

EFFECT OF BITUMEN FUMES ON THE FEV₁ AND FVC OF LUNG FUNCTION TEST AND PREVALENCE OF MUSCULOSKELETAL DISORDER AMONG THE ROAD CONSTRUCTION WORKERS

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ABSTRACT

Objectives: The present study was undertaken to see the changes of pulmonary function along with the posture adopted by road construction workers to analyze the causations of discomfort feelings related with those posture. Workers exposed to emissions from hot bitumen can sometimes experience irritation to the eyes, nose and respiratory tract, headaches, dizziness or nausea

Methods: After selection of site, 22 workers mean age (28.1 ± 2.35 yr.) were randomly selected. All of them had a minimum working experience 2-5 years in their present occupation. The height, weight, body surface area (BSA) and body mass index (BMI) of all the subjects were measured. Forced vital capacity (FVC) and Forced expiratory volume in one second (FEV₁) were also computed.

Results: The mean age, BMI, BSA of road construction workers are 28.1±2.35 yrs, 18.46±1.763 kg/m², 1.439±0.021 m² respectively. Some of them reported (15%) chest tightness, cough, and breathlessness just after the work schedule. There are significantly decreased FEV₁ (P<0.001) and decreased FVC (P<0.001) of about 15.82% and 17.45% respectively.

Conclusions: Road construction workers are generally exposed to bitumen fumes during their working period which may be the cause of their reduced FVC & FEV₁. If they wear a gas mask, it will prevent inhalation of bitumen fumes. This precaution may protect them from the lung ailments. Besides this the working environmental posture should be corrected by introducing some mechanical device which may prevent a musculoskeletal disorder.

Keywords: Bitumen, Hydrocarbon vapors, Respiratory problems, Asphalt, PAH.

INTRODUCTION

Bitumen contains very low amounts (ppm quantities) of PCAs. These are a class of chemicals that contain predominantly carbon and hydrogen, but may include other elements, such as nitrogen, sulphur and oxygen. The name "polycyclic" refers to the general structure of the compounds, which comprise groups of condensed aromatic rings. As a chemical group PCAs are of interest from an occupational health standpoint because some members of the group are considered potential human carcinogens e. g. benzo-a-pyrene (IARC 1985).

Epidemiological studies of occupational exposure to bitumens have indicated an increased cancer risk in road paving workers and roofers (IARC 1985; Partanen et al., 1995; Partanen and Boffetta, 1994). These studies have limitations, and the conclusions on the specific causes of the observed excess cancer risk of the lung, oral cavity, larynx, esophagus, stomach, skin and bladder and for leukemia are not explicitly verified. The excess cancer risk cannot be attributed specifically to bitumen, because the workers may be exposed not only to bitumen but also to coal-tar pitches and other materials. Also, the relation between bitumen exposure and cancer was not determined (Partanen et al., 1995).

Workers exposed to emissions from hot bitumen can sometimes experience irritation to the eyes, nose and respiratory tract, headaches, dizziness or nausea (Brandt et al., 1993; Norseth et al., 1991). These symptoms normally only occur under conditions where workplace fume/ vapor concentrations are very high and are typical of those experienced by exposure to other hydrocarbon vapors. Symptoms can be more severe in workers who are suffering from asthma or other respiratory problems.

There was however a slight, but statistically significant, increase in the overall incidence of lung cancer in asphalt workers but the incidence was not consistent across countries. The study was unable to draw conclusions however on the presence or absence of a cause / effect link between the incidence of lung cancer and exposure to

emissions from bitumen. The main reason for this was the lack of adequate data on worker exposure to other factors that may have contributed to the slightly increased incidence of lung cancer, such as smoking habits and exposure to coal tar (Boffetta, 2003).

Bitumen is a major component in asphalt, and it contains PAH (Polycyclic aromatic hydrocarbon). The risk of an increased inhalation of PAH from bitumen is difficult to estimate. Some studies indicate an increased risk of cancer for workers exposed to asphalt fumes, but it is probable that the exposure to PAH be much higher when coal tar was a common component in asphalt (Partanen and Boffetta, 1994). The concentrations of PAH from coal tar pitch are some orders of magnitude higher than those from bitumen (Machado et al., 1993). There is no obvious correlation between the total concentrations of PAH in bitumen fumes from paving asphalt and mutagenicity; yet PAH exposure cause cancer (Jarvholm et al., 1999).

