Nigerian Journal of Physiological Sciences 17 (1-2): 42-47 © Physiological Society of Nigeria, 2002

EFFECT OF EXPOSURE TO DUST GENERATED FROM CRUSHING OF GRANITE ROCKS ON THE LUNG FUNCTION OF SOUTH EASTERN NIGERIAN CHILDREN.

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Summary We measured and compared ventilatory function indices: forced vital capacity (FVC); forced expiratory volume in one second (FEV_1), forced expiratory volume in one second as a percentage of forced vital capacity (FEV_1 %) and peak expiratory flow rate (PEFR)of 442 granite dust-exposed Nigerian children (221males and 221 females)aged 6-16years to those of 472(238 males and 234 females) age, weight and sex-matched Nigerian children not exposed to any known pollutant as control. The respirable dust levels in the dusty (test) and control environments were also measured. The respirable dust level in the dusty environment ($0.064 + 0.003 mg/m^3$) was significantly higher ($P<0.001$) than in the control environment ($0.0133+ 0.004mg/m^3$). The mean values of FVC, FEV_1, and PEFR of the dust-exposed children were significantly lower ($P< 0.001$) than those of children in control sites. FEV_1% was however not significantly different, thus, indicating restrictive lung defect in the dust exposed children. Chronic exposure to granite rock dust may therefore impair lung function in children.

Key Words: *Granite dust, lung function, children*

Introduction

Respirable dust particles in air may damage the respiratory and other systems of the body (Wang et *al*, 1998; Horak, 2000). Numerous studies have shown that exposure to toxic fumes industrial gases in urban areas, organic and inorganic dust may be responsible for pulmonary function impairment in humans (Musk, et al., 1980; Crosbie, 1986; Meister,1990; Osim et al, 1996; Nowak, 1998; Osim et al, 1999). However, these studies were done on adults. Studies on the effect of exposure to dust generated from industries on the lung function of Nigerian children are lacking inspite of the fact that dust generating industries in Nigeria rarely provide precautionary measures. Furthermore, there are no studies on the effect of granite dust on the lung function of the African let alone the Nigerian child.

The aim of this study therefore was to ascertain the lung function status of children in schools close (less than 1 kilometer) to a factory that emits a lot of granite dust, the Crushed Rock Industry in Akamkpa, Cross River State in Nigeria, which crushes granite rocks for sale. Cross River State is situated in South Eastern Nigeria. The lung function values of the dust exposed children were then compared with the normal population of children who are not exposed to any known air pollutant to find out whether granite dust exposure had any lung function impairment on the children.

Materials and Methods

Subjects

Two groups of subjects (dust-exposed and their controls) were used in this study. A total of 442 dust-exposed Nigerian children (221 males and 221 females) aged 6-16 years were studied. These children were chosen from schools within one kilometer from the Crushed Rock Industry in Akampka Cross River State of Nigeria They had lived in the environment since birth. They were also of Nigerian parentage and none of them were cigarette smokers or children of cigarette smokers.

The control group comprised 472 apparently healthy Nigerian children (238males and 234 females) aged 6-16years. These control children were selected from about six primary and secondary schools in the Calabar metropolis. None of them were cigarette smokers or had been exposed to any other known air pollutant. They were all Nigerians.

The age weight, and height range of the children in the test and control groups were similar (Tables 5 and 6) since these anthropometric parameters affect lung function(Aderele and Oduwole 1983, Mashalla *et al* 1992)

The ventilatory function indices: forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory volume as a percentage of forced vital capacity (FEV_1 %) and peak expiratory flow rate (PEFR) were measured to access pulmonary (lung) function. The vitalograph was used to measure FVC and FEV_1 while $FEV_1\%$ was computed from FVC and FEV_1. PEFR was measured using a Mini-Wright Peak Flow Meter. These measurements were done as described by Osim *et al.*, (1992).

Test Procedure

On the first day of measurement in each of the schools, a portion of the wall was calibrated using the metre rule and a piece of white chalk for use in height measurement of subjects. The children were called in groups and instructed on the test procedure after which it was demonstrated to them for better understanding. The subjects were then called into the 'test' room individually where a questionnaire was completed before the tests were performed. The questionnaire recorded names, smoking habits, any history of respiratory (pulmonary) disease; while height without shoes and weight with light clothing were measured and recorded.

Dust Sampling

The concentration of respirable dust in both test and control sites were measured using a gravimetric dust sampler manufactured in the Department of Physics, University of Calabar, Nigeria. The instrument measures the concentration of respirable dust as it maintains a constant supply of air at 2 litres per minute through its filter for 4 hours.The respirable dust was sampled in three control and three test sites and their means were calculated.

