Anthrop. Közl. *33;* 193–202. (1991)

EFFECT OF STONE DUST ON MORPHO-PHYSIOLOGICAL FUNCTIONS IN MALIS OF RAJASTHAN

S. L. Malik and *A. Swami*

Department of Anthropology, University of Delhi, Delhi, India

Abstract: *In order to study the impact of stone dust exposure on physiological functions, physical fitness, body size and physique, data were collected from 250 adult (125 males and 125 females) Malis working in stone quarries of Rajasthan. For comparison, 250 adult (125 males and 125 females) Malis dealing in dairy products were taken. It both the sexes, the stone quarry workers have lower FVC, FEV_1 and PEFR than the controls. The stone quarry workers are less fit, have lower grip strength, higher blood pressure and pulse rate than the Pastoral Malis. Differences between the two groups are marginal in linear dimensions, but the stone quarry workers are lighter, having smaller breadths, circumferences and skinfolds than controls. The exposed workers have lower mesomorphic and endomorphic components and higher ectomorphic component than the controls.*

It has been concluded that the dust particles of respirable fraction emitted during the process of grinding, milling and blasting, can enter and get deposited in the respiratory tract and lungs and obstruct functioning of airways. This results in lower lung functions producing adverse effects on cardiovascular system, physical fitness, strength, and to some extent on body size and physique.

Key words: *Body measurements; Somatotype; Morpho-physiological functions; Lung function; Physical fitness; Malis of Rajasthan.*

Introduction

Increasing attention is being paid in India to improve working conditions and maintain regulations related to occupational health, but the efforts are still inadequate, perhaps because of numerous difficulties. One of them is certainly the non-availability of accurate data on occupational health and accidents. For example, dust control measures and regular medical examinations are still almost invariably absent in stone quarries, specially the small ones situated remotely. On the other hand, health hazards related to dust exposure of various types of organic and inorganic dusts are well documented (Amandus et al. 1989, Balmes et al. 1990, Cotton et al. 1983, Jorensen et al. 1981 Lee, 1989, Shah et al. 1983, Sharma and Singh 1990).

The present study aims to examine the effects of stone dust exposure on lung functions, pulse rate, blood pressure, grip strength, physical fitness, body measurements and somatotypes using data from stone quarry workers of Rajasthan (India).

Material and Methods

The study was conducted in Alwar district of Rajasthan (*Fig. 1*). The district has a dry climate with hot summer, a cold winter and a short monsoon season. The temperature ranges from 8 °C to 45 °C, with mean annual temperature around 26 °C. Data were collected on the endogamous group of Malis. The exposed group comprised 125 adult males and 125 adult females working actively in different stone quarries in Alwar district. The control group consisted 125 adult males and 125 adult females. The members of the control group trade in milk and its products. They are similar in age, smoking habits and social habits, except those created by their respective work environment.

