Bull. Environm. Contam. Toxicol. 19, 617-623 (1978)

Human Blood Cholinesterase Activity— Holland Marsh, Ontario, 1976

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INTRODUCTION

Organophosphorus pesticides, such as parathion, malathion and diazinon and related compounds, have since 1970 replaced DDT as pesticides of choice for pest control in crops, such as carrot, onion and lettuce. In 1975 some eleven tons of these materials were applied over an area of 7500 acres, which constitutes the region known as Holland Marsh. Devoted primarily to intense vegetable farming, this region is located 30 miles north of Toronto, Ontario, Canada. It is 7 miles long, 1 to 3 miles in width and cultivated by 400 farmers. The soil is classified as peat muck, and the average farm size is 25 to 30 acres. Holland Marsh is served by eight cooperative packing houses which process 90% of the crops. Produce is then delivered to Toronto and Hamilton, Ontario, Detroit in Michigan, and areas of New York State, including Buffalo and Rochester.

Since organophosphorus pesticides are largely applied by means of tractor-drawn air spray equipment some concern has been felt for the health of the residents of this area. As a gauge of overexposure determinations of plasma pseudocholinesterase and red cell acetyl-cholinesterase have been made in various groups of residents of Holland Marsh. The results have been examined for seasonal, occupational and environmentally exposed groups. The farmers were tested in the spring, summer and fall, packing house employees during the summer and school children during the month of June. Residents of Ontario, Canada, in good health and having no known environmental or occupational exposure to organophosphorus and carbamate pesticides were used as a control group and these samples were collected over a period from April to December, 1976. In all some 960 measurements were made of cholinesterase activity and derived from 315 subjects.

Methods

Blood was taken from the finger and cholinesterase activity determined by modification of the method described by MICHEL(1949). Heparinized plastic tubing was substituted for glass tubing as used by MICHEL. The plastic tube was heat sealed for transportation and storage. All blood samples were kept for a period of 24 hours prior to the determination of cholinesterase activity at

0007-4861/78/0617 $1.40

a temperature of 10° C.

Results

At each blood collection blood samples were taken from one or either of the two investigators. Neither of these persons had any obvious exposure to organophosphorus or Carbamate pesticides. This gave a measure of the variability of the method. It was found that for the two investigators the mean values and standard deviations over a period of April to December, 1976 for plasma pseudocholinesterase were 1.22 ± 0.11 and 1.02 ± 0.11 ΔpH/hr., respectively, and for red cell acetylcholinesterase were 0.84 ± 0.12 and 0.82 ± 0.12ΔpH/hr., respectively.

The mean value, standard deviation and range for pseudocholinesterase and red cell acetylcholinesterase for various groups is given in Table 1.

TABLE 1

Group	No. of Samples	Plasma			Red Cell		
		Mean	S.D.	Range	Mean	S.D.	Range
Control	48	0.99	0.17	0.55-1.43	0.75	0.10	0.50-1.04
School children	31	0.97	0.21	0.41-1.44	0.73	0.08	0.57-0.95
Produce Packers	104	0.76	0.20	0.34-1.38	0.72	0.08	0.52-0.97
Farmers-1 (Apr-June)	119	0.84	0.24	0.41-1.58	0.83	0.12	0.36-1.27
Farmers-2 (Aug-Oct)	82	0.75	0.18	0.41-1.32	0.64	0.08	0.46-0.95
Farmers-3 (Nov-Dec)	49	0.93	0.20	0.51-1.40	0.78	0.11	0.45-1.05

There is a statistically significant difference between the mean value of Farmers-1 and Farmers-2 with respect to both pseudocholinesterase and red cell acetylcholinesterase ($P < 0.001$, and $P < 0.005$, respectively). Produce packers and Farmers-1 show a significant depression of cholinesterase activity in plasma with regard to the control group ($P < 0.001$ for both). From all outward appearances these groups did not show any abnormal clinical signs although there was a statistically significant depression of cholinesterase activity. Whilst these results are equivocal it would seem that this study would support the suggestion that red cell acetylcholinesterase activity is a more reliable indicator of organophosphorus pesticides intoxication. The blood cholinesterase levels of 132 pesticides applicators (farmers)

were determined during the period April to December, 1976. In as far as individuals were available samples were collected on three occasions. The distribution of pseudocholinesterase levels for the three groups of farmers is shown in Fig. 1.