Comparisons Performed

From the forced expiratory spirograms, comparisons between ventilatory function indices FVC, FEV_1, FEV_1 %, and PEFR were done for dust exposed children and their controls. The mean concentrations of respirable dust levels in both sites (test and control) were also compared.

Statistical analysis

The student's unpaired t-test was employed in the comparison of ventilatory function indices and dust levels in the control and test environments. Data are presented as mean and standard error of the mean (SEM). A P-value of < 0.05 was considered as significant

Results

Comparison of Mean FVC Per age of Control Children With The FVC of Dust Exposed Children

Table 1 shows the comparison of mean FVC values per age of male and female children in control and test (dusty) environments. Among the males, FVC was significantly lower ($P<0.05$-0.001) in test children when compared to their control except at ages 6,7,9and 12 where there was no significant difference. Also, among the females, mean FVC was significantly lower ($P<0.05$-0.001) in the female children when compared to their control except at ages 6,7,9,10and 11 where there was no significant difference.

The common trend was that after the age 12, mean FV C values of male and female children in dusty environment were significantly lower ($p<0.05$-0.001) than those in control sites.

TABLE: 1 COMPARISON OF MEAN FVC VALUES PER AGE BETWEEN CONTROL AND TEST (DUST EXPOSED) GROUPS IN MALE AND FEMALE CHILDREN

MALES				FEMALES		
Age (Years)	Control	Test (dust-exposed)	P-value	Control	Test (dust-exposed)	P value
6	0.98±0.04	0.94±0.04	NS	0.86±0.12	0.88±0.03	NS
7	1.23±0.14	1.17±0.02	NS	1.06±0.04	0.99±0.04	NS
8	1.44±0.05	1.07±0.05	***	1.31±0.04	0.86±0.06	***
9	1.43±0.03	1.37±0.06	NS	1.30±0.05	1.36±0.04	NS
10	1.83±0.06	1.42±0.09	***	1.40±0.06	1.25±0.04	NS
11	1.77±0.07	1.51±0.06	**	1.58±0.12	1.34±0.06	NS
12	1.75±0.07	1.69±0.04	NS	2.11±0.11	1.64±0.07	***
13	2.32±0.10	2.09±0.07	*	2.28±0.11	2.02±0.09	*
14	2.81±0.09	2.08±0.06	***	2.70±0.12	2.25±0.04	***
15	2.68±0.11	2.31±0.11	*	2.81±0.12	2.45±0.07	**
16	3.18±0.10	2.65±0.07	***	2.72±0.09	2.48±0.07	*

NS = Not significant; * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$

Comparison of Mean FEV_1 Per Age of Control Children With The FEV_1 of Dust exposed Children

Table 2 shows the comparison of mean FEV_1 values per age of male and female children in control and test (dusty) environments. In the male children mean FEV_1 was significantly lower ($P < 0.05$-0.001) in all ages of the test children when compared to their control except in ages 6,7and 9 where there was no statistical difference. Among the females, mean FEV_1 was significantly lower ($P<0.05$-0.001) in all ages of test children when compared to control except at ages 6, 7, 9, 10 and 11, where there was no statistically significant difference

The common trend was that after age 11 mean FEV_1 values of male and female children in dusty environments were significantly lower ($P < 0.05$- 0.001) than those in control sites

TABLE 2: COMPARISON OF MEAN FEV_1 VALUES PER AGE BETWEEN CONTROL AND TEST (DUST EXPOSED) GROUPS IN MALE AND FEMALE CHILDREN

MALES				FEMALES		
Age (Years)	Control	Test (dust-exposed)	P-value	Control	Test (dust-exposed)	P-value
6	0.82±0.06	0.77±0.04	NS	.75±0.05	0.70±0.03	NS
7	1.02±0.03	0.96±0.03	NS	.93±0.03	0.85±0.04	NS
8	1.24±0.04	0.89±0.05	***	.12±0.04	0.75±0.06	***
9	1.22±0.04	1.20±0.05	NS	.12±0.03	.15±0.04	NS
10	1.60±0.06	1.22±0.08	***	.11±0.06	1.07±0.04	NS
11	1.56±0.05	1.26±0.06	***	.30±0.11	1.16±0.07	NS
12	1.40±0.06	1.24±0.04	*	1.67±0.10	1.29±0.04	***
13	1.97±0.09	1.60±0.08	**	1.73±0.11	.42±0.09	*
14	2.22±0.06	1.71±0.08	***	.19±0.13	.36±0.05	***
15	2.01±0.10	1.72±0.11	**	.18±0.13	.83±0.07	*
16	2.57±0.10	2.11±0.06	***	2.23±0.12	.61±0.08	***

NS = Not significant; * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$

Comparison of Mean FEV_1% Per Age of Control Children With The FEV_1% of Dust-Exposed children

Table 3 shows comparison of mean FEV_1% values per age group of male and female children in control and test (dusty) environments. There was no statistically significant difference between the mean values of FEV_1% in control and test (dust exposed) groups of male and female children in all age groups.