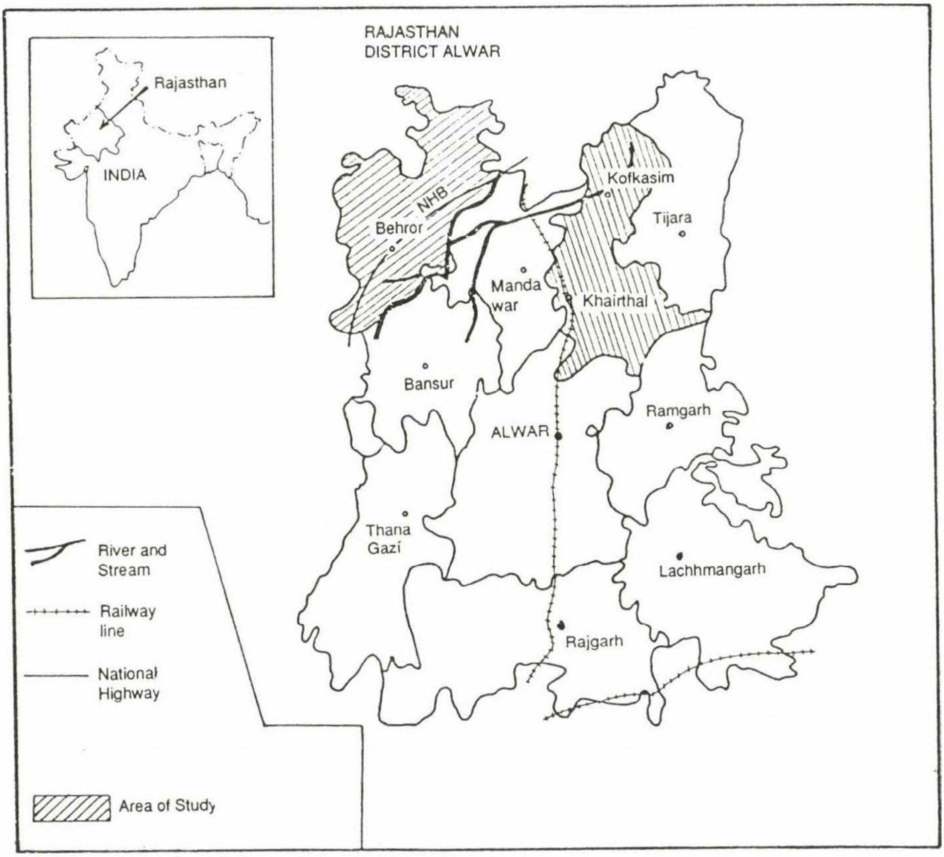

Fig. 1: Map of Alwar district showing area of study

Forced vital capacity (FVC), forced expiratory volume 1st second (FEV_1) and peak expiratory flow rate (PEER) were measured in sitting position with Morgan's portable spirometer following standard technique (Consolazio et al. 1963, Cotes 1975, Weiner and Lourie 1969). Best of three attempts were taken for further analysis.

Indirect ausculatory method was used for taking blood pressure in sitting position. Pulse rate and blood pressure were taken as per the recommendation of International Biological Program (Weiner and Lourie 1969).

Hand grip strength of right and left hands were taken with a dynamometer and recorded in kilograms (Weiner and Lourie 1969). The subjects were encouraged to press the maximum keeping the active arm in hanging position, close to the body but not touching it.

Physical fitness was evaluated using the famous Harvard step test, described in detail by Hockey (1973). This test is most suitable for measuring cardio-vascular endurance of subjects under field conditions. The test' is based on the premise that, for a given submaximal work, a person with higher physical fitness will have a smaller increase in heart rate and a faster recovery rate. Rapid fitness index was calculated using the formula:

$$RFI = \frac{\text{Duration of exercise (in seconds) x 100}}{\text{5.5 x Pulse count from 1 to 1.1/2 min. after exercise}}$$

Body measurements were taken following standard techniques (Tanner et al. 1969). Subjects were somatotyped from ten anthropometric measurements using Heath and Carter's method (Carter 1975, Heath and Carter 1967). Somatotype dispersion distance (SDD) and somatotype dispersion index were calculated using the formulae given by Ross and Wilson (1973).

One way analysis of variance test was used for comparing the control and the exposed groups for various biological variables.

Results and Discussion

Both exposed males and females have significantly lower FVC, FEV_1, and PEFR than control workers (*Fig. 2*). Mean values of pulse count and blood pressure are significantly greater in exposed than in control groups (*Fig. 3*).

Right and Left hands grip strengths are significantly lower in the exposed female workers than in the controls (*Fig. 4*). In males, though the trend is in the same direction, the differences between the two groups is statistically not significant at 5% probability level.

There are no marked differences between the control and the exposed groups in linear body dimensions such as stature, sitting height, lower extremity length etc., but the exposed subjects are significantly lighter, possess smaller breadths, circumferences and skinfolds than the control group (*Figs. 5, 6, 7, 8*). The mean values of age in the exposed and the control groups are similar in both males and females.