Road construction workers in India are facing the inhalation of bitumen fumes and dust during the construction of roads. Early reviews suggest that the inhalation of PCAs, which is one of the ingredients of bitumen may cause lung dysfunction. As there is no report about the pulmonary function changes among such workers, the present study was undertaken to see the change of pulmonary function along with the posture adopted by road construction workers to analyze the causations of discomfort feelings related with those posture.

MATERIALS AND METHODS

Location of the area

The study was conducted in "Kandi" block of the district of Murshidabad, West Bengal, India.

Selection of subjects

After selection of site, 22 workers mean age (28.1 ± 2.35 yr.) were randomly recruited. All of them had a minimum working experience of 2-5 years in their present occupation.

Measurement of physical parameter

The height and weight of road construction workers were measured by an anthropometer (Martin's anthropometer) and "Crown" weight machine (Mfg. by Raymon surgical co.) respectively. The body surface area (BSA) (m²) and body mass index (BMI) (Kg/m²) of all the subjects were also computed (Banerjee and Sen, 1955).

Measurement of pulmonary function tests

Ventilatory pulmonary function tests comprised mainly of recording the FVC & FEV₁ using D. T. spirometer (Manufactured by: Maestros Medline System Ltd., Made in India, Model no.-POP-10, Serial no.-081243-048). Each individual performed the tests after 5 hours working period. FVC (Forced vital capacity) & FEV₁ (forced expiratory volume in one second) were recorded.

The definition of acute & chronic changes in lung function (FEV₁) from exposure to dusts causing byssinosis as recommended by the "WHO" (WHO, 1983) study group is adopted in the present study. The result is in [table 1].

Study of work schedule

The workers reported that they are engaged in this work about 6 months in a year (Feb-July). They work only in the day time between 8am -5pm with a rest pause of one hour between 12 noon to 1 pm.

Analysis of the working posture

The most frequent postures adopted by the workers were taken into consideration and the posture analysis was done by REBA method (Hignett, 1998; McAtamney and Hignett, 1995) [table 2].

RESULTS AND DISCUSSION

The Road Construction workers are exposed to hot bitumen fumes for about 6 hours (working period 8am-5pm a day). Within the period there are rest pauses of 3 hr having lunch break for 1 hr and other causes for 2 hrs. The mean ages, BMI, BSA of worker are

28.1±2.35 yrs, 18.46±1.763 kg/m², and 1.439±0.021 m² respectively. Some of them reported (15%) chest tightness, cough, and breathlessness just after the work schedule. These symptoms resemble with byssinosis (Chattopadhyay et al., 1993). The table 6 and 5 shows that there is decreased FEV₁ (P<0.001) and decreased FVC (p<0.001) 15.82% and 17.45% respectively which are highly significant. This sort of FEV₁ & FVC changes were also observed in jute mill workers (WHO, 1983; Chattopadhyay et al., 1993; Zhou ET AL., 1989), cotton workers (Gokani et al., 1987) and other dust polluting industries. So, it appears that road construction workers exposed in bitumen fumes, must have developed some respiratory abnormalities and have a risk associated with irritation in respiratory tract. Our findings partly support the views of Brandt et al., 1993; Norseth et al., 1991 (Brandt et al., 1993; Norseth et al., 1991). As, bitumen fumes is an irritant of respiratory tract, the lung function test like FEV₁ and FVC were monitor to see its effect. It was studied after 5 hours because the results would reflect prolonged and delayed effect as well as the tests were perform in better ambient condition.

From the study is appears that 40.9% road construction workers did not have any effectual changes in FEV₁ & FVC and 27% have the mild effect of obstruction, 4.54% have moderate, 9.09% have severe and 18.18% have combined obstruction and restriction.

Table 1:

Category	Definition
No effect	A consistent decline (40.9%) in FEV ₁ upto 5% or an increase in FEV ₁
Mild effect (27%)	A consistent decline of FEV ₁ between 5-10% during the work
Moderate (4.54%)	A consistent decline of FEV ₁ between 10-20% during the work
Severe effect (9.09%)	A consistent decline of FEV ₁ of more than 20% during the work

Combined obstruction & restriction -- 18.18%

Table 2: REBA chart- Analysis of working posture of the Road construction workers