TABLE 3: COMPARISON OF MEAN FEV_1% VALUES PER AGE BETWEEN CONTROL AND TEST (DUST EXPOSED) GROUPS IN MALE AND FEMALE CHILDREN

MALES				FEMALES		
Age (Years)	Control	Test (dust-exposed)	P-value	Control	Test (dust-exposed)	P-value
6	86.00±2.20	82.22±1.81	NS	85.73±3.34	85.62±1.60	NS
7	83.82±2.29	82.15±1.64	NS	87.81±1.90	86.06±1.49	NS
8	86.16±1.39	82.34±1.80	NS	87.13±1.46	86.33±1.79	NS
9	84.77±2.34	88.25±1.67	NS	86.63±2.29	88.02±1.06	NS
10	87.38±2.18	85.70±1.91	NS	78.09±2.06	75.16±1.37	NS
11	88.82±2.00	84.82±1.76	NS	81.83±2.77	84.94±2.34	NS
12	80.27±2.28	79.38±1.57	NS	75.17±2.46	77.70±3.19	NS
13	84.35±2.13	80.67±2.90	NS	67.51±2.51	70.45±1.67	NS
14	78.47±1.88	81.39±2.09	NS	76.83±2.56	72.18±2.03	NS
15	75.01±3.19	73.68±2.04	NS	81.24±3.21	74.27±2.08	NS
16	81.07±2.34	79.47±0.06	NS	77.02±3.21	74.15±2.18	NS

NS = Not significant

Comparison of Mean PEFR Per Age Of Control children With The PEFR Of Dust-Exposed Children

Table 4 shows the comparison of mean PEFR values per age of male and female children in control and test environments. Among the male children, mean PEFR was significantly lower (P< 0.05-0.001) in all ages of the test children when compared to their control except in ages 6, 7, and 8 where there was no significant difference. Among the females mean PEFR was significantly lower (P<0.05-0.001) in all the ages of the test children when compared to their control except at ages 6, and 7 where there was no statistically significant difference.

The common trend here was that after age 8, mean PEFR values of male and female children in dusty environments were significantly lower (P<0.05- 0.001) than those in the control sites.

TABLE 4: COMPARISON OF MEAN PEFR VALUES PER AGE BETWEEN CONTROL AND TEST (DUST EXPOSED) GROUPS IN MALE AND FEMALE CHILDREN

MALES				FEMALES		
Age (years)	Control	Test (dust-exposed)	P-value	Control	Test (dust-exposed)	P-value
6	177.83 ±9.27	158.89±8.34	NS	174.27±8.69	171.33±7.04	NS
7	214.63±8.05	218.36±7.05	NS	199.76±7.08	201.11±8.84	NS
8	242.67±7.46	219.49±6.89	NS	244.19±7.08	208.84±7.64	***
9	280.46±7.39	243.43±9.83	**	259.28±8.19	237.45±4.18	*
10	294.03±8.55	252.20±11.06	**	280.18±9.53	243.61±5.94	**
11	315.88±10.48	280.45±9.07	*	305.98±13.75	243.56±6.70	***
12	297.58±11.67	251.22±8.38	**	336.71±12.90	298.44±1079	*
13	370.50±15.38	323.46±13.90	**	368.90±8.94	331.05±6.49	*
14	393.49±11.47	338.71±10.49	***	365.13±15.71	333.62±9.18	*
15	385.50±18.04	353.10±7.82	*	401.12±14.82	380.65±6.92	*
16	457.10±12.01	403.68±10.81	***	405.82±12.55	377.15±7.54	*

NS = Not Statistically significant; * = P<0.05; ** = P<0.01; *** = P<0.001

Comparison of Mean values of Ventilatory Function Parameters (FVC, FEV_1 FEV_1% PEFR) and Anthropometric Parameters (Age, weight, Height)in Control and Dust-Exposed Children

Table 5 shows a comparison of mean values of ventilatory function parameters (FVC, FEV_1, FEV_1%, and PEFR) and mean values of anthropometric parameters (age, weight, and height) in all the control and test (dust-exposed) male children. The mean values of FVC, FEV_1, and PEFR of the test group were significantly lower (P<0.001) than those of the control group. There was no significant difference in FEV_1% when both groups were compared. There was also no significant difference between the values of anthropometric parameters of the two groups.

The comparison was also repeated for female children. Tables 6 compares the mean values of ventilatory function parameters (FVC, FEV_1, FEV_1% and PEFR) and mean values of anthropometric parameters (age, weight and height) in all control and dust-exposed female children. All ventilatory function parameters were significantly lower (P<0.01 and 0.001) in the test group when compared with the control group except mean FEV_1%, which were not statistically significant. There was also no significant difference in anthropometric parameters of the two groups.

