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Elevated blood pressure in Nigerian farm workers occupationally exposed to organophosphate pesticides

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Abstract

Background: Previous studies showed that persistent exposure to organic pollutants (POPs) increases the risk of chronic diseases such as hypertension. However, very little is known about chronic exposure to non POPs such as organophosphate (OP) pesticides and the risk of developing hypertension in this environment. This study therefore, measured clinical and anthropometric indices as well as serum activity of acetylcholinesterase (AChE) in farm workers exposed to organophosphate pesticides.

Materials and methods: Sixty farm workers (30 pesticide applicators and 30 farmers) and 30 apparently healthy individuals who are not occupationally exposed to OP (controls) were enrolled into this study. A short structured questionnaire was used to obtain anthropometric indices. Body weight, height and blood pressure (BP) were measured using standard methods while serum activity of AChE was assayed using High Performance Liquid Chromatography (HPLC). Data were analyzed using the Student's t-test and Pearson correlation as appropriate. $P<0.05$ was considered statistically significant.

Result: Serum AChE activity was significantly decreased while BMI and SBP were significantly elevated in farmers compared to control. Similarly, there was significant elevation in BMI, SBP and DBP, and significant reduction in AChE activity in applicators compared to controls. However, only AChE activity was significantly lower in applicators compared with farmers.

Conclusion: The present study shows that chronic exposure to OP pesticides may be associated with increased risk of developing hypertension. Hence, farm workers should be encouraged to use personal protective equipment to reduce exposure to OP and may benefit from periodic assessment of their blood pressure.

Keywords: *Acetylcholinesterase, Pesticides applicators, Farmers, Hypertension, Organophosphate pesticides.*

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Résumé

Contexte: Des études antérieures ont montré que l'exposition persistante à des polluants organiques (POP) augmente le risque de maladies chroniques comme l'hypertension. Cependant, très peu est connu à propos de l'exposition chronique à des non POP tels que les pesticides organophosphorés (OP) et le risque de développer l'hypertension artérielle dans cet environnement. Par conséquent, cette étude a mesuré les indices cliniques et anthropométriques ainsi que l'activité sérique de l'acétylcholinestérase (AChE) dans les travailleurs agricoles exposés aux pesticides organophosphorés.

Matériels et méthodes: Soixante travailleurs agricoles (30 applicateurs de pesticides et 30 agriculteurs) et 30 individus apparemment en bonne santé qui ne sont pas exposées professionnellement à des OP (contrôles) ont été enrôlés dans cette étude. Un court questionnaire-structuré a été utilisé pour obtenir des indices anthropométriques. Le poids corporel, la taille et de la pression artérielle (PA) ont été mesurés à l'aide des méthodes standard tandis que l'activité sérique de l'acétylcholinestérase a été testée en utilisant la chromatographie liquide à haute performance (HPLC). Les données ont été analysées en utilisant le 'Student' test t de et la corrélation de Pearson, comme approprié. P <0,05 était considérée comme statistiquement significative.

Résultat: L'activité sérique de l'acétylcholinestérase a été considérablement diminuée, tandis que l'IMC et PAS étaient significativement plus élevés chez les agriculteurs par rapport au contrôle. De même, il y avait une élévation significative de l'IMC, PAS et PAD, et réduction significative de l'activité de l'acétylcholinestérase dans les applicateurs par rapport aux contrôles. Cependant, seule l'activité l'acétylcholinestérase (AChE) était significativement plus faible chez les

applicateurs rapport aux agriculteurs.
Conclusion: L'étude présente montre que l'exposition chronique aux pesticides organophosphorés peut être associée à un risque accru de développer l'hypertension artérielle. Par conséquent, les travailleurs agricoles devraient être encouragés à utiliser l'équipement de protection personnelle pour réduire l'exposition aux OP et peuvent bénéficier d'une évaluation périodique de leur pression artérielle.

