CHAPTER III
METHODOLOGY

The chapter contains information on the various aspects of the plan of investigation. The problem, the Research Design, the Variables in the study are explained. The Operational Definitions and the procedure followed for the development of the tool for gathering relevant data are presented. The procedure for the collection of data and the plans for statistical analysis are also described under separate sections.

One of the major focus of the study was to gain an insight of the Perceived Musculoskeletal Pain and Postural Discomfort faced by the Marble Cutting workers. The second focus was to assess the environment of the workplace parameters namely Noise, Light, Temperature and Humidity and Vibration. The study also aimed to study the Physiological cost of work by measuring the heart beats of the respondents while at rest, work and at recovery. The study also gathered information regarding the fatigue as perceived by the respondents.

An Interview Schedule was designed and developed for gathering information encompassing the focus of the research. The interview schedule was mainly concerned with the analysis of the perceived Health Status, Perceived Musculoskeletal Pain experienced by the respondents and fatigue as perceived by the respondents. The researcher had also developed an observation sheet which collected information related to the environment of the workplace of the respondents namely Noise, Light, Vibration, Temperature and Humidity. The Observation method was also used to record the Postural Discomfort of the respondents.

The variables identified for the Survey Research Design were classified into Independent and Dependent Variables. The Independent variable was further sub classified into Personal and Situational Variables. Age (in years) and Perceived Health Status. The Situational Variables were the Years of Working Experience, Environment of the Workplace. The Perceived Musculoskeletal Pain, Physiological Cost of Work and Perceived Fatigue were the Dependent Variables.

In order to achieve the aims of the present study, a detailed plan of work and sequential procedure followed are presented in this chapter under the following sub-heading:

3.1. Research Design

3.2. Variables and Schematic Diagram of the Variables

3.3 Operational Definitions

3.4 Locale of the Study

3.5 Unit of Enquiry

3.6 Sampling Size and Sampling Procedure

3.7 Development of the Tool

3.8 Description of the Tool

3.9 Data Collection

3.10 Data Analysis

3.11 Ergonomic Intervention Programme

3.1 Research Design

According to Kerlinger (2007), research design is the plan, structure and strategy of investigation conceived so as to obtain answers to research questions and to control variance. The descriptive research design was found to be most suitable for the present study as it aided in gathering information on anthropometric data, environmental factors like noise, temperature, humidity and light, vibration, postural discomfort as experienced by the respondents. The research design of the study was descriptive because information regarding the perceived musculoskeletal pain experienced by the marble cutting workers, physiological cost of work and fatigue experienced by the respondents was also collected. Descriptive research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Inferences about relations among variables are made, without direct intervention, from

concomitant variation of independent and dependent variables Kerlinger (2007).

3.2. Variables

A concept which can take on different quantitative values is called a variable (Kothari and Garg, 2019). The study variables are those specific factors may have an effect on the workers' perceptions of their health and pain experienced by them. The variables for the study were formed in three sets namely independent and dependent variables.

3.2.1. Independent Variables: The variable that is antecedent to the dependent variable it is termed as an independent variable (Kothari and Garg, 2019).

For the present study the independent variables were categorized under two subheads:

a. Personal variables
    i. Age (in years)
    ii. Perceived Health Status
b. Situational variables
    i. Years of Working Experience
    ii. Environment of the Workplace
        a. Noise Level
        b. Presence of Light

3.2.3 Dependent Variables: A variable that depends upon or is a consequence of the other variable is termed as dependent variable (Kothari and Garg, 2019). For the present study dependent variables were:

a. Perceived Musculoskeletal Pain
b. Physiological Cost of Work
c. Perceived Fatigue