TABLE 5 COMPARISON OF MEAN VALUES OF VENTILATORY FUNCTION PARAMETERS (FVC, FEV_1, FEV_1%, AND PEFR) AND MEAN VALUES OF ANTHROPOMETRIC PARAMETERS (AGE WEIGHT AND HEIGHT) IN CONTROL AND TEST (DUST EXPOSED) MALE CHILDREN.

Parameters	Control (N = 238)	Test (dust exposed) (N = 221)	P-value
FVC (L)	1.99 ± 0.05	1.68 ± 0.04	(5.1667)***
FEV1 (L)	1.63 ± 0.04	1.34 ± 0.03	(5.8000) ***
FEV1%	83.21 ± 0.69	82.72 ± 0.63	(0.5246) NS
PEFR (L/min)	311.76 ± 6.21	276.13 ± 5.37	(5.0712) ***
Age (years)	11.18 ± 0.20	11.00 ± 0.22	(0.6207) NS
Weight (kg)	33.11 ± 0.72	32.42 ± 0.68	(0.7040) NS
Height (cm)	135.54 ±1.11	134.60 ± 0.85	(0.4820) NS

NS = not statistically significant; *** = P < 0.001; N = number measured

TABLE 6: COMPARISON OF MEAN VALUES OF VENTILATORY FUNCTION PARAMETERS FVC, FEV1, FEV1%, AND PEFR)AND MEAN VALUES OF ANTHROPOMETRIC PARAMETERS(AGE, WEIGHT, AND HEIGHT) IN CONTROL AND DUST EXPOSED FEMALE CHILDREN.

Parameters	Control (N=234)	Test (dust exposed) (N=221)	P – value
FVC (L)	1.83 ± 0.05	1.60 ± 0.04	(3.8333) ***
FEV1 (L)	1.48 ±0.04	1.2 0 ± 0.02	(7.0000) ***
FEV1%	80.23 ± 0.81	80.48 ± 0.87	(0.2104) NS
PEFR (L/min)	304.38 ± 6.25	247.89 ± 5.90	(6.5762) ***
Age (years)	10.89 ± 0.21	10.94 ±0.23	(0.1612) NS
Weight (kg)	34.41 ± 0.89	33.69 ± 0.86	(0.6000) NS
Height (cm)	137.89 ± 1.25	136.39 ± 1.18	(0.8771) NS

NS=not statistically significant; ** = P < 0.01; *** = P < 0.001, N = number measured.

Dust Sampling

The mean concentration of respirable dust in three sites where children were exposed to dust was 0.064 ± 0.003 mg/m^3 while that in the control sites was 0.03± 0.003 mg/m^3. The respirable dust level in the test (dusty environment) was therefore significantly higher (P < 0.001) than in control sites

Discussion

Results showed that mean values of FVC, FEV_1, and PEFR of dust – exposed children were significantly lower than the values of children in control sites. FEV_1% was however not significantly different. These deviations are characteristic of restrictive lung defect, (West, 1979). These results show that children living in the vicinity of a dust emitting rock crushing industry developed lung function impairment.

Although our results show a significant lowering of lung function values in dust- exposed children compared to their control group, it was not possible to determine all the factors that may be responsible for lung function impairment in these children. However, dust sampling in both dusty and control environments suggests that chronic exposure to granite dust may be a factor since the respirable dust level in the dusty environment was very high when compared to the control environment. Granite rocks contain quartz (silica), plagioclase and feldspar (Ekwueme, 1993). Some of the constituents notably silica have been implicated in lung function impairment (Begin *et al*, 1993). However, these previous studies did not involve children. Although the relatively high dust level might be a factor, there may be other confounding factors. Poisonous gases such as carbon monoxide, carbon dioxide, nitrous fumes and ammonia are emitted from the explosives used in rock blasting which reportedly damage the respiratory system and impair lung function (Raphael et al., 1989; Kocks and Scott, 1990; Harre et al, 1997).It is therefore likely that poisonous gases contributed to the impairment of lung function of children in the dusty environment. Unfortunately, environmental gas levels were not measured owing to technical problems.

Impairment of lung function in granite dust-exposed children was not observed in younger male or female children, especially those aged six and seven years. On the other hand, older children, commonly those over the age of 12 years had significant lung function lowering when compared to their control. Since all the children were born and bred in the vicinity, it is therefore likely that duration of exposure to granite dust is important in the etiology of lung function impairment. So, with time, lung function impairment would endanger the health of exposed adults. Precautionary measures such as relocation of schools and homes far away from granite dust emitting is therefore recommended.

In conclusion, chronic dust exposure to granite dust impairs lung function in children.

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Received: *November 8, 2002*
Accepted: *December 22, 2002*