Chapter 6

Discomfort Survey

6.1 Introduction

The WBV measurement using human vibration analyser, calculation of A(8) and V(8), and their comparison with the HGCZ of ISO2631-1:1997, illustration of WBV exposure of three groups of HEMM operators using box-plot are presented in the last chapter. Methods adopted in discomfort survey are discussed in this chapter. How to calculate different types of discomfort indices is also explained. Lastly, results and analysis are discussed.

6.2 Method

Discomfort and pain are feedback from the human body to alert a disease, or the body limitations [82]. Data pertaining to physical discomforts experienced by HEMM operators were collected from three opencast coal mines using WBV measurement instrument followed by a questionnaire survey. A total of 150 HEMM operators – 110 dumper, 20 drill and 20 shovel operators – were the subjects under this study. A questionnaire approach was used in this study in the line to that developed by Staurt Buttle [82], and Dawson et al. [86]. Vibration measurement was done according to Standard No. ISO 2631-1: 1997 [61] and OSHA guidelines [87].

The questionnaire survey through personal interview was conducted in local language to make the subjects understand the content of the survey. Particular features of the survey are:

i). Questions were related to the areas of the body pain and discomfort.

ii). Duration (in years) of operating the HEMM were collected for an indication of exposure to vibration.

iii). Ordinal scales were used to keep the form simple. Scales were verbally qualified.

iv). Comments and suggestions from the subjects were encouraged at the end.

6.3 Discomfort Index (DI) Calculations

A report of the intensity of pain gives an indication of the magnitude or severity of discomfort experienced. If the intensity and prevalence are looked separately, there would be difficulty in assessing or prioritizing which may be more serious – a lower prevalence with high intensity or high prevalence with low intensity. Based on the nature of the work in opencast coal mines and the illnesses & injuries reported, a high prevalence of discomfort was expected. The number of body parts reported and the corresponding intensity of discomfort were combined to get a single measure of discomfort an individual was experiencing. These comparisons of data were handled to prioritize the discomfort levels in opencast coal mines.

For the calculation of discomfort indices, 11 body points were considered namely, neck, shoulder, forearm, elbow, wrist, fingers, upper back, lower back, knees, legs, and feet (Figure 6.1). These body points were grouped into five body regions namely

(i) neck and shoulder were grouped as neck region; (ii) elbow, wrist and fingers as hand region; (iii) upper back as upper back region; (iv) lower back as lower back region; and (v) knees, legs and feet as leg region. The scorings of the body points were collected through the questionnaire. The scores were represented as ordinal scales ranged from1 to 5. The subjective quantification scales for discomfort were rated as: *never = 1, rarely = 2, occasional= 3, often =4, and always =5.*

