CHAPTER 4

METHODOLOGY

The different factors associated with manual material handling and its related problems (MSDs) are indicated in Chapter 3. The methodological aspects dealing with each of the factors are dealt in this chapter as mentioned below:

4.1 Personal and Medical History

The information on personal and medical history was obtained through a specially designed questionnaire which covered general information, mode of carrying loads, years of experience, type of activity, load characteristics, feeling of fatigue, frequency of pain, absenteeism due to MSDs, medical history during preceding five years and family income. The general physical characteristics along with the personal and medical history of the industrial (foundry and sugar industry) and operational (women carrying water and scaffolders) workers involved in load carrying activities were recorded and described in chapters 5 and 6 respectively. Data was also collected from different hospitals of Agra to find out the health and musculoskeletal problems of workers involved in different activities of load carrying. In hospitals information was collected from the medical reports as well as by personal interview. Informed consent was obtained from each subject before the starting of study.

4.2 Body Pain

To understand the degree of body pain and body ache, a questionnaire was administered to the subjects. The prevalence of self-reported MSDs among the subjects was evaluated using NIOSH checklist Cohen et al. [Coh97]. The subjects’ response regarding severity of pain in the last two years, work-day lost due to pain, their perception on the causation of pain and the remedial measures taken to alleviate pain were recorded. Severity of pain was scored on the scale of mild, moderate, severe and unbearable (1–4) and loss of productivity was measured in terms of loss of working days and restricted duties.
4.3 Anthropometry

A standard anthropometric kit was used for all the lengths, breadths, thickness, and circumference measurements. Body weight was recorded by using a frequently checked and calibrated weighing scale, whereas skinfolds were taken by skinfold caliper. Table 4.1 indicates forty two different body dimensions including age and weight recorded in this study to obtain concerned subjects anthropometric status. Measurements were recorded in standing and sitting positions. These dimensions were selected based on the recommendation by the International Biological Programme (IBP) [Wei81] and engineering design requirements.

**Table 4.1: Body Dimensions of Subjects Recorded in this Study**

<table>
<thead>
<tr>
<th>Body Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age, years</td>
</tr>
<tr>
<td>2. Weight, kg</td>
</tr>
<tr>
<td>3. Vertical reach, cm</td>
</tr>
<tr>
<td>4. Vertical grip reach, cm</td>
</tr>
<tr>
<td>5. Eye height, cm</td>
</tr>
<tr>
<td>6. Acromial height, cm</td>
</tr>
<tr>
<td>7. Elbow height, cm</td>
</tr>
<tr>
<td>8. Illiacrystale, cm</td>
</tr>
<tr>
<td>9. Metacarpel III-height, cm</td>
</tr>
<tr>
<td>10. Wall to acromian distance, cm</td>
</tr>
<tr>
<td>11. Arm reach from the wall, cm</td>
</tr>
<tr>
<td>12. Bi-acromial breadth, cm</td>
</tr>
<tr>
<td>13. Chest breadth, cm</td>
</tr>
<tr>
<td>14. Inter scye breadth, cm</td>
</tr>
<tr>
<td>15. Waist breadth, cm</td>
</tr>
<tr>
<td>16. Hip breadth, cm</td>
</tr>
<tr>
<td>17. Chest circumference, cm</td>
</tr>
<tr>
<td>18. Sitting height, cm</td>
</tr>
<tr>
<td>19. Sitting vertical grip reach, cm</td>
</tr>
</tbody>
</table>
20. Sitting eye height, cm  
21. Sitting acromion height, cm  
22. Sitting popliteal height, cm  
23. Knee height sitting, cm  
24. Abdominal depth sitting, cm  
25. Buttock knee length, cm  
26. Hip breadth sitting, cm  
27. Functional leg length, cm  
28. Shoulder grip reach, cm  
29. Upper arm length, cm  
30. Fore arm length, cm  
31. Hand length, cm  
32. Span, cm  
33. Foot length, cm  
34. Instep length, cm  
35. Foot breadth, cm  
36. Bimalleolar breadth, cm  
37. Head length, cm  
38. Head breadth, cm  
39. Triceps skinfold, mm  
40. Sub scapular skinfold, mm  
41. Supra-iliac skinfold, mm  
42. Biceps skinfold, mm

### 4.4 Body Composition

To understand the nutritional status and body build of subjects, ponderal index (PI), percentage of body fat, lean body weight (LBW) and body surface area (BSA) were determined.