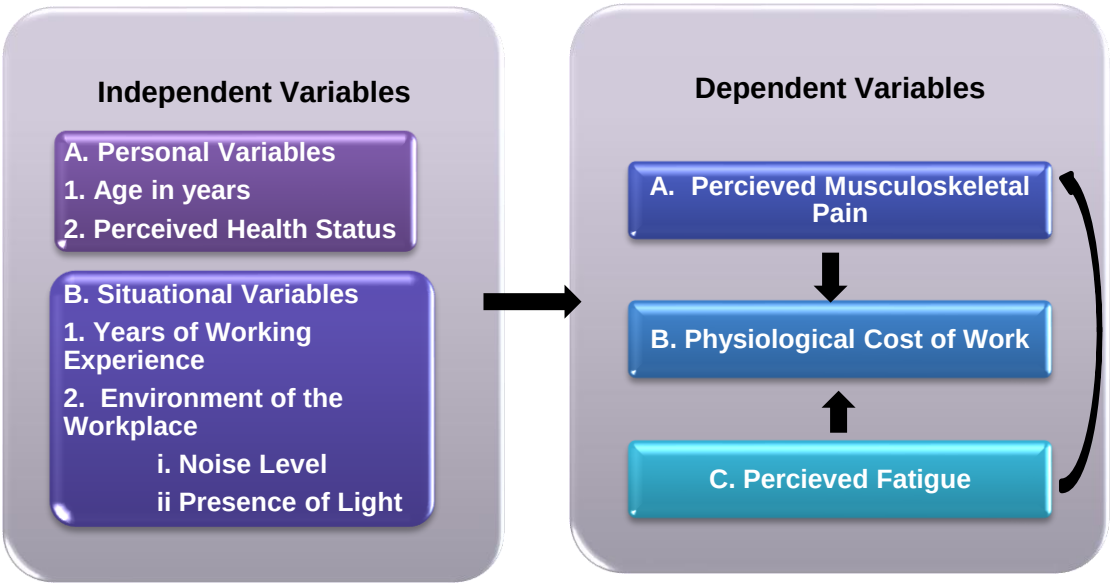

Figure 4: The Schematic framework showing the Hypothetical Relationship between the Variables under the study

3.3. Operational Definitions

An operational definition assigns meaning to a construct or a variable by specifying the activities or "operations" necessary to measure it (Kerlinger 2007). The operational definitions thus considered under study are discussed as below:

3.3.1. Marble Cutting Workers for the present study were the ones who were involved in cutting the marble slab into customized tiles.

3.3.2. Anthropometric data for the present study were the body dimensions of the respondents including namely (include body diagram)

a. **Height** was the vertical distance of the respondents measured in inches from the floor to the vertex (i.e. the crown of the head).

b. **Arm Span** for the present study was the maximum horizontal distance of the respondents measured in inches between the fingertips when both arms were stretched out sideways.

c. **Standing Shoulder Height** was the vertical distance of the respondents measured in inches from the floor to the acromion (i.e. the bony tip of the shoulder).

d. **Standing Elbow Height** was the vertical distance of the respondents measured in inches from the floor to the radiale. (The radiale is the bony landmark formed by the upper end of the radius bone which is palpable on the outer surface of the elbow.

e. **Standing Upper Arm Length** for the present study was the distance measured in inches from the acromion to the underside of the elbow in a standard sitting position of the respondents.

f. **Standing Forearm Length** for the present study was the distance of the respondents from the back of the elbow to the tip of the middle finger in a standard sitting position.

g. **Standing Eye Height** was the vertical distance of the respondents measured in inches from the floor to the inner canthus (corner) of the eye.

h. **Standing Vertical and Horizontal Maximum and Minimum Reaches** for the present study was the standing in erect posture, forward comfortable arm reaches from back and height from the floor measured in inches of the respondents.

The data for the anthropometry were gathered with the help of a non-stretchable measuring tape and weighing scale.

3.3.3. Assessment of the Environment of the Workplace in the Marble Industry for the present study included the environmental factors namely Noise, Light, Temperature, Humidity and Vibration and the Workstation Dimensions where marble cutting activity was conducted in the marble industry.

a. **Noise level in the Marble Industry** for the present study referred to the noise produced by the marble cutting workstation. It was measured with the aid of Digital Noise meter in dB. It was categorized as “Moderate Noise” and “High Noise” for statistical testing.

b. **Presence of Light in the Marble Industry** for the present study referred to the light present at the workstation. It was measured with the aid of Digital Lux meter and measured in “lux”. Three readings were measured at the workstation and an average was calculated. The data were categorized as “Less Light” and “Appropriate Light”.

c. **Existing Temperature in the Marble Industry** for the present study referred to the existing temperature at the workstation. It was measured with the aid of Digital Thermo hygrometer in ^{o}C.

d. **Presence of Humidity in the Marble Industry** for the presence study referred to the humidity present at the workstation. It was measured with the aid of Digital Thermo hygrometer in %.

e. **Vibration Produced by the Marble Cutting Workstation in the Marble Industry** for the present study referred to the vibration produced by the marble cutting machine. It was measured with the aid of Vibrometer in Hz.