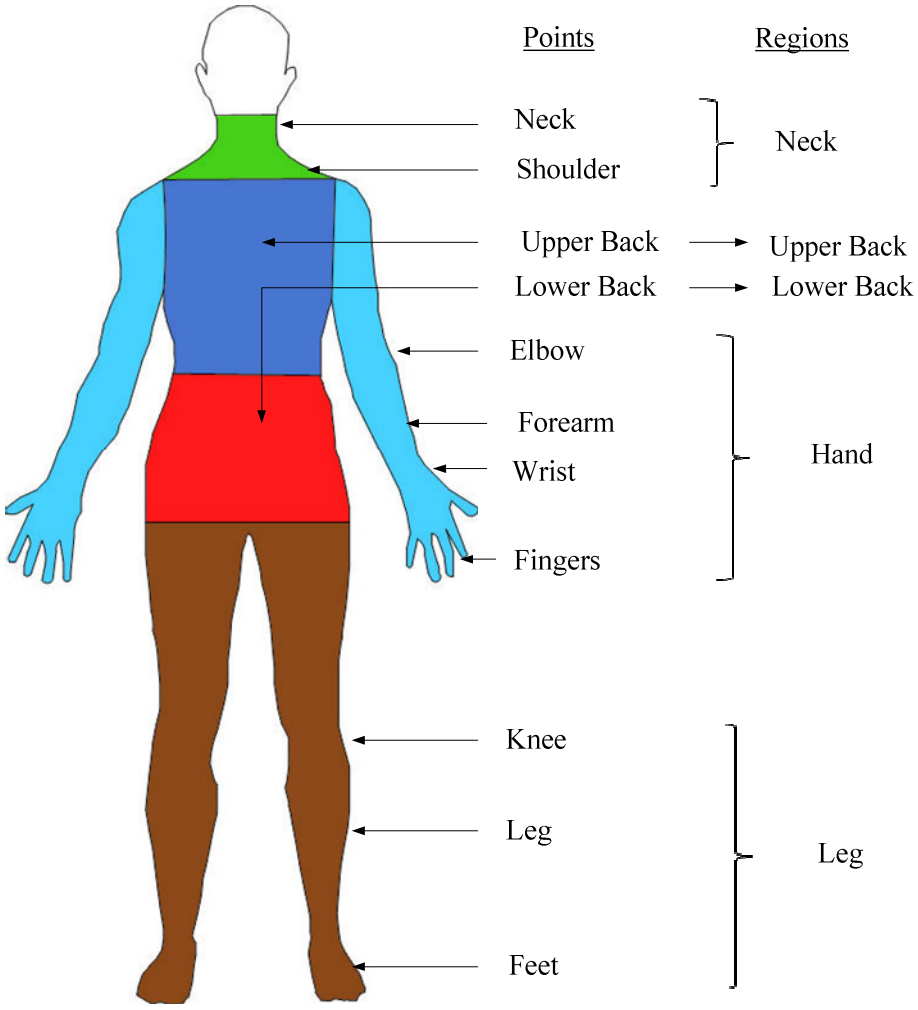

Figure 6.1 Body points and regions

The DI is used to combine the prevalence and intensity. The whole-body DI (WBDI) calculation method is given in Eq. (6.1) as proposed by Stuart-Buttle [82].

$$\mathbf{WBDI} = \frac{\sum \mathbf{I_{PI}}}{\sum \mathbf{PP} \times \mathbf{MI}} \quad (6.1)$$

where,

I_{PI}: intensity of points indicated,

PP: possible points to be indicated, and

MI: maximum intensity

Points of the body were grouped into five body regions as explained earlier. The body region DI ($BRDI$) was determined indicating the discomfort in that body region as given in Eq. (6.2):

$$\boldsymbol{BRDI} = \frac{\sum \boldsymbol{I_{BR}}}{\sum \boldsymbol{PP_{BR}} \times \boldsymbol{MI}} \quad (6.2)$$

In Eq. (6.2),

I_{BR} : intensity of points of body region,

PP_{BR}: possible points of body region, and

MI: maximum intensity

In BRDI calculation, the number of points in each body region varied. For this reason, the BRDI could only be used for comparison of points within the body regions and not between the regions themselves. In order to compare among the body regions, a mean maximum intensity (MMI) was taken to normalize the number of parts. The sum of the maximum intensities was divided by the total number who reported discomfort. Mining jobs under study were coded into three categories: dumper, drill and shovel operators. The primary job reported on the data collection sheet was categorized into one of these three task groups.

6.4 Results and Analysis

There are five body regions considered for the discomfort analysis of HEMM operators. The percentage of discomfort in the body regions and their MMI is depicted in Figure 6.2.