Figure 9 depicts that male stone quarry workers (1.60–1.59–3.54) have significantly lower values in endomorphic and mesomorphic components and higher, but not significantly, ectomorphic component than the controls (2.95–2.57–3.32). Similarly female stone quarry workers (2.00–1.70–2.41) also have significantly lower endomorphic and mesomorphic components and significantly higher ectomorphic component than control females (2.47–3.13–2.00). The exposed females show lower variation in physique, as evident from SDI, than the control females (*Fig. 9*), but the control males and the exposed males do not differ significantly with respect to this trait.

The stone quarry workers, both males and females, are physically less fit as compared to their respective controls (control females = 99.87; exposed females = 67.30 : Control males = 113.49; exposed males = 87.82).

A lot of dust is produced during milling, blasting and grinding in stone quarries. During these processes dust particles of respirable fractions are also produced. When inhaled these particles of respirable fraction can get deposited in the gas exchanging portions and in the conducting airways of the lungs. These depositions decrease the velocity and amount of gas thus limiting the gas exchange (West 1974). Any airway obstruction in the lungs result in lowered lung functions (Cotes 1978). Thus lowered pulmonary test functions in the exposed Malis, both males and females, show impairement of lungs due to stone dust exposure.

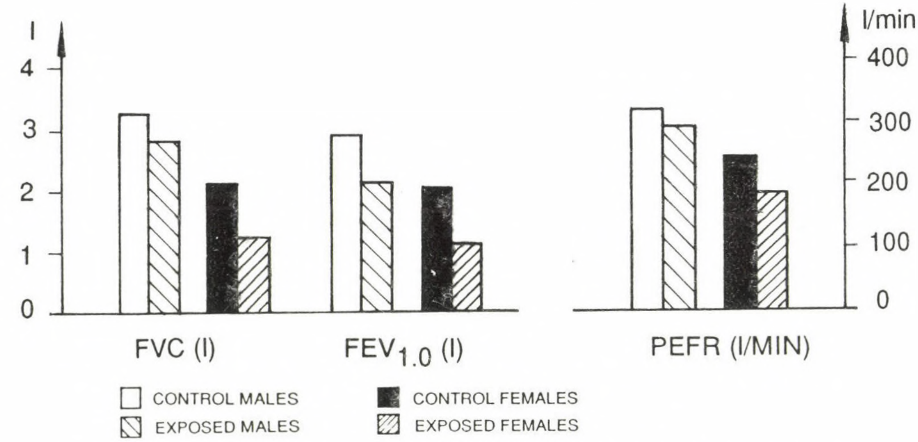

Fig. 2: Impact of stone dust on lung functions: comparison of control and exposed workers