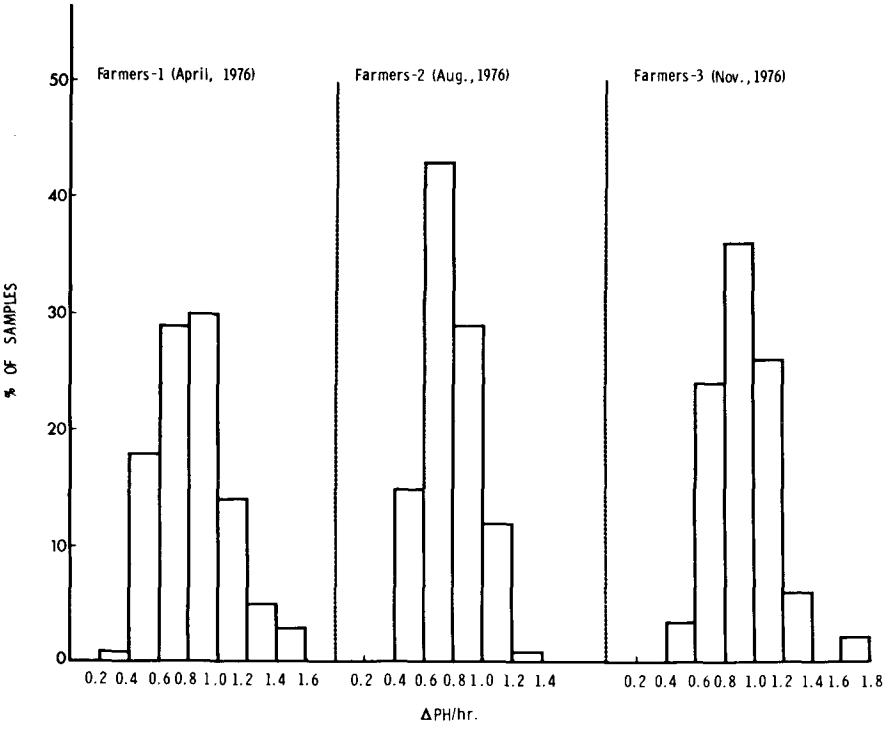

Fig. 1 - Distribution of plasma pseudocholinesterase activity - Δ pH/hr. for farmers exposed to organophosphorus pesticides.

The distribution of red cell acetylcholinesterase was similar to that of pseudocholinesterase. It can be seen that there is a decline in pseudocholinesterase activity during Aug-Oct, 1976, a period when spraying was at its height.

The pseudocholinesterase activity of the control group, produce packers and school children are shown in Fig. 2.

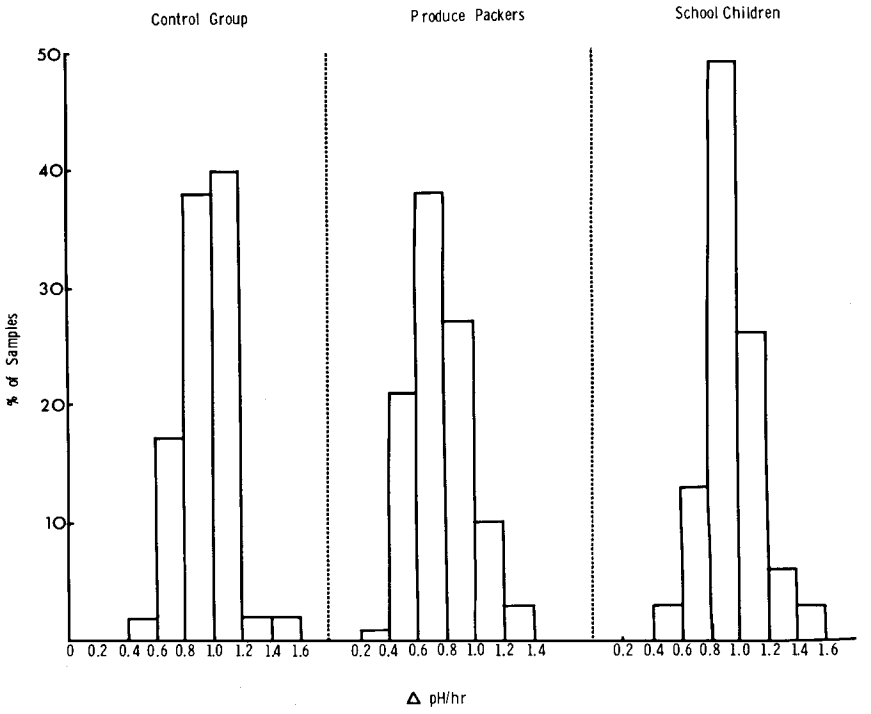

Fig. 2 - Distribution of plasma pseudocholinesterase activity - Δ pH/hr. for control group, produce packers and school children.

The values for the produce packers were statistically significantly lower than that of the control group with respect to both pseudocholinesterase and red cell acetylcholinesterase. ($P < 0.001$, and $P < 0.05$, respectively). The values for school children did not differ from that of the control group in respect of either pseudocholinesterase or red cell acetylcholinesterase.

Individual differences for the farmers have been examined during the period of April to August, August to October, and October to December, 1976. In the first group the comparison was made between 75 subjects and in the second group, between 33 subjects. The results are shown in Fig. 3 for red cell acetylcholinesterase.