3.3.4. Workstation Dimensions for the present study involved the dimensions of the workstation like Height, Width and Length (in inches) of the marble cutting workstation through a non-elastic measuring tape where the respondents performed the activity of cutting marble.

3.3.5. Physiological Cost of Work for the present study of the respondents was assessed on the basis of energy consumed (kj/min) and Heart Rate (beats/ min) of the marble cutting workers through the digital heart rate monitor while cutting tiles from the marble slab. The data were then computed and categorized into “Very Light”, “Light”, “Moderately Heavy” and “Heavy”, “Very Heavy” and “Extremely Heavy”.

3.3.6. Perceived Fatigue for the present study was the Fatigue experienced by the marble cutting workers after work. as reported by them by pre validated FACIT scale. The summated rating scale had 5 point

continuum for the responses “Not at all”, “A Little Bit”, “Somewhat”, “Quite a bit” and “Very Much” which were scored 4 through 0 respectively for positive statements. The scores were reversed for the negative statements. Higher scores reflected less fatigue among the respondents and vice-versa. The data were categorized as “Less Fatigue” and “Severe Fatigue”.

3.3.7. Postural Discomfort for the present study was the position of limbs and the carriage of the body of the respondents as a whole. Rapid Entire Body Assessment (REBA) was used to analyze the postural discomfort experienced by the respondents. The postural discomfort was categorized as “Medium Risk”, “High Risk” and “Very High Risk”.

3.3.8. Perceived Musculoskeletal Pain (MSP) for the present study was the pain experienced by the respondents since the past 12 months and last 7 days in their body parts namely neck, shoulder, upper arm, lower arm, elbows, wrists, palms, back (upper back, middle back and lower back), hips, thighs, knees, ankles and feet while doing the various movements with each body part, resting and by carrying out the activity as reported by them. The pain experienced in their various body parts through the Modified Nordiac Questionnaire.

3.4. Locale of the Study

The present study was conducted in the International hub of marble, Kishangarh Tehsil of Ajmer district of Rajasthan, India. Kishangarh is a village in Kotri Temple in Bhilwara District of Rajasthan State, India. It belongs to Ajmer Division. It is located 37 km towards east from District headquarters of Bhilwara, 5 kms from Kotri., 228 kms from State capital Jaipur. Kishangarh is known for its marble. The marble industry in Kishangarh has been developed in three stages. The marble industry has successfully established itself as the international trade center for marble. There are more than 9000 marble sellers in one place. There are 30,000 workers employed to provide services to run the marble hub in Kishangarh.

3.5. Unit of Enquiry

The unit of enquiry for the present study were the workers involved in cutting Marble on the Marble Cutting Workstation in the Marble Industry. The respondents for the present study comprised from the last stage of the workers who specialized in cutting the leftover marble into tiles.

3.6. Sampling Size and Sampling Procedure

The sample comprised of 220 marble cutting workers working on the marble cutting workstation in the marble industry. The respondents for the present study were healthy and did not suffer from any chronic or acute diseases at the time of data collection. The care was taken to select the respondents who were regular to work. The workers aged above 50 years of age were also excluded from the sample to avoid biasness. The respondents selected for the study had minimum two years of experience and above in the profession of cutting marble in the marble industry.

Purposive sampling design was utilized for selecting the sample. The main goal of purposive sampling was to focus on particular characteristics of a population that were of interest, which would enable to provide answer to the research questions. Purposive Sampling involves identifying and selecting individuals or groups of individuals that are especially knowledgeable about or experience with a phenomenal interest (Cressvelle and Clark, 2011).

The benefits of adopting Purposive Sampling are:

i. Purposive sampling allowed greater depth of information from a smaller number of carefully selected cases (Patton, 2002)
ii. Purposive sampling technique aided with the justification to make generalizations from the sample that was studied.

3.6.1. Sampling and Selection Procedure

The sample was selected through multistage criteria:

i. At the first stage a list of industries was procured from the Kishangarh marble association.

ii. In the second stage, 400 randomly selected marble industries were approached personally with a request to send data regarding the details of their marble cutting workstations. Out of 400 marble industries, 250 industries had the marble cutting workstation. The list revealed that the number of marble cutting workstation varied from industry to industry. Most of the industries had two marble cutting workstations, only few had three marble cutting workstations. The researcher thus approached the 250 industries for seeking permission of data collection out of which only 70 industries having 2-3 marble cutting workstation agreed to co-operate with a condition that their names should not be disclosed.

iii. In the third stage, a list of industries and their workers were prepared.

iv. In the last stage, 220 respondents were selected purposively who were healthy and did not suffer from any chronic or acute diseases at the time of data collection. The workers aged above 50 years of age were also excluded from the sample to avoid biasness. The respondents selected for the study had minimum two years of experience and above in the profession of cutting marble in the marble industry (Figure 5).