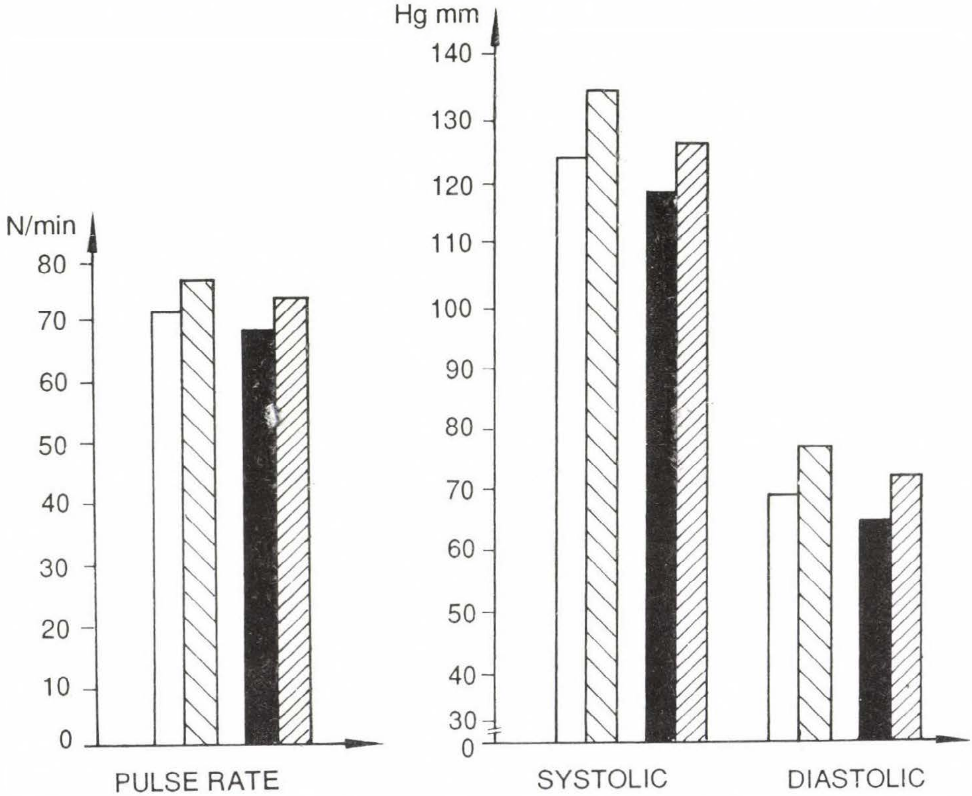

Fig. 3: Impact of stone dust on pulse rate, blood pressure: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

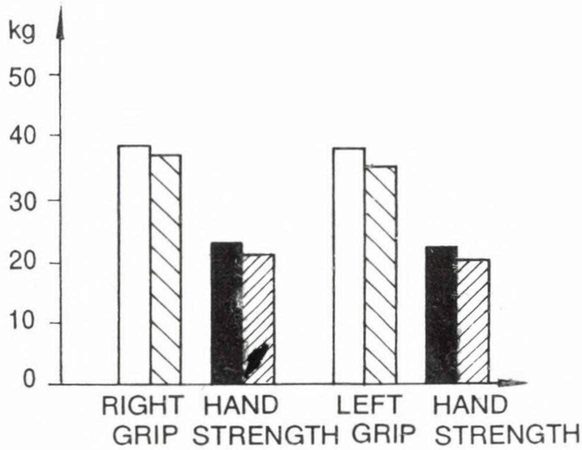

Fig. 4: Impact of stone dust on lung functions: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

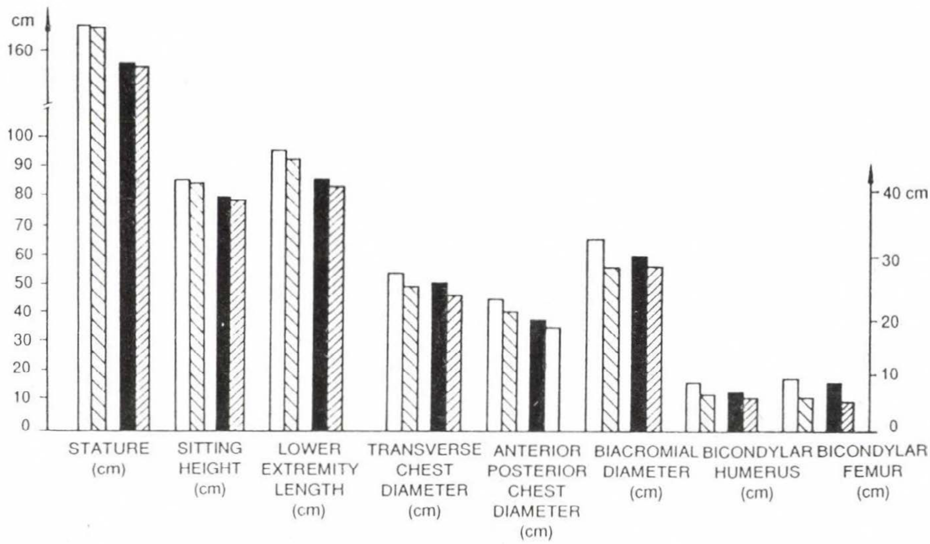

Fig. 5: Impact of stone dust on anthropometric measurements: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