Activity	Figure(stick Dia gram)	Duration(min/Day)	Frequency	Descrip-tion of Posture	REBA Action level	Risk Level	Action(Include Further Asses-ment)
Spreading of bitumen adhesive on the road		240	2 movement/second	Back bend forward, neck bent forward, both arms below the shoulder level, both knees bent, force needed greater than 10kg	4	Very High	Necessary now
Collection Of hot bitumen from melting machine		180	1 movement/second	Back bend forward, neck bent forward, both arms below the shoulder level, both knees bent, force needed less than 5kg	3	High	Necessary soon
Collection Of bituminized stone chips from the mixture		240	2 movement/second	Back bend forward, neck bent forward, both arms above the shoulder level, force needed between 5-10kg	4	Very High	Necessary now
Dragging of bitumen-nized stone chips		210	2 movement/second	Back bend forward, neck bent forward, both knees bent, force needed between 5-10kg	4	Very High	Necessary now

Table 3: Physical characteristics of road construction workers

Parameters	Mean	±SE
Age(years)	28.1	±2.35
Height(cm)	159.636	±1.818
Weight(kg)	46.73	±1.23
BMI(kg/m ²)	18.46	±1.763
BSA(m ²)	1.439	±0.021

Table 4: Discomfort feeling (pain) at different body parts among road construction workers

Body Parts	No. of subjects	%
Neck	5	22.72
Shoulder	7	31.82
Wrist	1	4.54
Hand	2	9.09
Lower back	14	63.64
Upper back	14	63.64
Knee	3	13.64
Ankles	2	9.09
Feet	3	13.64

Table 5: Forced vital capacity (FVC) among road construction workers**FROCED VITAL CAPACITY (FVC)**

Predicted	Obtained
3.044 ± 0.109	2.513 ± 0.133

Table 6: Forced expiratory volume in one second (FEV₁) among road construction workers**FROCED EXPIRATORY VOLUME IN FIRST SECOND (FEV₁)**

Predicted	Obtained
2.523 ± 0.096	2.124 ± 0.147

It is therefore concluded on basis of this study that abnormality in lung function does exist in road construction workers exposed to hot bitumen containing PCAs. However, this study does not indicate the extent of concentration of PAH that inhaled by the workers during the working period. PAH have the several source for example, exhaust from engines, food and tobacco smoke. In the presence study, tobacco smokers are excluded from the study. The exhaust from the traffic does not consider and other ambient conditions are not taken into consideration. Thus, bitumen fumes are the most probable exposure of PAH which causes the abnormality in lung functions.

The road construction workers felt discomfort in the different parts of the body. It has been observed that most of the workers felt discomfort at Lower back (63.64%), Upper back (63.64%), Shoulder (31.82%), Neck (22.72%), Knee (13.64%), Hand (9.09%), Ankles (9.09%), Wrist (4.54%) and Feet (13.64%) [Table-4]. This discomfort of different parts of the body may be due to constant backward and forward bending posture for a prolong period of time. Musculo-skeletal disorder develops due to awkward working posture (Kivi and Mattila, 1991; Gangopadhyay *et al.*, 2004; Gangopadhyay *et al.*, 2008). It has been proposed that specific posture are adopted for workers execute movement and exerting movement force to perform specific task in working environment. Such postures cause injuries and incur extra forces to complete the task. The road construction workers as per REBA scoring fall into high risk area. Hence it was clearly evident that road construction workers felt discomfort due to awkward posture at their working

period. This result corroborates with work of Gangopadhyay *et al.*, 2008, Gangopadhyay *et al.*, 2005 and Ponnett *et al.*, 1991 (Gangopadhyay *et al.*, 2008; Gangopadhyay *et al.*, 2005; Ponnett *et al.*, 1991). According to Chaffin and Anderson, 1984 (Chaffin and Anderson, 1984) and Leskinen, 1993 (Leskinen, 1993) the amount and quality of forward bent working posture influences the compressive force on the vertebral disk and erector spine muscle (Chaffin and Anderson, 1984). In this study the forward bent posture may be responsible for muscle pain and musculo-skeletal disorder in different parts of the body including low back.

REBA method which shows a promising posture analysis tool (Hignett, 1998; McAtamney and Hignett, 1995) shows that the action level 4 which is very high risk level and needs immediate necessary correction. In the present study, the workers tool should be modified to avoid the awkward posture. The spreading of bituminized stone chips should be done by mechanized process.

CONCLUSION

Road construction workers are generally exposed to bitumen fumes during their working period. It may be the cause of their reduced FVC & FEV₁. If they wear a gas mask, it will prevent inhalation of bitumen fumes. This precaution may protect them from the lung ailments. Besides this the working environmental posture should be corrected by introducing some mechanical device that may prevent a musculoskeletal disorder.

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