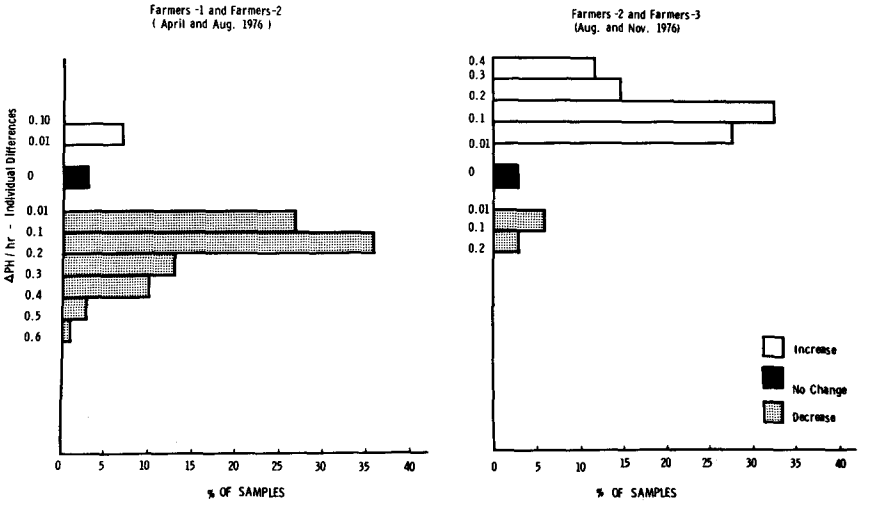

Fig. 3 - Seasonal difference in red cell acetylcholinesterase activity in farmers, Holland Marsh, Ontario.

It is seen that there is a distinct reversal in the trend of the results obtained in the two periods. In the first period there is a marked decrease in acetylcholinesterase activity. However, in the second period this activity has increased. The change in pseudocholinesterase levels for the individual farmers was similar to that for red cell acetylcholinesterase. In the above comparison the number of farmers in each group was not the same, but, if the results of those farmers who were sampled on at least three occasions during the season are compared as shown in Table 2, the similar depression of enzyme activity occurs in the summer with a return of this activity when the spraying season has ended.

TABLE 2

Cholinesterase Activity - pH/hr for 33 farmers sampled three times during season year

Time of	Plasma			Red Cell		
sampling	Mean	S.D.	Range	Mean	S.D.	Range
April-June	0.84	0.21	0.42-1.56	0.79	0.10	0.58-1.04
Aug-Oct	0.75	0.15	0.44-1.01	0.64	0.09	0.54-0.95
Nov-Dec	0.92	0.20	1.51-1.47	0.78	0.08	0.61-0.96

DISCUSSION

The normal levels of cholinesterase activity used in this study were obtained from the control subjects. This gave a mean value of 0.99 ± 0.17 and 0.75 ± 0.10 Δ pH/hr. for plasma and red cell, respectively. This would imply that a normal range for cholinesterase activity in plasma and red cell would be 0.69 - 1.29 and 0.55 - 0.95 Δ pH/hr. based upon ± twice the standard deviation, respectively. However, MICHEL (1949), as a result of a study on 12 subjects, proposed a mean value of 0.70 and 0.75 Δ pH/hr. for plasma and red cell, respectively. Although the values from MICHEL and the present study for red cell acetylcholinesterase activity are similar, there is a difference between values for plasma pseudocholinesterase level. It is suggested that red cell acetylcholinesterase values are a better indicator of overexposure to organophosphorus and carbamate pesticides than are plasma levels (GOLZ and SHAFFER).

In the present study the produce packers had an apparent lower pseudocholinesterase activity. They were mainly first generation Portuguese landed immigrants. The difference is likely due to ethnic and dietary differences (RHEINHOLD, 1953).

RIDER et al (1957) in their study on 400 male and 400 female subjects found that there was a significant difference between sexes with respect to plasma pseudocholinesterase. Pseudocholinesterase levels for men were higher than those for women. However, there was no significant difference between red cell acetylcholinesterase levels for men and women.

In the present study it was found that there was no significant difference between either pseudocholinesterase level or red cell acetylcholinesterase level between men and women.

This study indicates that there is no difference with respect to age. However, there is some disagreement concerning the change of plasma enzyme in relation to age. Some investigators find an increase (RIDER et al, 1957) and others find a decrease (SHANOR et al, 1961). SIDELL (1975) in his group of 433 men and 258 women saw no intersex difference above the age of 60 in plasma pseudocholinesterase levels. RIDER et al (1957) found no change in red cell acetylcholinesterase activity with age either in men or women.

A seasonal variation in human pseudocholinesterase was found by SAKAINO (1955) with the levels being higher in summer than in winter. If such a seasonal change towards higher pseudocholinesterase levels in the summer was operating in this study then any depression due to organophosphorus pesticides could be partially or completely masked. The results of the present study are consistent with moderate overexposure to organophosphorus pesticides among those growers tested on the Holland Marsh.

Blood cholinesterase levels have been determined for farmers and their families living in an area normally designated as Holland Marsh. The results indicate that there is a diminution in cholinesterase level during the months of greatest organophosphorus pesticide use. There were no clinical cases of parathion or carbamate poisoning among those studied.

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This work was supported by a grant from the Pesticides

Advisory Board, Ontario Ministry of the Environment.