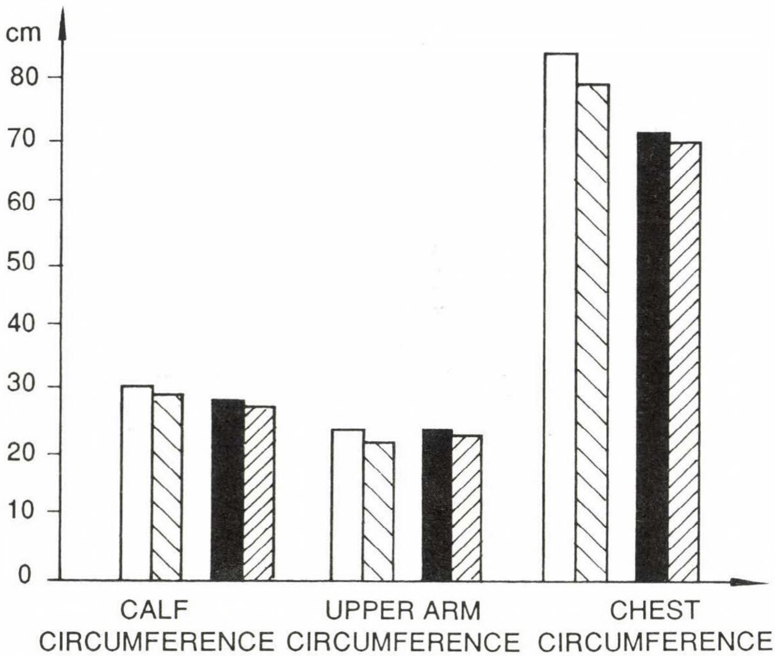

Fig. 6: Impact of stone dust on circumferences: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

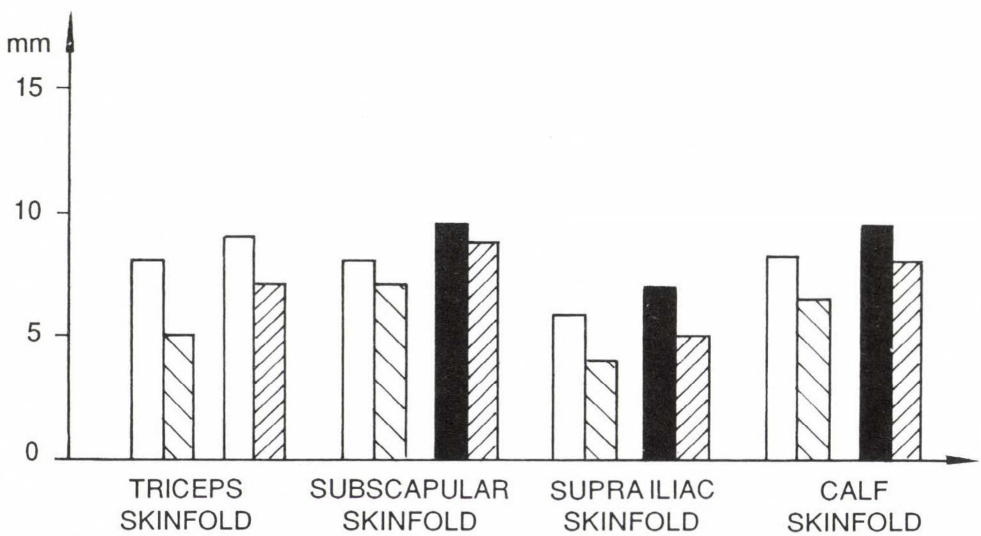

Fig. 7: Impact of stone dust on skinfolds: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