The PI was calculated by using the following formula [Smi323]

\[
Ponderal\ index\ (PI) = \frac{\sqrt[3]{wt\ (kg)} \times 1000}{ht\ (cm)}\]

Ponderal index (PI) = \frac{\sqrt[3]{wt\ (kg)} \times 1000}{ht\ (cm)}
The body height (ht.) and the body weight (wt.) of the subjects were recorded by using the anthropometric rod and weighing scale respectively for determining the PI.

The body fat was calculated by a two-step procedure in which the body density (D) was first estimated by using the equation developed by Durnin and Rehaman [Dur67] and Durnin and Womersley [Dur74].

\[
\text{Body Density (D)} = 1.1599 - 0.0717 (\log X)
\]

Where \( X = \text{biceps} + \text{triceps} + \text{subscapular} + \text{superailiac skin folds}. \)

To determine the body density, the skinfold thickness at some specific sites of the body viz. biceps, triceps, subscapular and superailiac was measured using skinfold caliper.

The percentage of body fat was then calculated from body density using the formula developed by Siri [Sir56].

\[
\%\text{Body Fat} = ((4.95/D) - 4.5) \times 100
\]

LBW was calculated by using absolute body fat [Bal80].

\[
\text{Absolute Body Fat (kg)} = \frac{\text{wt} \times (\%\text{Body Fat})}{100}
\]

\[
\text{LBW} = \text{wt} - \text{Absolute Body Fat (kg)}
\]

The BSA was calculated by using the equation developed by Banerjee et al. [Ban58].

\[
\text{BSA} = (\text{wt})^{0.425} \times (\text{ht})^{0.725} \times 74.66
\]

\( (\text{m}^2) \quad (\text{kg}) \quad (\text{cm}) \)

4.5 Dietary Intake

For the dietary intake study, subjects engaged in foundry, sugar, carrying water and scaffolding activities were chosen at random. All the subjects were from different families and having different dietary intake. Data was collected by direct food weighing technique for a period of three consecutive
days for all the meals. Total raw food was first weighed, followed by cooked food and then the quantity consumed by the subject. The nutritive and calorific values of the food were calculated by using the standard values of Indian food [Gop89].

4.6 Load Characteristics

It was observed that in case of foundry activities, workers used shallow roundish container (Tasala) made of mild steel (MS), laddel, heavy equipment and castings. In case of sugar industry, workers used sugar bags, heavy equipment in different activities. In scaffolding activities, workers generally used poles or boards, guard rails, ladders made of MS and wood. For water carrying activities, women used water containers made of aluminum, steel, brass or plastic, commonly called as ‘Handa’. The shape and size of various containers used in all the four fields were recorded.

4.7 Work-Rest Pause Pattern

Initial investigation was done to find out the different foundry, sugar, carrying water and scaffolding activities, where considerably large numbers of subject were engaged.

1. In foundry industry, following activities were noted:
   - Making and carrying the pattern.
   - Making and assembling the mold.
   - Pouring the metal into the mold.
   - Carrying the casting blocks.

2. In sugar industry following activities were noted:
   - Loading and unloading of sugarcane.
   - Carrying of Heavy Equipment during maintenance and repair
   - Manual transportation of sugar bags.

3. In carrying water following activity was noted:
   - Carrying water from source to home.

4. In Scaffolding the following activities were noted:
   - Carrying of scaffolding poles or boards, guard rails, and ladders.
   - Mantling and dismantling of scaffolds.
The whole day work, rest and pause were recorded simultaneously with the help of electronic stopwatches. The stopwatches were used for recording the time taken for loading, carrying, unloading, returning and the rest breaks. Stopwatches were operated manually while observing the subjects activity. Along with the work-rest pattern data on number of trips made, amount of load carried and distance travelled were also noted. On the basis of distance and time, speed of walking was calculated.

Working heart rate was monitored in the field by using a waist mounted ECGLAB Holter 12.0 Plus (Biomedical, USA). Heart rate was monitored for three consecutive trips for each subject. First heart rate was taken at the starting of the trip followed by the heart rate at destination and back to the starting point which was then further averaged and analyzed. Average, resting, starting and returning heart rate of the subjects were also noted.