Mots-clés: *acétylcholinestérase, applicateurs de pesticides, agriculteurs, hypertension, pesticides organophosphorés.*

Introduction

Pesticides are chemicals used in agriculture to protect crops against destructive pests both on the field and during storage [1-3]. They are commonly used by the nearly 40% of the Nigerian workforce employed in agriculture [4]. Severalpesticides have been used in agricultural practice in order to enhance food production and they are known to differ greatly in their modes of action, uptake by the body, metabolism, elimination from the body and toxicity to humans [5]. Among the pesticides, organophosphates (OP) are widely used, as these compounds are non-persistent in the environment [6]. OP are frequently sprayed in cocao, cashew and mango plantations in South-Western Nigeria which is a tree crop belt of the country and remains a key area with possible pesticide poisoning [7]. Occupational exposure to OP pesticides is through skin absorption, inhalation and accidental ingestion. It has been shown that OP applicators and farmers do not consistently use personal protective equipment such as face masks, gloves and overalls [8] which can reduce exposure. This led to the increased risk of adverse neurotoxicological, reproductive, developmental and immunological effects as well as leukaemia, brain and prostate cancers which have previously been demonstrated in this group of individuals [9-12].

OP pesticides exert their toxic effects by inhibiting the enzyme acetylcholinesterase (AChE) which is responsible for the hydrolysis of acetylcholine (ACh), a neurotransmitter that conducts nerve impulses across neuromuscular junctions in the nervous system of vertebrates as well as insects. This leads to accumulation of ACh with generalized cholinergic action and resulting in rapid, uncontrolled twitching of voluntary muscles which may eventually lead to paralysis, respiratory failure and death [13-14]. Though blood test for monitoring exposure of farm workers to OP pesticides is serum AChE activity [15], most of the farmers and OP applicators are neither economically buoyant nor enlightened enough to understand the importance of AChE assay which in most cases are not routinely available. Hence, there is the need for a simple and easily affordable routine test as well as simple clinical indices that could be used to monitor occupational exposure to OP in resource limited settings such as Nigeria.

An earlier report by our group showed that exposure to OP alters hematological and immunological indices [17]. Furthermore, adverse effects on lungs and liver following exposure to OP have been reported in some experimental studies [18, 19]. There is however, dearth of knowledge on the adverse effect of exposure to OP and risk of hypertension. To examine the association between long-term exposure to OP pesticides and risk of developing hypertension, we studied farm workers and administrative workers residing in villages where farming was predominant.

Materials and Methods

After obtaining a written informed consent from each participant and ethical approval from the Joint Ethical Committee of University of Ibadan/University College Hospital, sixty (60) farm workers (30 OP applicators and 30 farmers) and thirty (30) controls were recruited from Ibarapa community in Oyo state, Nigeria for this study.

Body weight was taken with a bathroom scale placed on a flat surface. The subject while wearing light clothing and without any shoes stood on the zero scale. The reading was recorded to the nearest 0.5kg.

Height of each participant was measured in meters with subjects standing bare footed as upright as possible on a hard level ground against a vertical wall and without raising the heels from the ground with the feet kept together while the back and heel were aligned with a ruled bar against the vertical surface. The measurement was made by moving a sliding head piece to the vertex of the subject's head and the reading at that point was recorded to the nearest 0.1 meter. Body Mass Index (BMI) was calculated as the ratio of body weight to the square of height.

Table 1: Blood pressure and anthropometric indices in pesticide applicators, farmers exposed to Op pesticides and the controls.

Index	Controls (n=30)	Farmers (n=30)	OP applicators(n=30)
Age (yrs)	46.00±10.00	47.00±18.00	46.00±15.00
AChE (IU/ml)	9.38±0.82	7.88±0.63*	6.63±0.90*#
Weight (kg)	59.90±11.20	61.60±10.40	62.10±10.40
Height (m)	1.67±0.07	1.62±0.07	1.61±0.07
BMI (kg/m^2)	21.50±3.10	23.40±3.60*	23.90±5.10*
SBP (mmHg)	111.67±7.34	149.23±19.68*	145.10±19.98*
DBP (mmHg)	71.00±10.84	95.23±13.55	98.63±13.28*

*Significantly different from controls
#Significantly different from farmers

Blood pressure was measured with the use of electronic sphygmomanometer following the calibration of the instrument with mercury sphygmomanometer to nearest 2mmHg. Blood pressure was done when the patients have rested for ten minutes and in a sitting position and recorded to the nearest mm Hg according to standard procedures.

Venous blood was aseptically obtained from the antecubital fosa vein and dispensed into plain sample bottle. After clotting, the blood sample was spun at 1000xg for 5 minutes; serum was obtained and stored at -20°C until analysis. Serum activity of AChE was assayed using High Performance Liquid Chromatography (HPLC).