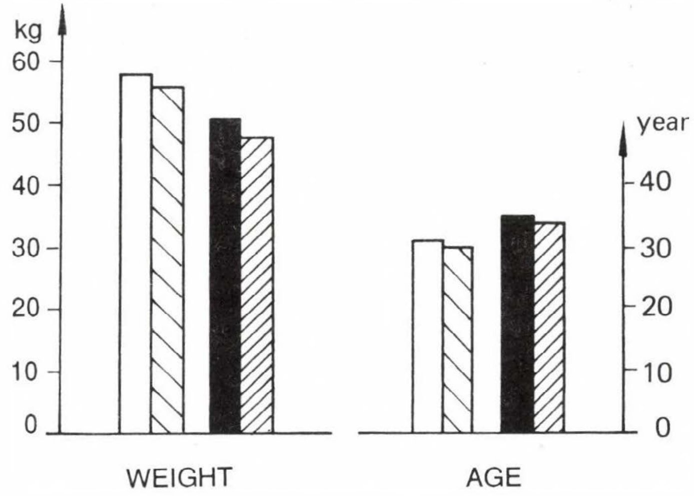

Fig. 8: Impact of stone dust on weight and age: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

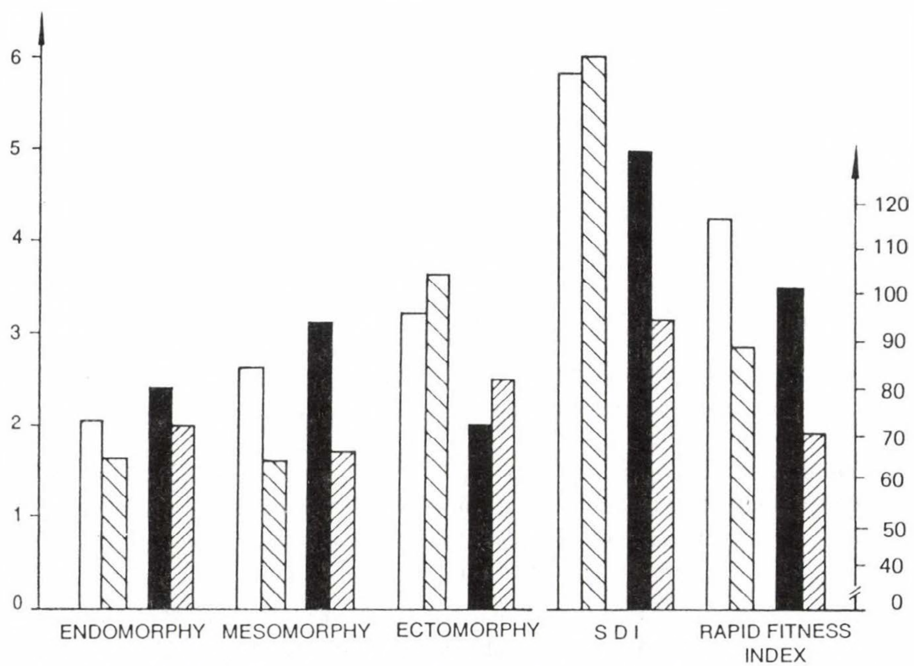

Fig. 9: Impact of stone dust on somatotype and Rapid Fitness Index: comparison of control and exposed workers (for key to the signs of bars used see Fig. 2)

Pulmonary test functions indicate merely the presence of an underlying structural change without describing the nature of structural change (Mauderly 1989). None the less they provide information of the presence, type and extent of impairement, as they are responsive indicators to an inhaled material (Silbaugh et al. 1981).

The stone dust contains substantial amount of silica and is thus capable of causing a lung disorder called silicosis. The biologic effects of inhaled particles depend on their retention at a specific time. Dust particle deposition is not uniform in all the airways. In upper respiratory tract, enhanced deposition occurs in areas characterised by constriction, directional changes and higher air velocities, e.g. larynx, esopharyngeal bend and nasal passages (Shift 1981, Shift and Proctor 1988). In tracheobronchial region increased depositions occur at upper trachea, lobar bronchi and bronchial bifurcations (Schlesinger et al. 1982). In pulmonary region, bronchiolar and alveolar duct bifurcations are also the site of preferential deposition for wide range of particles which are small enough to reach these areas (Broody and Roe 1983, Holma 1969). In these sites of preferential depositions, the mechanism of clearance is also retarded (Hilding 1957). Thus in tracheobronchial and pulmonary regions there are greater chances of particle depositions that can cause airways obstruction and lower the pulmonary test functions. Such an airway obstruction is also the precursos to other pulmonary ailments. It can thus be inferred that the lower pulmonary test functions are mainly due to high level and long duration of dust exposure in Malis.

