A BIOMECHANICAL AND MRI ANALYSIS OF BACK PAIN AMONG DRIVERS EXPOSED TO TRACTOR VIBRATIONS

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ABSTRACT

Fifty tractor drivers and (TD) and a control group of fifty non-tractor drivers (NTD) were selected for study from the same ethnic group, economic status and location. All were examined clinically, and data obtained for health and socioeconomic background and MRI scans of the spine were obtained for all the subjects. The level of vibration inputs among the tractor drivers was obtained by measuring the vibrations experienced at the driver seat for three tractor models on village roads and farms. It was observed that the Indian tractor driving farmers were subjected to whole body vibrations, which exceed ISO 2631-1 (1985, 1997) health limits. Tractor driving farmers reported regular back pain more often (56%) than non-tractor driving farmers (32%). However, MRI examination of the study group and control group did not reveal any significant difference in degenerative changes between the two groups, and disc degeneration levels were high in both the groups. Disc degeneration as revealed by MRI investigation is not adequate to predict prevalence of back pain. It is possible that the cause of backache could lie in mechanisms and tissues that undergo changes not demonstrable by MRI and clinical evaluation.

Key words: biomechanics, epidemiology, vibrations, agricultural tractors, and operators

LOW BACK PAIN is reported to be common among persons exposed to whole body vibrations. Tractor drivers are exposed to low frequency whole body vibrations making them vulnerable to backache. As tractors do not have suspension systems, the vibration levels (particularly for those without suspended cabins) are high compared to other road vehicles (Bovenzi & Betta, 1994). It is believed that vibrations cause back problems by mechanical failure of tissues or even from interference in tissue metabolism.

Exceeding the ISO norms for vibration exposure may lead to earlier degenerative changes in spine causing low back pain. This study investigates the effect of long term (more than 5 years) exposure to whole body vibrations among tractor driving farmers. The tractor driving farmers were compared with age, experience, ethnic group, land holding and education level matched non-tractor driving farmers. All participants were evaluated by a detailed clinical examination followed by Magnetic resonance imaging (MRI) of lumbo-sacral spine.

OBJECTIVE

This study was done to identify the cause of back pain in tractor driving farmers.

METHODS

HEALTH STUDIES

Fifty tractor driving farmers and fifty non-tractor driving farmers were selected from two villages 50 km from Delhi. The two groups were selected based on the following criteria: minimum tractor driving or farming experience of atleast 5 years; age group 25 to 45 years; minimum land holding of two hectares; not suffering from any other disease; not regularly using any public/private vehicle for travel; and willing to participate in the study. In addition, information was also collected on age; education; occupation(s), including number of years of active farming and tractor driving; tractor details and hours of driving experience in a year; details of land holding; food habits; smoking and alcohol intake. Information on physical work on and off the farm and economic status were also recorded.

Specific information on any low back symptoms in the recent past or earlier was recorded. A detailed general physical and systemic clinical examination was done in all the participants. Straight leg raising test was done in all patients and was recorded as positive if it was restricted to less than 70º. Magnetic resonance imaging (MRI) of lumbar spine was done in all the 100 participants in this study. These were then evaluated using a specially designed proforma by a radiologist, an orthopaedic surgeon and a neurosurgeon.

Level of tractor vibrations: measured and simulated

A tri-axial accelerometer from B&K Deltatron (Type 4504) mounted on the tractor seat was used to measure vibration levels. The vibration measurements were conducted both on farm terrain and on the transportation track of village paths and paved city roads with 20 HP, 35 HP and 50 HP tractors. The accelerations were measured on the most frequently used tractor engines on forms in the study area. The accelerometer was placed at the operator seat interface. No measurements were done on the body of the tractor driver. The measured vibration accelerations were compared with ISO 2631-1 (1985, 1997).

A tractor-operator model was adapted for prediction of vibration accelerations on the ISO 5008 track. The tractor model with tyres represented by dashpots and springs, placed in parallel for horizontal direction, was taken from the model developed by Crolla *et al.,* 1990 and a tractor operator model from Patil *et al.,* 1977. The total degrees of freedom of the tractor-operator model are 19, the tractor having 11 and the human body-seat having 8 degrees of freedom. The predicted vibration accelerations were compared with ISO 2631-1 (1985, 1997).

RESULTS

VIBRATION LEVELS

Farmers in Indian villages use tractors for farm operation as well as transportation. The transportation tracks used by farmers include village paths and paved roads. The comparisons reveal that measured vibrations exceed the '8 hours exposure limit' in one-third-octave frequency band procedure of ISO 2631-1 (1985) on both farm and non-farm terrains. Overall ISO weighted RMS acceleration on all farm and non-farm terrain working time of 3 hours exceeded the upper limit of 'health guidance caution zone' of ISO 2631-1 (1997). The tractor-operator model gave results for vibration exposure similar to measured values.