4.8 Field Environmental Condition

4.8.1 Thermal Environment

Following work environmental parameters were recorded for whole day to calculate the heat stress index in the field environment

1. Wet-bulb Temperature (WBT)
2. Dry-bulb Temperature (DBT)
3. Globe-bulb Temperature (GBT) (under sun and shade)
4. Relative Humidity
5. Air Velocity

Wet-bulb Globe Temperature (WBGT) index was calculated both in indoor and outdoor conditions using the following formulas:

\[ WBGT = 0.7 \text{ WBT} + 0.3 \text{ GBT} \] (indoor or outdoor without solar load)
\[ WBGT = 0.7 \text{ WBT} + 0.2 \text{ GBT} + 0.1 \text{ DBT} \] (outdoor with solar load)

4.8.2 Ground Conditions

The walking speed of subjects is dependent on the work terrain. Therefore, it was necessary to observe the terrain of the field condition.
4.9 Biomechanical Studies

To understand the degree of biomechanical stresses developed while carrying different loads in different modes, two separate studies were conducted.

1. Location of whole body centre of gravity (CG) in normal standing condition and changes in CG location due to load carrying activities.
2. Changes in the spinal curvature while carrying different loads in different modes.

4.9.1 Determination of Whole Body Centre of Gravity

4.9.1.1 Reaction Board Method

Reaction board method was used for the determination of whole body CG in a normal standing posture. In this method by using the principle of moments [Wel76] the location of the gravitational line was determined for three different planes i.e., frontal, sagittal, and transverse planes of the human body. CG is the interesting point of these three planes.

In the present study, a wooden board, fabricated at the departmental workshop, of length 225 cm was used. Pivot was provided on both the edges of the board having an intermediate distance of 210 cm. One end of the board was resting on a highly sensitive electronic weighing balance which was frequently checked and calibrated against the standard certified weights and the other end was supported on a metal plate fixed on a wooden block of the same height as the platform balance. On both sides of the board two metric scales were fixed ranging from 0-210 cm. At the foot board end a wooden block was placed to make the reaction board level. The CG board was made perfectly horizontal by means of spirit level. Care was taken that the board does not sag in the middle while the subject stands at its centre.

4.9.1.1.1 Experimental procedure

The weight of the subjects was taken by an electronic weighing scale and stature; and height was recorded by anthropometer. All the subjects were in normal clothing during experimentation. Partial weight of the board was first determined; the subject then lies on the board with heels against the foot board. This partial weight of the subject and board was noted.
Calculations,

\[
CG \text{ location from foot board end } = \frac{(S + B) - B \times L}{W}
\]

Where,

- \(B\) - Partial weight of the board (kg)
- \((S+B)\) - Partial weight of the subjects + board (kg)
- \(W\) - Weight of the subjects (kg)
- \(H\) - Height of the subject (cm)
- \(L\) - Length of the board (cm)

The CG location in Z-axis was determined while the subjects were in lying condition. CG was also located in the sagittal (X-axis) and the transverse plane (Y-axis), while the subject was standing on middle of the board. The subject was asked to give equal amount of pressure on both the feet. The outline of the feet was traced on the paper and the partial weight was noted. For the sagittal plane, the subject stood sidewise on the scale and for the transverse plane, the subject stood facing towards the foot board. The intersection point of the CG lines in frontal and sagittal plane on the foot mark gives the CG location in X and Y axis and shown in appendix.

The CG location in X-axis was determined by measuring the foot length as well as the intersecting point from the anterior part of the foot. The CG location in Y-axis was determined by measuring the foot breadth and also the point of intersection to the right side of the foot. The results were expressed in terms of percentage in the respective axis.

The CG location in Z-axis was determined as a percentage of the body height in vertical axis. The intersection of these three axis is the CG point in a three dimensional plane.

### 4.9.1.2 Segmental method

The location of CG while in working condition was determined using the segmental method as described by Wells and Luttgens [Wel76]. This technique makes use of a photograph of the subject and involves finding the location of CG of each of the body segments with respect to an arbitrarily
placed X and Y axis and knowledge of the ratio between the individual segmental weight and the total body weight.

To find out the CG in normal condition and the shift of CG while carrying different loads in different modes, video recording of the subjects was taken in working condition which was later analyzed through video position analyzer for obtaining the CG location and different joint angles.

From the video analyzer, the location of different body joints along with the location of load CG in terms of X and Y coordinates was obtained. These data were then fed into the computer for determining the final CG with the help of a specially developed software package. Before calculating the final CG the package developed a stick diagram based on the different joint coordinate data. From the final output the location of CG in terms Z and Y axis were determined for both with and without load conditions and the diagrammatic view shown in appendix.