Earlier studies have reported that certain chemicals, such as lead, cadmium and oral contraceptive steroids increase systematic arterial blood pressure and heart rate as an acute event by a variety of mechanism (Billingham 1980, Merin 1981, Rubin and Rubin 1982, Steffy 1982, Van Stee 1982, Zakari and Aviado 1982). However not much work has been done to study the effect of mineral dust or organic dust on cardiovascular system. In present study the stone quarry workers have significantly higher pulse rate and blood pressure. The cardiovascular stress, on one hand, and lowered pulmonary functions on the other confirm the effect of dust on physiology of man.

Lowered pulmonary test functions and increased respiratory diseases and symptoms in the exposed workers (Malik and Swami 1991) indicate reduction in oxygen diffusion and oxygen supply to tissues in Malis. This restricted oxygen supply, in combination with the loss of appetite and lower food intake, as compared to the pastoral Malis, reduces energy liberation. This may be responsible for the reduced performance and a decrease in mesomorphic and endomorphic components in stone quarry workers. Lower body weight, skinfolds, breadths and circumferences in exposed Malis may also be a consequence of this. Katch and McArdle (1981) had a similar observation that under condition of lower food intake, fat deposition is low.

The physique of Malis having low endomorphy and high ectomorphy, in general, seems to be advantageous for living in the desert climate of Rajasthan, special under limited nutritional resources and heavy work load. Under hot conditions persons with linear physique are able to dissipiate heat more effectively, and they also produce less heat.

In conclusion, stone dust exposure results in lower lung functions, produces adverse effects on cardiovascular system, reduces physical fitness, strength, and decreases body weight, fat, breadths, circumferences and endomorphic and mesomorphic components.

*

Paper presented at the Fifth International Symposium of Human Biology, Keszthely, Hungary, June 1991; Received 20 September, 1991.

References

Amandus HE, Petersen MR, Richards TB (1989) Health status of Anthracite surface Coal Miners. — *Archives of environmental health, 44;* 75—81.

Balmes J, Cullen MR, Mathay RA (1990) Occupational and environmental lung diseases. — *in:* George RB, Light RW, Matthay MA, Matthay RA (Eds.) *Essential of Pulmonary and Core Medicine.* — William and Wilkins, Baltimore.

Billingham MF (1980) Morphological changes in drug induced heart diseases. — *in:* Bristow MR (Ed.) *Drug Induced Heart Diseases.* — Elsevier, Holland.

Broody AR, Roe MW (1983) Deposition pattern of inorganic particles at alveolar level in the lungs of rats and mice. — *Am. Rev. Respir. Dis., 128;* 724—729.

Carter JEL (1975) *The Health and Carter Somatotype Method.* — San Diego, California.

Consolazio CF, Johnson RE, Pecora LT (1963) The *Physiologic Measurement of Metabolic Function in Man.* — McGraw Hill, New York.

Cotes JE (1978) *Lung Function: Assessment and Application in Medicine.* — Blackwell Scientific Publication, Oxford.

Cotton DJ, Graham BL, Li Kyr, Froh F, Bernett GD, Dosman JA (1983) Effect of grain dust exposure and smoking on respiratory symptoms and lung functions. — *Journal of Occupational Medicine, 25;* 131—141.

Heath BH, Carter JEL (1967) A Modified Somatotype Method. — *American Journal of Physical Anthropology, 27;* 57—74.

Hilding AC (1959) Ciliary streaming in the bronchial tree and the time element in Carciogenesis. — *N. Eng. J. Med., 256;* 634—640.

