burden reduction between treatment and control groups at follow-up sampling (3 months post-treatment) are significant, with $f < 0.001$ and < 0.005 for pesticides and polychlorinated biphenyls respectively. The difference at post-treatment was significant for polychlorinated biphenyls with $f < 0.001$.

^b McCall numbers are according to Sawyer (1977)

Fig. 1. Pesticide blood concentrations as a fraction of those found at initial sampling. Pesticides measured include hexachlorobenzene, oxychlorodane, heptachlor epoxide, dichlorodiphenyl-dichloroethylene, dichlorodiphenyltrichloroethane and dieldrin. Mean blood concentrations for each chemical and sampling point are shown for the treatment group (+) and for the control group (\diamond). The bar labelled treatment period indicates the period during which treatment was provided. There was no significant difference in blood levels between the two groups during the period of study

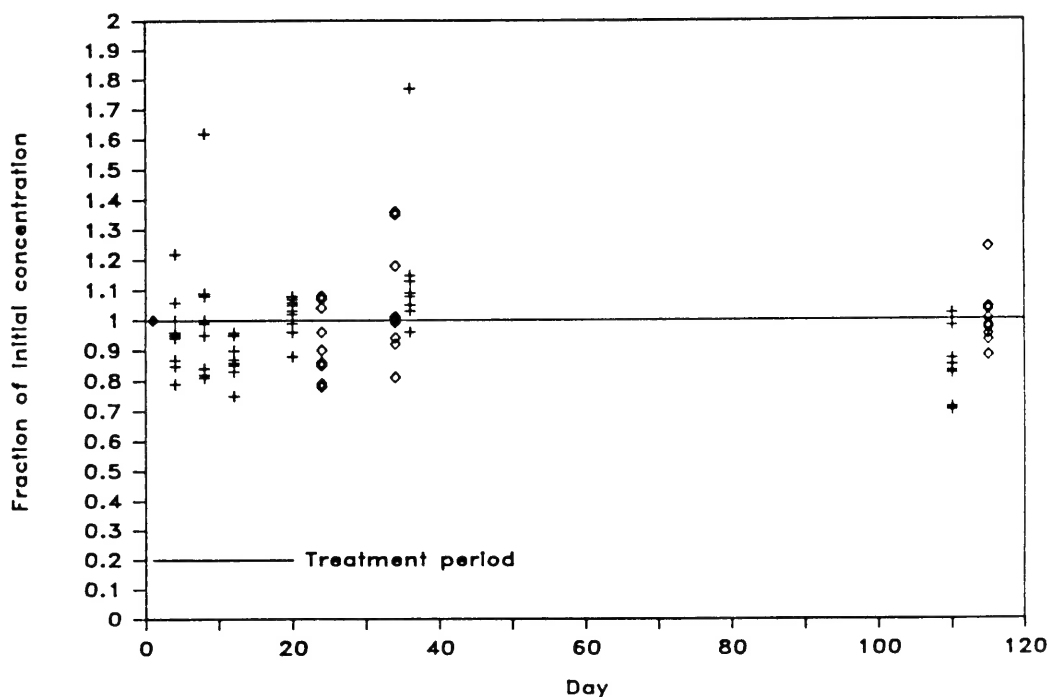


1) The mean difference in body burdens between treatment and control groups at post-treatment was 8.6% for the pesticides and 15.5% for the polychlorinated biphenyls. At the 3-month follow-up, the mean difference between groups was 25.4% for the pesticides and 14.7% for the polychlorinated biphenyls.

There was no significant change in body weight of the participants. Earlier studies (Schnare *et al.*, 1984) had indicated no significant change in body-fat mass as a result of treatment.

The chemical concentrations found in the blood suggest that excretion of body burdens keeps pace with mobilization from fat stores. At pretreatment sampling blood concentrations varied from the limit of detection (0.05 ppb for most chemicals) to > 32 ppb dichlorodiphenyldichloroethylene. Typical concentrations of HCB and polychlorinated biphenyl congeners were 0.4–1.0 ppb, and the range of concentrations at later samplings did not vary significantly. Figures 1 and 2 indicate that blood levels of pesticides and polychlorinated biphenyls did not change significantly during or immediately after treatment.

Fig. 2. Polychlorinated biphenyl blood concentrations as a fraction of those found at initial sampling. The polychlorinated biphenyls measured were the 6- and 7-chloride congeners in Table 1. Mean blood concentrations for each chemical and sampling point are shown for the treatment group (+) and the control group (\diamond). The bar labelled treatment period indicates the period during which treatment was provided. There was no significant difference in blood levels between the two groups during the period of study



DISCUSSION

Body-burden reduction

Reductions in chemical body burdens after treatment with the Hubbard method had been confirmed previously for chlorinated pesticides and polyhalogenated biphenyls. Roehm (1983) reported large reductions in patients exposed to pesticides and polychlorinated biphenyls and a continued reduction over a 9-month period in the absence of any other treatment. We documented similar large body-burden reductions of polychlorinated and polybrominated biphenyls in subjects exposed during the chemical mishap in Michigan in the early 1970s (Schnare *et al.*, 1984).

The reductions in electrical-worker body burdens reported here are significant in that earlier studies were made in the absence of re-exposure. Reduction despite re-exposure suggests that excretion pathways can be exploited successfully. It remains to be seen, however, whether the reductions would occur without vigorous mobilization.

Symptom remission

Although the electrical workers in this study were screened for their health and did not present a significant number of symptoms of chemical exposure, two previous studies have examined chemical-related symptoms. These symptoms, and their remission, are important in that body-burden reduction is of less importance if reversible symptoms are not relieved concurrently.

Root *et al.* (1985) reviewed the literature on 46 chemicals and found that symptoms of chemical exposure were similar for widely differing chemicals. They also reported symptom remission in 120 patients occupationally exposed to a variety of chlorinated pesticides and solvents. The prevalence of pretreatment symptoms in these patients was not significantly different from that reported by Anderson *et al.* (1979) for the population exposed to polybrominated biphenyls in Michigan. After treatment, symptom prevalence was significantly less, and the patient population could not be differentiated from a healthy population. Similar symptom remission was reported in a population receiving treatment for drug detoxification (Schnare *et al.*, 1982).

Symptom remission associated with body-burden reduction may be a particularly important research topic for HCB exposure. Symptoms of HCB exposure reported by Peters *et al.* (1982) are similar to those most significantly reduced in the Root population and include weakness, paraesthesias, nervousness, constipation, joint pain and skin fragility. We observed remission of similar symptoms after treatment in subjects exposed to polybrominated biphenyls, which has held for over 2 years.

A second area of symptom remission which has been studied is behavioural. As Spyker (1975) indicated, human behavioural changes serve as the earliest indicator that some subtle toxic action is occurring in the body, often at a time when the process can still be reversed. Improvements in mental acuity, long-term stored memory and abnormal personality are documented results of treatment to reduce chemical body burdens (Schnare *et al.*, 1982). Some of these improvements took place more than a decade after chemical exposure, suggesting that chemically related neurological and behavioural symptoms are to some extent reversible.

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