The output of the computer-generated stick diagram was then processed to obtain the trunk, shoulder and hip joint angle, and also to determine the CG location in vertical plane in relation to ground to head (Z-axis) distance. A vertical drop was projected from the CG point to the ground line from which the CG location in Y-axis was also determined.

In case of vertical (Z-axis) displacement, the CG was expressed as percentage of the body height. In case of horizontal (Y-axis) displacement the CG was expressed as percentage of the distance from right foot to the left foot. These data were then analyzed to find out the shift in CG while carrying different loads in different modes.

4.9.2 Measuring the Spinal Curvature

The flexicurve technique was used to measure and record the movement of the spine [Bur86]. It is a simple, inexpensive and easy technique to use. The shape of the spine was obtained by using a draughtsman flexible curve of 1 meter length capable of bending only in one plane, and which maintains as adopted shape of the spine that could be transferred on to paper.
The method used was as follows:

- **Identification of body landmarks**: The cervical (C1-C8), upper (L1) and lower lumber (L5) points were marked.

- **Moulding the flexicurve to the spine**: First with the subject in erect standing posture and then holding different loads in different modes, the flexicurve was moulded to the mid-line contour of the entire spine. The flexicurve was then carefully removed, placed on the drawing sheet and the contour was drawn, with the location of the points L1 and L5.

- **Measurement of mobility**: Tangents were then drawn to both flexion and extension curves at the point of C6–C8 and L3–L5 regions. To do this a ruler was placed on the curves and the tangents were drawn and the diagrammatic view shown in appendix. The angle formed by the intersection of these tangents was measured using a protector and this was the measure of sagittal movement occurring in the cervical and lumbar regions.

- Thus the spinal curvature was recorded on subjects by this method.

### 4.10 Physiological Factor

To understand the physiological demands for carrying activities, heart rates were measured by using a computerized electrocardiogram (ECG) system (SCHILLER, Switzerland).

#### 4.10.1 Lung Function Test

Lung function test was carried out by using Spirometer (COSMED, Italy) to ascertain that all the subjects were free from any pulmonary disorder. So the forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) were calculated. Study was carried on randomly selected male and female industrial workers (foundry and sugar industry) and operational workers (women carrying water and scaffold workers) and measurements were taken while the subjects were in standing posture. Figure 4.1 shows the experimental setup of lung function test.
4.1.1 Procedure

After holding the breath, the mouth piece was inserted inside the mouth and the nostrils of the subject were blocked by using a nose clip. The subjects were asked to breathe normally and then take as deep a breath as possible. Towards the end of the expiration the subjects were encouraged to continue the effort until no further air could be exhaled. Trials were made a couple of times before taking the final reading to ensure reproducibility and the values from the larger of two reproducible curves were recorded.

4.1.2 Determination of Maximum Aerobic Capacity

For determining maximum aerobic capacity, industrial (foundry and sugar industry) and operational (women carrying water and male scaffolders) workers of different age group were randomly selected from the respective working population. All the subjects were physically in good health having no medical problem prior and during the period of experimentation. This was ascertained by studying their resting heart rate and blood pressure.

4.1.2.1 Experimental procedure

Subjects were asked to run on treadmill (SCHILLER, Switzerland) as shown in Figure 4.2 at the constant speed of 6 km/hr. with different grades viz., 0, 5, 10, 15, 20 and 25 [Kem90] for 5 minutes only. In certain cases if a subject did
not reach his/her maximum $O_2$ uptake 25, then the speed was increased to 7, 8 and 9 km/hr. at the highest grade (grade 25) as per requirement. All the subjects were trained on the treadmill prior to the experiment and were made absolutely familiar with the experimental protocol.

Figure 4.2: Experimental Setup of Treadmill

4.10.2.2 Collection and analysis of expired air

The oxygen consumption was determined by using the open circuit method. A Douglas bag of 50 litre capacity was used for collecting the expired air during each load. The bag and accessories like stopcock and hose pipe were placed on the side table so that their weights were not carried by the subjects. The oxygen content of the expired air was determined with the help of a paramagnetic oxygen analyzer. The instrument was frequently checked and calibrated against the calibration gas mixture and also with normal outside air.

The pulmonary ventilation rate was measured by using a Wright’s respiratory meter and a stopwatch. The respirometer was connected to the inlet of a Collins 2-way J-valve and was then fitted to the mouth of the
subject by using a head harness. The outlet from J-valve was connected to the Douglas bag through a 2-way stopcock. Necessary STPD (standard temperature and pressure dry) corrections were made to the ventilation rate by using the STPD nomogram [Con63].