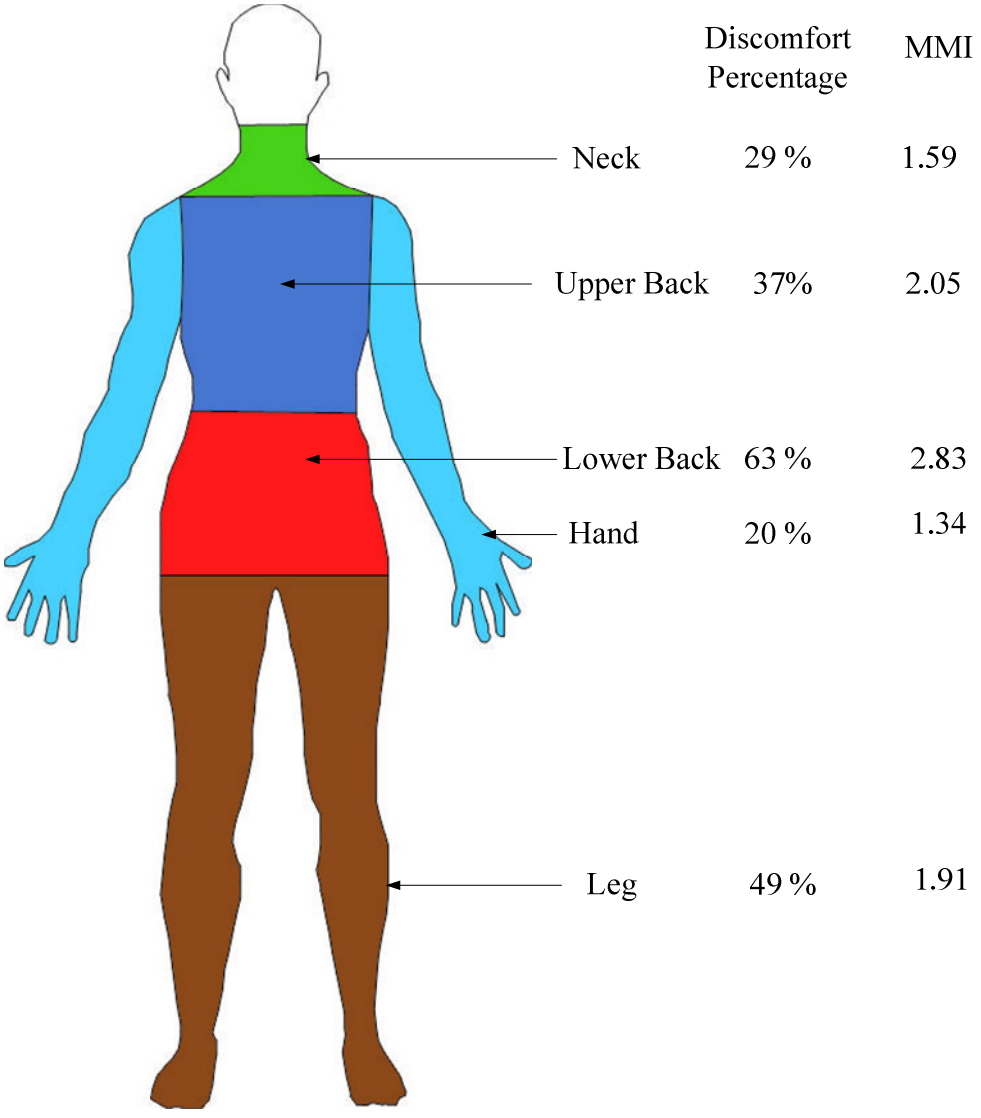

Figure 6.2 Discomfort percentage and MMI for body regions of HEMM operators

6.4.1 Effect of WBV on different parts of the body of the operators

There are five body regions considered for the discomfort analysis as stated earlier. Discomfort analysis of HEMM operators is presented in Table 6.1. Because of the discomfort reported in multiple body regions, the total number of operators may vary in each group of operators. In the case study, both the dumper operators and shovel operators are having maximum discomfort in lower back region and minimum in the hand region on the other hand, the drill operators are having maximum discomfort in lower back as well as in leg, and minimum in the hand region. This is due to the nature of the work for the drill operators. They have to do prolonged work both in sitting as well as standing posture.

It is revealed that maximum discomfort is observed in lower back region of HEMM operators and minimum in the hand region. Lower back regions are more exposed to vibration than the hand regions. Also, the lower back regions are heavier than the hand regions and they are coming in immediate contact to the vibrating machine; therefore, impact of vibration seems to be more on lower back regions.

Table 6.1 Distribution of discomfort in various body regions

Discomfort in body region	Number of dumper operators (%)	Number of drill operators (%)	Number of shovel operators (%)	Total number of HEMM operators (%)	Body region DI
Neck region	30 (27)	8 (40)	5 (25)	43 (29)	0.32
Hand	24 (22)	3 (15)	3 (15)	30 (20)	0.25
Upper back	43 (39)	6 (30)	6 (30)	55 (37)	0.41
Lower back	72 (65)	12 (60)	10 (50)	94 (63)	0.57
Leg region	56 (51)	12 (60)	6 (30)	76 (49)	0.34

6.4.2 Correlation analysis of HEMM operators

Correlation matrices for dumper, drill and shovel operators have been presented in Figures 6.2, 6.3 & 6.4 respectively. Detailed correlation among the 10 variables for all the three categories of HEMM operators can be seen through the figures. Some of the important findings from correlations are highlighted below.

- Experience of dumper, drill and shovel operators is moderately correlated to their age (0.63-0.73).
- A(8) value of dumper, drill and shovel operators is highly correlated to their VDV(8) value (0.81-0.97).
- Correlation of Hand and neck discomfort for drill operators (DI=0.57) is more than that for dumper & shovel operators (DI=0.41-0.48).
- Upper back DI of dumper operators has less correlation with neck DI (0.33) and is also moderately correlated to hand discomfort (0.55).
- Leg DI of dumper, drill and shovel operators is moderately correlated to hand DI (0.55-0.77).
- Body DI of dumper and shovel operators is moderately correlated to neck DI (0.59-0.68), whereas drill operators body DI is highly correlated to neck DI (0.86).
- Body DI of dumper as well as shovel operators is highly correlated to hand DI (0.83-0.87) and drill operators body DI is less correlated to hand DI (0.48).
- Body DI of dumper, drill and shovel operators is highly correlated to their leg DI (0.77-0.85).