Results

Table 1 shows the mean serum AChE activity, blood pressure and anthropometric indices in OP applicators and OP exposed farmers compared to control. Serum AChE activity was significantly decreased while BMI and SBP were significantly elevated in farmers compared to control. Similarly, there was significant elevation in BMI, SBP and DBP, and significant reduction in AChE activity in applicators compared to controls. However, only AChE activity was significantly lower in applicators compared with farmers. Blood pressure and the anthropometric indices were similar between the 2 groups.

Significant positive correlation was observed between AChE activity and BMI in the applicators group (Table 2).

Discussion

This study found significantly increased blood pressure and BMI in OP applicators and farmers when compared with controls. This observation shows that individuals who are chronically exposed to OP pesticides have increased risk of developing hypertension as well as chronic diseases associated with increasing BMI.

The observed lower AChE activity in applicators and farmers is not a novel finding. It is in line with the report of Misra et al. [15] who reported decreased acetylcholinesterase activity in individuals exposed to organophosphate. However, the significant reduction in AChE activity observed in applicators compared with the farmers suggest that the relative likelihood of OP toxicity is higher in applicators than farmers.

Previous studies have shown that exposure to persistent organic pollutants (POPs) increases the risk of chronic diseases such as hypertension. This led to the banning of organochlorine pesticides use. Experimental evidence suggests that dichlorodiphenyltrichloroethane (DDT) which is a POP can act on several arms of the renin angiotensin system (RAS) to increase the risk of hypertension [20]. Studies have also shown that environmental pollutants such as lead (Pb) inhibits the activity of sodium potassium adenosine triphosphatase (Na^+-K^+ ATPase) which has an inverse association with blood pressure [21 - 24].This mechanism may explain the observed elevated blood pressure in both applicators and farmers. Karki et al. [25] reported an association between acute organophosphate poisoning and hypertension. This was attributed to sympathetic and parasympathetic over-activity which caused myocardial damage due to the acute OP poisoning [26, 27].

Also, it has been reported that there is increased risk of hypertensive disorders of

Table 2: Correlation between clinical and anthropometric indices with serum AChE level in pesticide applicators and farmers

AChE	Pesticide Applicators r,p	Farmers r,p
Age (yrs)	0.30, 0.09	0.30.0.88
Weight (kg)	0.29, 0.13	-0.12,0.55
Height (m)	-0.09, 0.61	0.05,0.80
BMI (kg/m^2)	0.36, 0.04*	-0.24,0.20
SBP (mmHg)	0.02, 0.91	-0.53,0.78
DBP (mmHg)	0.18, 0.34	0.02,0.91

*Significant at $P<0.05$ (2-tailed)

pregnancy following pesticides exposure during pregnancy [28] as well as increased cardiovascular risk profile at school age due to prenatal pesticide exposure [29]. It is thought that repeated sympathetic and parasympathetic over-activity for prolonged period may produce clinically evident or subclinical conditions which clinical measurements may reveal for prompt attention. Ludomirsky et al [30] described three phases of cardiac toxicity after organophosphate poisoning: phase 1; a brief period of increased sympathetic tone; phase 2: a prolonged period of parasympathetic activity; and phase 3: Q-T prolongation followed by torsade de pointes ventricular tachycardia, and then ventricular fibrillation.

Our observed elevated diastolic blood pressure in the applicators compared with the controls might not be surprising as it was also observed that AChE activity was more depressed in this group. Furthermore, there was significant positive correlation between AChE activity and BMI in pesticide applicators. This indicates that applicators are more at risk of possible OP-induced hypertension and increasing BMI than the farmers.

There is steady rise in obesity throughout the world. The role of environmental chemicals in obesity continues to garner increased attention; this has given rise to the concepts of obesogens [31]. Studies have shown that there is a link between pesticides, increased BMI and insulin resistance [32, 33]. This might be responsible for our observed higher BMI (although still within the normal range) in applicators and farmers compared with controls. A number of chemicals have been shown to interact with the signaling pathways involved in weight regulation [31].

In conclusion,we have shown that chronic exposure to OP pesticides may be associated with increased risk of developing hypertension. Hence, clinical indices such as blood pressure may serve as valuable tool for monitoring population exposed to OP. Also, farm workers should be encouraged to use personal protective equipment to reduce exposure to OP and may benefit from periodic assessment of their blood pressure.

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