Anthropometric measurement and clinical evaluation

The anthropometric details of TDFS and NTDFS are summarised in Table 1. The two groups were very similar in height, chest expansion and arm span measurements. They differed only in abdominal girth and body weight. These differences were statistically significant with p-values of 0.006 and 0.046 respectively. The tractor driving farmers were heavier and had a larger waist size.

Table 1 Anthropometric dimensions of TDFs and NTDFs

Anthropometric dimensions	Mean		Standard deviation		Pvalue
	TDF	NTDF	TDF	NTDF	
Height (cm)	169.17	169.60	6.23	4.65	0.687
Chest Expansion(cm)	6.83	6.95	2.03	1.71	0.755
Abdominal Girth(cm)	79.92	75.8	8.21	6.42	0.006**
Arm Span(cm)	177.82	177.32	8.57	5.67	0.701
Weight(kg)	57.93	55.00	8.10	6.23	0.046**

(** Statistically significant at 5% level)
Note: TDFs = tractor-driving farmers, NTDFs = non-trcator driving farmesrs

The tractor-driving farmers complained of low back pain much more frequently than the non-tractor driving farmers. Clinical examination, however, did not reveal any significant differences between the two groups. Table 2 summarises the clinical findings among TDFs and the NTDFs.

Table 2 Abnormal physical findings in clinical examination

Tests	TDFs	NTDFs	P value
Spinal deformity	1(2)	2(4)	0.557
Spine tenderness	5(10)	3(6)	0.460
Straight leg raising test	2(4)	3(6)	0.646
Sacroiliac joint	0(0)	0(0)	-
Sensory impairment	5(10)	1(2)	0.092
Abnormality in reflexes			
Biceps-right/left	3(6)	0(0)	0.377
Triceps-Right/left	2(4)	0(0)	0.153
Supinator-right/left	2(4)	0(0)	0.314
Knee-right/left	7(14)	0(0)	0.023**
Ankle-right	1(2)	1(2)	0.367
Ankle-left	1(2)	0(0)	0.314

(Numbers in parentheses indicate percentages, ** Statistically significant at 5% level)

Magnetic resonance imaging

MRI Analysis

MRI films were evaluated independently by three specialists; orthopedic surgeon, radiologist and neurosurgeon. The analysis was done for abnormalities encountered at spinal levels from Dorsal 11^{th} vertebra to Sacral 1st vertebra (D11-S1) in disc bulge, disc height, disc size and shape, signal intensity, facets and end plates. Results of the MRI evaluation by three specialists revealed no difference between the TDFs and NTDFs for the various abnormalities as given in Tables 3 and 4.

Degenerative changes were specifically looked for in the region of discs and facet joints. When all types of abnormalities were considered, 96% of participants showed degenerative changes in one form or the other in both the groups.

DISCUSSION

Exposure to whole body vibrations while driving tractors is reported to be one of the causes of low back pain among tractor drivers. However, the exact site of origin of pain is not clear. Till recently the only tool available for evaluation was either clinical examination or CT scan/ Radiological evaluation using Roentgen rays. Radiological evaluation, however is unsafe as a tool for investigation for epidemiological purposes. Rosseger and Rosseger (1964) have reported on radiographic changes in the spine of tractor drivers. Radiological evaluation picks up only more advanced changes in the spine and any way these cannot pickup early degenerative changes in the disc. Computer tomography scan also has the disadvantage of demonstrating only more advanced cases of degeneration with the added risk of subjecting the person to ionising radiations. MRI on the other hand is safer and can demonstrate early degenerative changes in the intervertebral disc spaces without subjecting the patient to ionising radiation. Magnetic resonance imaging has become available only recently and has been used in very few epidemiological studies. The current population-based study is one of the few studies to have used MRI to evaluate degenerative changes in the spine subjected to low frequency whole body vibrations. The validity and reliability of the MRI assessment of disc degeneration are central issues to the interpretation of study results. In addition to visualizing disc height and contour variation, several investigators have shown that T2 weighted MRIs show biological changes in degeneration based on proteoglycan content and chondroitin-to-sulphate ratio (Boos et al 1993, Ross and Modic 1992).