The heart rate was determined from the continuous recording of a Beckman Dynograph where Manubrium-Xiphoid (M-X) lead was used for picking up the ECG signal using a pair of Ag-Agcl surface electrodes. The output from Dynograph was then fed to data analyzer through which continuous monitoring of the heart rate was achieved as shown in Figure 4.3.

![Figure 4.3: ECG Signals](image)

**4.10.3 Heart Rate Variability Measurement**

Heart rate variability was measured with the help of ECGLAB Holter 12.0 Plus (Biomedical, USA). For determining heart rate variability, industrial (foundry and sugar industry) and operational (women carrying water and male scaffolders) workers of different age group were randomly selected from the respective working population. All the subjects were physically in good health having no medical problem prior and during the period of experimentation. This was ascertained by studying their resting heart rate and blood pressure. In this study the heart rate variability was measured by time domain analysis.
4.10.3.1 Time Domain Analysis

The time domain measures are based on the amount of time, in milliseconds, in the beat-to-beat intervals of the heart or from the differences between the normal beat-to-beat intervals. Technically, the beat-to-beat interval is defined as the time in milliseconds between normal “R” to “R” waves on an ECG which is divided into small squares. The standard deviation of the normal R-R interval (SDNN) is taken which is one of the most important and clinically meaningful time domain measures.

4.10.3.1.1 Procedure

The electrodes were placed on the subjects as shown in the Figure 4.4. Then the subjects were asked to carry load of 10 to 50 kg in different modes at the walking speed of 2.5 km/hr. on treadmill. The workers were asked to perform the work for 30 minutes. And the values of SDNN were then recorded from the report generated by the ECG Holter.

Figure 4.4: Placement of Electrodes
4.11. Electromyography

To understand the muscular involvement while carrying the load, electrical activity of the muscles, electromyography (EMG) was recorded. EMG signals from different muscles were picked up by means of Ag-AgCl surface electrodes affixed to the skin. The amplitude of the signals reflected the degree of muscular involvement and it is therefore possible to assess the degree of muscular load from EMG. Measurements of higher signal amplitude usually reflect higher muscular force for a given muscular activity.

Electromyographic signs of fatigue can be used as indicators of muscular overload. High doses of muscular involvement causes localized muscle fatigue [Cha73] which involves muscular decrement, sensation of fatigue and pain, and changes in the EMG signals. These changes are closely related to the fatigue process. In present study, EMG technique was used in order to assess the efforts exerted by the different muscles during load carrying in different modes. A Dynograph recorder was used to record the EMG signals from three different selected muscles i.e., neck, trapezoid (right) and erector spinae (right).

4.11.1. Selection of Muscles for EMG

The muscles that needed to be studied were selected either by palpating each muscle or by activating the muscle of interest. The muscles chosen for EMG [Jen83] were those which were mainly responsible for the process of load carrying. Details of muscles are given below in Table 4.2.

Table 4.2: Details of the Muscles Selected for Study

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td>The proximal attachment is on the spinous of the lower cervical and upper thoracic vertebrae. It extends upward and attaches to the pinous processes of the upper cervical vertebrae. It contributes to extension, lateral flexion, and rotation of the neck.</td>
</tr>
</tbody>
</table>
Trapezoid

The proximal attachment of the total muscle is on the base of the skull, ligaments of neck, and the spinous processes down to and including the twelfth thoracic vertebrae. It attaches onto the outer portion of the clavicle, the acromion process, and the upper surface of the scapular spine. It allows rotation, depression and retraction.

Erector Spinae

The muscle attaches proximally on the posterior surface of the sacrum, crest of the illium, and spines of the lumbar and thoracic vertebrae. It extends up the back and attaches to the back portion of the ribs at several places to the posterior of the thoracic and cervical vertebrae, and to the base of the skull. It extends, rotates and laterally flexes the trunk and neck.