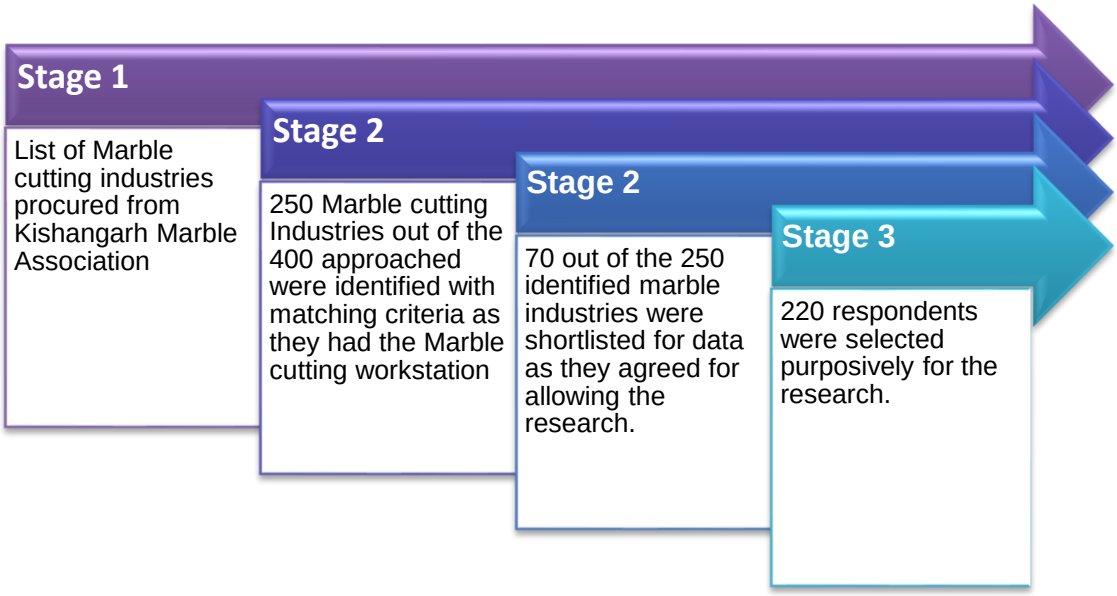

Figure 5: Sampling and Selection Procedures

3.7. Development of the Tool

An exhaustive reviewing of literature assisted and enabled the investigator in the construction of the tool. The care was taken to include questions that elicited the information needed to attain the objectives of the study.

3.7.1. Selection and Development of Tool

An interview schedule cum observation sheet was resorted to gather the data for the present study.

a) Interview Schedule

According to Ruane (2005), the interview is a purposeful conversation wherein the interviewer has a set research agenda which is key points or questions that must be addressed. Interview schedules are more structured than guides, listing the exact questions and, if the questions are closed-ended, the exact answers to be presented to all respondents. Structured schedules produce more standardized interviews and when using a forced-choice format, a more quantitative interview.

The Interview Schedule was used as a tool for gathering the demographic profile, perceived musculoskeletal pain and perceived fatigue. The interview schedule was selected due to the following reasons:

- To achieve uniformity of stimulus aiding in greater reliability.
- To obtain personal information and some extra information.
- To elicit complete information from the respondents.
- To avoid incompletely filled in entries.
- To clarify doubts of the respondents.

b) Observation Sheet

The Observation Sheet served as a recording device for recording the anthropometric measurements of the respondents, the environment of the workplace and physiological cost of work which made possible accurate entry data and it aided to concentrate on the circumscribed elements essential to the analysis.

The observation sheet was selected because of the following advantages:

- To eliminate bias and to ensure collection of accurate data.
- To aid in prompt data collection as the respondents were not educated.
- It aided to concentrate on the circumscribed elements essential to the analysis.

3.8. Description of the tool

The objectives drawn for the study guided the development of an appropriate Interview Schedule and Observation Sheet comprising of the following sections:

Section I Demographic profile of the marble cutting workers : This section comprised of questions regarding background information of the respondents such as Age (in years), Educational Qualification, Work Experience (in years), Handedness, and Perceived Health Status of the respondents before work, during work and after work.