- Lower back DI of dumper operators is low correlated to hand DI (0.36) and Lower back DI of drill operators is moderately correlated to hand DI (0.52).
- Lower back DI of dumper operators is low correlated to upper back DI (0.49) and Lower back DI of drill operators is moderately correlated to upper back DI (0.51).

Table 6.2 Correlation matrix for dumper operators

Variable	Age	Experience	VDV (8)	A(8)	Neck DI	Hand DI	Upper back DI	Leg DI	Body DI	Lower back DI
Age	1.00									
Experience	0.73**	1.00								
VDV(8)	-0.03	-0.09	1.00							
A(8)	-0.15	-0.15	0.87**	1.00						
Neck DI	-0.11	-0.05	-0.15	-0.12	1.00					
Hand DI	-0.23*	-0.12	-0.09	-0.06	0.39**	1.00				
Upper back DI	-0.25**	-0.22*	-0.08	-0.07	0.35**	0.56**	1.00			
Leg DI	-0.10	0.00	-0.21*	-0.21*	0.61**	0.54**	0.41**	1.00		
Body DI	-0.23*	-0.14	-0.18	-0.15	0.68**	0.83**	0.74**	0.81**	1.00	
Lower back DI	-0.17	-0.19*	-0.07	-0.06	0.03	0.36**	0.49**	0.11	0.48**	1.00

*Correlation is significant at $p < 0.05$ (2-tailed), **Correlation is significant at $p < 0.01$ (2-tailed)

Table 6.3 Correlation matrix for drill operators

Variable	Age	Experience	VDV (8)	A(8)	Neck DI	Hand DI	Upper back DI	Leg DI	Body DI	Lower Back DI
Age	1.00									
Experience	0.71**	1.00								
VDV(8)	0.18	0.08	1.00							
A(8)	0.10	-0.10	0.89**	1.00						
Neck DI	-0.15	-0.10	-0.01	0.13	1.00					
Hand DI	-0.17	-0.23	-0.14	-0.07	0.57**	1.00				
Upper back DI	-0.11	0.05	0.08	0.13	0.35	-0.11	1.00			
Leg DI	0.10	0.08	-0.18	-0.10	0.56*	0.77**	-0.08	1.00		
Body DI	-0.08	-0.01	-0.14	-0.04	0.86**	0.66**	0.42	0.77**	1.00	
Lower back DI	-0.04	0.10	-0.11	-0.13	0.23	-0.30	0.51*	-0.13	0.37	1.00

*Correlation is significant at $p < 0.05$ (2-tailed), **Correlation is significant at $p < 0.01$(2-tailed).

Table 6.4 Correlation matrix for shovel operators

Variable	Age	Experience	VDV (8)	A(8)	Neck DI	Hand DI	Upper back DI	Leg DI	Body DI	Lower Back DI
Age	1.00									
Experience	0.63**	1.00								
VDV(8)	-0.09	-0.33	1.00							
A(8)	-0.13	-0.39	0.97**	1.00						
Neck DI	0.39	0.53*	-0.36	-0.33	1.00					
Hand DI	0.23	0.32	-0.23	-0.20	0.48*	1.00				
Upper back DI	0.08	0.11	0.07	0.00	-0.03	0.26	1.00			
Leg DI	0.26	0.23	-0.23	-0.24	0.32	0.76**	0.33	1.00		
Body DI	0.40	0.41	-0.24	-0.23	0.59**	0.87**	0.48*	0.85**	1.00	
Lower back DI	0.39	0.19	0.05	0.11	0.13	0.52*	0.41	0.44	0.66**	1.00

*Correlation is significant at $p < 0.05$ (2-tailed), **Correlation is significant at $p < 0.01$(2-tailed).

6.5 Summary

Discomfort survey helped in compiling the symptoms of WBV induced hazards and is also capable of providing useful indications of ergonomic issues faced by the HEMM operators engaged in mining coal as a part of their occupation. Method of discomfort survey was discussed and five regions of body was narrated by figure. The calculation of different discomfort indices such as DI, WBDI, BRDI, MMI was explained. Results showed number and percentage of subjects having discomfort in different body regions. Correlation between the nine prominent variables for the three groups of HEMM operators was analyzed. The next chapter deals with the case–control study of the vibration exposed dumper operators (case group) with that of the control group workers of the mines.