4.11.2. Preparation of the Subject for EMG

The desired muscles were first identified over the skin surface by developing the contracture and were marked by sketch pen. Muscle site was then cleaned with cotton soaked in alcohol, to remove the dead superficial cells of the electodermal layer and then the skin was allowed to dry. Emery paper was used to rub the skin for further removal of highly resistant cells. Once again the site was wiped with alcohol and allowed to dry. A double sided adhesive tape was placed on the clean area to hold the electrode in position. Thus the pair of electrodes were placed on each muscle with an inter electrode spacing 1-2 cm. Each electrode was then filled with conductive jelly and connected to the Dynograph. The impedance between the electrodes was measured, which is an important factor affecting the quality of the signal. Care was taken that the resistance within two electrodes lies between 1-3 k.ohms. Other pairs of electrodes were fixed on respective muscles. The signals stored in the tape recorder were later on analyzed for the root mean square (RMS) values by using logic signal analyzer. Figure 4.5 shows the placement of electrodes on muscles.
4.12 Determination of Acceptable Load

For determining the acceptable load, randomly selected industrial (foundry and sugar industry) and operational (women carrying water and male scaffolders) workers brought to the laboratory. All the subjects were physically in good condition having no external clinical symptoms. First general information about the subjects was collected. Their hemoglobin content, blood pressure (mm of Hg), oral temperature, weight, height, and skinfold were taken by using Haemometer, BP apparatus (Hg-manometer type), stethoscope, thermometer, anthropometer and Lange skinfold caliper respectively. The resting $O_2$ consumption and heart rate were also noted.

In working condition, the heart rate and muscular activity were monitored throughout the experiment. Samples were taken for each minute and analyzed.

The subjects reported at 10 am and were asked to sit down calmly for 10-20 minutes to exclude the physical and emotional influences on the heart rate. Prior to the experiment subjects were made aware of the experimental protocol and were made familiar with the instruments.

The walking speed was simulated by using treadmill. The subjects were asked to carry a load of 10, 15, 20, 25, 30, 35, 40 and 50 kg on head, back,
shoulder and waist mode for 20 minutes each starting with 0 load. The loads were given at random at a speed of 2.5 km/hr. The duration of walking on treadmill was selected as 20 minutes. It was observed that for psychophysical evaluation a minimum of 10 minutes of work was necessary for light weights. After carrying each load, subjects were asked about the body pain and psychophysical rating to find out the responses regarding heaviness of the load. Heart rate was monitored throughout the experiment and O₂ consumption for each load was taken at the 5th minute of work. Each load carrying activity was followed by 10-15 minutes of recovery and 30 minutes of rest. In case the subject’s heart rate had not come down to the resting level after 30 minutes of rest, more rest pause was given.

After experiencing each load for 20 minutes, the subjects were asked to identify carrying mode and load of their choice.

In case of foundry, sugar and scaffolding, different loads of 10, 15, 20, 23, 30, 35, 40 and 50 kg were given to be carried in the head, shoulder and back mode; and in case of water carrying activity, the subjects were asked to carry 10, 15, 20, 25, 30 and 35 kg in different modes, viz. head, shoulder and waist. All those loads were selected based on the actual loads which the subjects carry in the field. During laboratory experimentation the same shape and size of the various carrying loads were used by the subjects as were used in the field study.

4.13 Work Stressors

To identify the aspects of work and stressors, the subjects were interviewed by a multi-method ergonomic checklist [Nag98]. The ergonomic checkpoints pertaining to this study include the enquiry on work system analysis, such as job characteristics, physical and psychosocial stresses of work, job diagnostic dimensions, constraints of workplace and tools, and hazards of physical environment. Keeping in mind the linguistic problem, the questionnaire was explained to the workers in local language. The checklist entries were responded by a single digit on a five-point Likert’s scale where strong disagreement to the statement (1) to strong agreement to the statement (5), were scored. The low value is the positive indicator of the perception of
absence of the stress. The relative loading of scores for each section of the checkpoints was arrived at from the ratio of the summated score value to that of maximum cumulative scores possible under that section. The values greater than mid value of maximum possible score were considered as the positive indicator of the stressors. In other words, for each of the work stressors, the relative loadings would range within 0 to 1 and the loading of each aspect of work equal to or more than 0.5 was considered as a stressor [Nag10].

4.14 Statistical Analysis of Data

Data analysis was performed using SPSS statistical software, version 17.0. T-test was performed to find out the significance level between heart rates obtained in different loads and in different modes. Also the significance level between EMG (RMS) data obtained in different loads and in different modes was checked by T-test. Multivariate analysis was done using binary logistic regression model with backward elimination method in order to understand the effects of work stressors and worker characteristics on the occurrence of MSDs. For the multivariate regression analysis the dependent variable was MSDs and the independent variables were all the work stressors variables as mentioned in the ergonomist checklist stated in appendix. The relationship of the work stressors to MSDs was examined by Pearson correlation.