In our study, a significantly large number of tractor-driving farmers reported having low back pain. But the clinical examination and MRI investigative results were not significantly different between the two groups. In symptomatic and asymptomatic persons, Buirski and Silberestein (1993) reported no statistical differences in the distribution of abnormal signal patterns on MRI and a small number of members in both populations demonstrated high signals from disc protrusion but they reported that this could not be used as a predictor of pain. Savage et al (1997) reported that there was no correlation between low back pain and disc degeneration. They did not observe any difference in the MRI appearance of the lumbar spine between car production workers, ambulance men, office staff, hospital porters and brewery draymen. Beattie and Meyers (1998) reported that MRI scans of lumbar region can be controversial for prediction of low back pain as these have a high technical capacity to detect degenerative disc diseases but the diagnostic accuracy of lumbar anatomic impairment related to low back pain is poor or unknown. Battie et al (1995) reported that the role of intervertebral disc in pain production, whether direct or indirect or nominal or large is unknown.

Table 3 Differences in abnormalities in MRI of TDFs (28) and NTDFs (16) reporting backache as observed by different specialists

Parameter	Orthopedic surgeon			Radiologist			Neuro-Surgeon		
	Numbers with abnormalities		P-value♦	Numbers with abnormalities		P-value♦	Numbers with abnormalities		P-value♦
	TDF	NTDF		TDF	NTDF		TDF	NTDF	
Disc bulge	6	5	0.46	20	11	0.85	20	10	0.54
Disc height	15	9	0.86	14	2	0.012	25	11	0.08
Disc size and shape	24	13	0.69	24	14	0.86	25	13	0.45
Signal intensity	26	14	0.55	25	14	0.86	21	13	0.63
Facets	14	9	0.68	22	11	0.46	11	7	0.77

♦ P values based on abnormality numbers as a proportion of subjects reporting backache.

Table 4 Differences in abnormalities in MRI of TDFs (22) and NTDFs (34) not reporting backache as observed by different specialists

Parameter	Orthopedic surgeon			Radiologist			Neuro-Surgeon		
	Numbers with abnormalities		P-value♦	Numbers with abnormalities		P-value♦	Numbers with abnormalities		P-value♦
	TDF	NTDF		TDF	NTDF		TDF	NTDF	
Disc bulge	2	5	0.53	14	21	0.88	10	19	0.44
Disc height	9	15	0.82	3	9	0.25	14	18	0.42
Disc size and shape	14	25	0.43	17	27	0.84	20	28	0.37
Signal intensity	17	28	0.64	21	28	0.14	13	21	0.84
Facets	13	22	0.67	14	21	0.88	7	12	0.78

♦ P values based on abnormality numbers as a proportion of subjects not reporting backache.

This study adds to the literature demonstrating that patient's complaint of low back pain need not necessarily have causal links with the degenerative changes seen in MRI records. Therefore, the source of such pain remains unclear and so do the methods for reducing it among tractor drivers except for the cessation of such activity.

As in the tractor driving farmers, the cause of neck pain among patients of late whiplash syndrome is also not clear. Patients of whiplash syndrome have chronic neck pain. Researchers worldwide have investigated the cause of chronic neck pain. Several MRI changes, most of them already demonstrable by standard X rays, have been reported among patients with late whip lash syndrome. Although none of these appear to be specific to whiplash syndrome they are reported to represent a higher risk factor (Bonuccelli et al 1999). However, in patients with late whiplash syndrome correlation between MRI and clinical findings have been reported to be poor (Karlsborg et al. 1998). As in tractor driving and non-tractor driving farmers studies among patients of chronic whiplash syndromes also do not reveal any definite cause for pain. Borchgrevink et al (1997) reported MRI of both brain and neck revealed no significant difference between the patients and a control group of volunteers. Voyvodic et al (1997) found no statistically significant changes on comparing the initial and follow up MRI in patients of whiplash injury. In a study of 34 consecutive cases of whiplash Karlsborg et al (1997) found no correlation between MRI and clinical findings. This was also reported by Pettersson et al (1994). Studies do report an association between neck pain and psychological symptoms (Wallis et al. 1996, Peebles et al 2001).

Some investigators have attributed psychological causes for pain in both the groups suffering from exposure to vibrations or whiplash. The diagnostic issues confounding the clinician or similar in both the cases. So are the implications for control of vibrations or the design of head and neck restraints in cars. If some of the cases of pain are not caused by actual tissue damage due to hyper extension during a crash then the new design may not result in significant reduction in complaints of chronic neck pain secondary to rare end crashes. Unless the real cause of pain is understood it will be difficult to design a better tractor seat or a safer car seat.

CONCLUSION

Back pain is reported more commonly by tractor driving farmers but disc degeneration as revealed by MRI investigation is not adequate to predict prevalence of back pain. It is possible that the cause of backache could lie in mechanisms and tissues that undergo changes not demonstrable by MRI and clinical evaluation. These findings could have bearing on discussions regarding pain experienced by vehicle occupants suffering from whiplash injuries. Unless the real cause of pain is understood it will be difficult to design a better tractor seat or a safer car seat.

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