Hockey RV (1973) *Physical Fitness the Pathway to Healthful living.* — The C. V. Mosby Company, St. Louis.

Holma B (1969) Scanning electron microscopic observation of particle deposition in the lung. — *Archives of Environmental health, 18;* 330—339.

Jorensen HS, Hedman BK, Stijerberg B (1988) Follow up study of pulmonary function and respiratory tract symptoms in workers in a Swedish iron core mine. — *Journal of Occupational Medicine, 30;* 228—233.

Lee KP (1989) Lung response to particulates. — *in:* cheremisinoff PN (Ed.) *Encyclopedia of Environmental Control Technology* Vol. *2; Air Pollution Control.* — Gulf Publishing Co., London.

Malik SL, Swami A (1991) Respiratory health effects of dusts in stone quarry workers of Rajasthan: an epidemiological study. — (communicated to Jour. Human Ecol.)

Mauderly JE (1989) Effect of inhaled toxicants on pulmonary functions. — *in:* McClellan O, Henderson RF (Eds). *Concepts in inhalation Toxicology.* pp. 347—401. — Hemisphere publishing Co., New York.

Mc Ardle WD, Katch F, Katch VL (1981) Physiology, Energy, Exercise, Nutrition and Human Performance. — Lea and Febigeer, Philadelphia.

Merin RG (1981) Cardiac Toxicology of inhalatien anesthetics. *in:* Balaza I (Ed.) pp 1—15. — CRC Press Inc. Boca Ratan, F. I.

Ross WD, Wilson BD (1973) A somatotype dispersion index. — *Research Quarterly, 44;* 372—374.

Schlesinger RB, Driscoll KE, Naumann BB, Vollmuth TA (1988) Particle clearance from the lungs: Assessment of effects due to inhaled irritants — *Ann. Occup. Hyg.* (in Press).

Shah SP, Kamat SR, Mahashar AA (1983) Pattern of asbestos workers in Bombay. — *Indian Journal of Occupational Health, 26;* 305—313.

Sharma PK, Singh G (1990) Assessment of ambient air quality in Tilaboni, Nakrakanda and Jhanjra block of Raniganj coal fields. — *Indian Journal of environmental protection, 10;* 105—112.

Shift DL (1981) Aerosol deposition and clearance in the human upper airways. — *Ann. Biomed. Eng., 9;* 593—604.

Shift DL, Proctor DF (1988) A domestic model for particles in the respiratory tract above the trachea. — *Ann. Occup. Hyg.* (in Press).

Silbaugh SA, Mauderly JL, Macken CA (1981) Effect of sulfuric acid and nitrogen dioxide on airway responsiveness of the guinea pig. — *Toxicol. Environ. Health., 8;* 31—45.

Seffy EP (1982) Cardiovascular effect of inhalation anesthetics. — *in:* Van Stee F. W. (Ed.) *Cardiovascular Toxicology.* — Raven Press, New York.
Tanner JM, Hienaux J, Jarman S (1969) Growth and physique studies. — *in:* Weiner JS and Lourie JA (Eds) *Human Biology: A Guide tofield Methods.* — IBP Handbook No. 9. Blackwell Suentific Publications Oxford.
Van Stee FW (1982) Cardiovascular toxicology: foundation and scope. — *in:* Van Stee FW (Ed.) *Cardiovascular Toxicology.* — Raven Press, New York.
Weiner JS, Lourie JA (1969) *Human Biology: A Guide to Field Methods.* — Blackwell Scientific publication, Oxford.
West JB (1979) *Pulmonary Pathophysiology — the Essentials.* — William and Wilkins, New York.
Zakhari E, Aviado DM (1982) Cardiovascular toxicology and aerosol pollutants, refrigerants and related solvents. — *in:* Van Stee EW (ed.) *Cardiovascular Toxicology* Raven Press, New York.

Mailing address: Dr S. L. Malik
Department of Anthropology
University of Delhi
Delhi 110 007
India