Section II Anthropometric data and Workstation Dimensions: This section dealt with the detailed Anthropometric data (in inches) of the respondents namely Height, Arm Span, Standing Shoulder Height, Standing Elbow Height, Standing Upper Arm Length, Standing Forearm Length, Standing Hand Length, Standing Eye Height, Standing Vertical and Horizontal Maximum and Minimum Reaches at the workplace. The Height, Width and Length (in inches) of the Workstation were also recorded in this section.

Section III Perceived Musculoskeletal Pain: This section of the Interview schedule was meant to elicit information on Perceived Musculoskeletal Pain experienced during the last 12 months and last 7 days in the various body parts namely neck, shoulder, upper arm, lower arm, elbows, wrists, palms, back (upper back, middle back and lower back), hips, thighs, knees, ankles and feet by the respondents. The information was facilitated with the help of Modified Nordiac Scale which was modified by the investigator. The Nordiac

Questionnaire was modified in order to identify the perceived musculoskeletal pain experienced while doing certain movements namely lifting marble slab (overhead, at chest level, below chest), while carrying the marble slab and keeping the marble slab on a surface, while tightening a screw, while sitting on floor/ mattress, while squatting, while running, while standing still, pain experienced while at rest, and identifying whether pain interferes in daily activities since the past 12 months and last 7 days The Nordic Questionnaire was developed from a project funded by the Nordic Council of Ministers. It was first published in 1987 by Kourinka et.al, 1987 in “Standardized Nordic Questionnaires for the analysis of musculoskeletal symptoms”.

Sections IV Postural Discomfort : This section focused on the ergonomic assessment to evaluate whole body Postural Musculoskeletal Pain and risks associated with job tasks. The Rapid Entire Body Assessment (REBA) checklist was used to assess the body posture, forceful exertions, type of movement or action of the respondents. Scores were assigned to each awkward body posture of neck, trunk and leg. The postural discomfort was categorized as “Negligible Risk”, “Low Risk”, “Medium risk”, “High Risk” and “Very High Risk”.

Section V Environment of the Workplace of the Respondents: This section focused on the information on the environment of the workplace of the Marble Industry which included the noise level (dB), presence of light (lux) existing temperature (^{o}C) and presence of humidity (%),and the vibration (hz), produced by the marble cutting workstation. This section also gathered information regarding the preferred level of light by the respondents at the workstation to get an insight of their perceived comfort and preferences. The specifications of digital thermo-hygrometer, digital noise meter, digital lux meter and Vibrometer are given as follows:

Plate 1: Digital Thermo Hygrometer

Digital Thermo Hygrometer specification (Plate 1)

Model:	412ATH
Name:	Indoor Outdoor Thermometer with Hygrometer
In-Range:	0º C 50º C (32º F 122º F)
Out- Range:	-40º C 70º C (-40º 158º F) ºC ← → ºF exchangeable
Accuracy:	± 1º C RH ± 5% Indoor-hygro range: 25% RH to 90% RH
Features:	1.5 meter sensor wire. One 1.5 Volt AA battery.

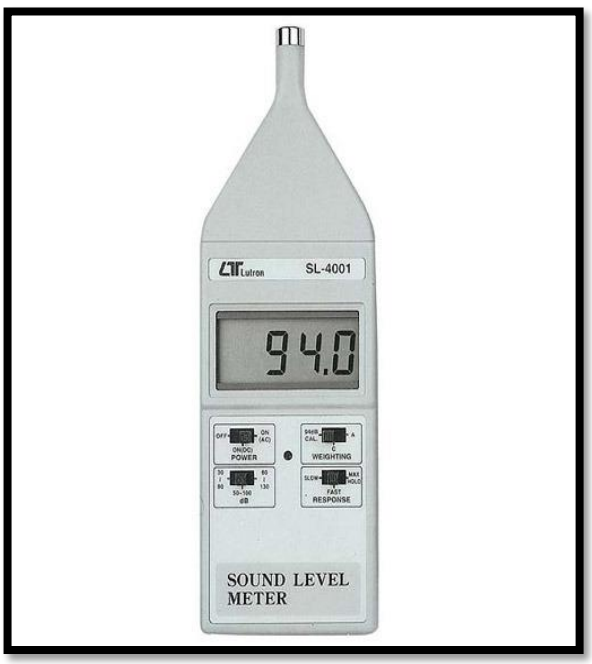

Plate 2 : Digital Noise Meter

Digital Noise meter specification (Plate 2)

Model:	SL4001
Function:	dB (A and C frequency weighting), time weighting, Max. hold, AC and DC output
Display:	liquid Crystal display, 3.5 digits Measurements: 3 ranges, 35 dB to 130 dB 13 Accuracy: 23 ± 5^{o} C, Calibrating input signal on 94 dB (31.5 Hz to 8kHz).
Frequency:	31.5 Hz to 8,000 Hz
Microphone:	electric condenser microphone, ½ inch standard size
Range selector:	30 to 80 dB, 50 to 100 dB, 80 to 130 dB, 50 on each step, with over and under range indicating
Operating temperature:	0^{o} C to 50^{o} C (32^{o} F to 122^{o} F).

Plate 3: Digital Lux Meter

Digital Lux meter specification (Plate 3)

Name:	Digital Battery Operated Lux meter
Range:	0 – 50000 Lux
Sr. No:	L-753831

Plate 4: Vibrometer

Vibrometer (Plate 4)

Object:	Accelerometer - Vibration meter
Manufacturer:	Pruftechnik Condition Monitoring GmbH
Type:	VIB 6.142R - VIBXpert II VIB 5.310
Serial number:	33655 - 031979 Channel A
	33660 - 031979Channel B
Frequency range:	2 Hz - 5000 Hz
Acceleration (Peak):	s. table
Number of frequency points on log scale:	14

Section 5 also focused on the Assessment of the Working Environment through PMA Ergonomic Checklist, ISO (9001: 2000). The PMA (Precision Metal forming Association) along with the association of OSHA (Occupational Safety and Health Administration) had developed a checklist to identify and think about the potential safety issues in the plant. The checklist comprised of collecting data regarding the provision of training for managing posture, repetition of task, stress and vibration. The checklist also covered the provision of use protective aids while working namely gloves, ear plugs or any other protective aid for the respondents.

Methodology

Section VI Physiological Cost of Work: This section dealt with information on physiological cost of work of the marble cutting workers. The Digital Heart Rate Monitor was be used to measure the heart rate (beats/ min) stresses during the activity. It was measured by the severity of physiological workload as given by Varghese et.al (1994). The data were then computed and categorized into “Very Light”, “Light”, “Moderately Heavy” and “Heavy”, “Very Heavy”, “Extremely Heavy”.

The details of the Digital Heart rate monitor used for the study are as follows (Plate 5):

Plate 5: Digital Heart Rate Monitor

Application range:	Adult and Paediatrics (age 3 or above).
Resolution:	SpO_2-1%, Pulse Rate – 1bpm, PI:0.1%.
Measurement Range:	SpO_2 -70~100%, PI: 0.3~20%,
	Pulse Rate – 30 ~ 250bpm.
Measurement Parameters:	SpO_2, PR, PI, Pulse Bar, Waveform.
Finger Thickness:	9mm-22mm (no less than 9mm)
Display type:	Dual Color OLED display
Dimensions:	60 x 32 x 30 mm (L x W x H)
Weight:	55±5g (including batteries)

Section VII Perceived Fatigue: The perceived fatigue was measured by the researcher through prevalidated FACIT Scale. The FACIT Fatigue Scale is a short, 13-item, that measures an individual's level of fatigue during their usual daily activities over the past week. The level of fatigue is measured on a five-point continuum (0 = not at all fatigued to 4 = very much fatigued). which were scored 4 through 0 respectively for positive statements. The scores were reversed for the negative statements. Higher scores reflected less fatigue among the respondents. The data were categorized as "Less Fatigue" and "Severe Fatigue"

3.8.1. Content Validity of the Scales

The extent to which conclusions drawn from research provide an accurate description of what happened or a correct explanation of What happens and Why (Jupp,2006). According to Ruane (2005) content validity assesses how good a fit is obtained between nominal and operational definitions - i.e., do the nominal and operational definitions coincide or overlap. Content validity is an important consideration whenever a researcher working with complex, multidimensional concepts. If concepts are defined as having more than one dimension, then multiple items must be used to document the concept. As is true for face validity, content validity is a subjective validity test. Essentially judgments are made as to whether or not the selected empirical indicators really do represent the full content of a concept's nominal definition. The precisely constructed Interview cum Observation Scale was then submitted to a panel of seven judges having expertise in the field of Ergonomics and those who had conducted researches in the field of Ergonomics. The judges for the content validity of the present research included were experts of Academics from the Department of Family Resource Management, SNDT, Womens' University, Mumbai, Nirmala Niketan College of Home Science, Mumbai BMS College of Home Science, Mumbai and Doctor from Department of Physiotherapy, Apollo Hospital, Ahmedabad.

The judges were requested to check the clarity and relevance of the content of the tool. They were also requested to state whether each statement fell in the category under which it was listed. A consensus of 80 per cent among the

judges was taken as a yardstick for inclusion of the statement in the final tool. No changes were required to be made in the tool.

3.9. Data Collection

The data of the present research was collected through survey method. The problems that hinder research in developing countries are complex, interrelated and often poorly understood. These include lack of research education and training for health professionals, lack of appreciation for the value of health care research as an important tool for progress, shortage of funding and research resources, special bioethical standards and concerns, limited access to health informatics and individualism and inability to work within groups Abu-Zidan and Rizk (2005). The issues were considered since the earlier stages of design process of data collection tool.

The survey research method best fits the research objectives of the present study due to the following reasons:

i. It allowed the researcher to reduce the concepts involved in the study to specific indicators to be able to quantitatively gather answer for the research questions of this study.
ii. The survey study brought flexibility in terms of scheduling the time when the participants were assigned to give response for the interview schedule.

The data were collected between September 2017- January 2018. The researcher had approached over 250 industries, out of which 150 industries responded back. On further co-operation only 70 industries agreed to co-operate. The data were gathered through observation sheet and interview schedule. The respondents were briefed regarding the purpose and benefits (employee well-being) of the project and asked to voluntarily participate, assured of confidentiality and anonymity by the researcher as requested by the industry owners.

The purpose of research was explained and a rapport was built so as to get true responses. The researcher personally conducted the interviews on a pre validated structured interview schedule. On an average, interview schedule

continued for approximately an hour or more. The workers were quite co-operative and enthusiastic in giving responses.

The observation sheet was filled in by the researcher through the use of scientific instruments namely Digital Thermo Hygrometer, Digital Noise Meter, Digital Lux Meter and Vibrometer. The observation sheet was also used to collect information on the posture of the respondents while at work.

During the data collection, investigator encountered difficulty in getting co-operation from certain industries due to the peculiar nature of the present study. Whereas certain co-operative industry owners stressed on being discrete regarding facilitating the information as they wanted the certain data to be confidential. The subjects and industry owners were thanked for their participation and informed that their efforts support the enhancement of the office environment and well-being of employees.

3.9.1. Anthropometric Data

The anthropometric measurements of the respondents were taken with the help of a non-elastic measuring tape and a weighing scale. The respondents were asked to stand straight on an even surface bare foot. The measurements were then recorded in inches simultaneously by the researcher in the observation sheet.

3.9.2. Survey of Environment of the Workplace

The environment of the workplace was surveyed by using the following instruments

Anthropometric kit: - By using anthropometric kit, the height, width and length of the marble cutting working station was measured.

i. Digital Thermo Hygrometer - It was used for measuring Humidity and Temperature of the marble cutting workstation. The researcher took three readings of the temperature and humidity at an interval of 20 minutes and then an average Temperature and Humidity were calculated. The measurements were taken between 10:00 a.m. to 11:00 a.m. when it was the middle of the shift which used to start from 6:00 a.m. to 2:00 p.m.

ii. Digital Noise meter - It was used to measure the level of noise produced while cutting the marble into tile by the workers. The Noise Meter was placed near the working station, three recordings were recorded at an interval of five minutes and then an average reading was recorded. None of the industries were located near the highway thus the question of noise being generated from running of vehicles was not there. The noise recorded was solely of the marble cutting machinery that were being used in the workplace.

iii. Digital Lux meter - It was used to measure the intensity of light available in the working area. The Lux Meter was placed at the location of the marble cutting workstation. Three readings were recorded and then an average light was recorded. The light was measured between 10:00 a.m. to 11:00 a.m. when it was the middle of the shift which used to start from 6:00 a.m. to 2:00 p.m.

iv. Vibrometer – The researcher identified the areas on machines where the workers most come in contact to and then the vibrometer was placed at those points for measuring vibration. The vibrometer VIB 6.142R - VIBXpert II VIB 5.310 was used for recording the measurements. The areas at which vibration was measured are:

   a. The Pulley,
   b. The Marble slab away from the marble Cutter,
   c. On the Wooden bar of the Counter,
   d. On the floor.

3.9.3. Perceived Musculoskeletal Pain

The data for the Perceived Musculoskeletal Pain was collected by an interview method. The researcher had used a body map for explaining the exact body parts at which pain was experienced during the last 12 months and last 7 days in the various body parts namely neck, shoulder, upper arm, lower arm, elbows, wrists, palms, back (upper back, middle back and lower back), hips, thighs, knees, ankles and feet by the respondents. The Nordiac Questionnaire was modified in order to identify the perceived musculoskeletal

pain experienced while doing certain movements namely lifting weight (overhead, at chest level, below chest), while carrying the weight and keeping the weight on a surface, while tightening a screw, while sitting on floor/ mattress, while squatting, while running, while standing still, pain experienced while at rest, and identifying whether pain interferes in daily activities.

3.9.4. Rapid Entire Body Assessment (REBA)

The postural discomfort was assessed with the aid of REBA. For observing the posture, a video recording of selected 50 respondents who had high musculoskeletal pain were recorded for a detailed Ergonomic Postural Analysis. The screenshots were then taken of the posture of the respondents. Using the REBA worksheet, the researcher assigned a score for each of the following body regions: wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees. After the data for each region was collected and scored, tables on the form were then used to compile the risk factor variables, generating a single score that represented the level of Musculoskeletal Disorder risk.

3.9.5. Physiological cost of work

The Digital Heart Rate Monitor was used to measure the heart rate stresses during the activity. It is a very light instrument, which can be taken to any place for measuring the heart rate. The transmitter in the Digital Heart Rate Monitor after receiving the heart beats signals transmits the same to a receiver mounted over the subject's fingers. The respondent was allowed to sit and rest for some time. After rest, the respondent was asked to start the activity for 30 minutes. Three recordings were recorded with equal interval method. An average was computed for acquiring Average Heart Rate

Based on the records of heart rate monitor, Energy expenditure for the activities were calculated by using the formula and inferences were drawn.

Energy Expenditure (Kj/min) = 0.159X Average Working Heart Rate (beats/min) – 8.72

Based on the energy expenditure (KJ/min), classification of the Physiological cost of work was computed as per the classification of Varghese et.al. 1994 (Table 4).

Table 4: Classification of Physiological Workload According to Severity of Work Load

Physiological Cost of Work	Varghese et.al. 1994
	Energy Expenditure (Kj/min)
Very light	< 5.0
Light	5.1 – 7.5
Moderately heavy	7.6 – 10.00
Heavy	10.1 – 12.5
Very heavy	12.6 – 15.0
Extremely Heavy	>15.0

3.10. Data Analysis

The procedure used to analyze the data were categorization, coding, tabulation and statistical analysis.

3.10.1. Data Categorization

The under mentioned categories were made to enable the researcher to analyze the data further for statistical application:

i. **Age (in years):** The obtained range of age (in years) of the respondents was arrived at on the basis of equal intervals as follows:
   - **a)** 28-34 years
   - **b)** 34-40 years
   - **c)** 41- 46 years

ii. **Educational Qualification:** The formal Education obtained by the respondents was categorized as follows:
   - **a)** Primary
   - **b)** Middle
   - **c)** Secondary
   - **d)** Higher Secondary

iii. **Experience in years:** It referred to the time period since when the respondents were involved in the task of cutting marble tiles. It was categorized as follows:
   - **a)** 5-10 years
   - **b)** 11-15 years
   - **c)** 16-20 years
   - **d)** 21-25 years

iv. **Postural Discomfort:** It referred to position of limbs and the carriage of the body of the respondents while working. The data were categorized as follows:

Level of MSD Risk	Score
a) Negligible Risk	1
b) Low Risk	2-3
c) Medium Risk	4-7
d) High Risk	8-10
e) Very High Risk	11+

v. **Noise Level:** It referred to noise in the Marble Industry while cutting the marble slab into tile at the marble cutting workstation. The data were categorized as follows:

a) Moderate Noise (93 dB -99 dB)

b) High Noise (100 dB – 106 dB)

c) Very High Noise (107 dB – 112 dB)

For statistical analysis the following categories were made on the basis of mean of the level of noise in the Marble Industries:

a) Moderate Noise (less than 103 dB)

b) High Noise (equal to more than 103 dB)

vi. **Presence of Light:** It referred to the amount of light present in the Marble Industry while cutting marble slabs into tile as was categorized as follows:

a) Less Light (Below Recommended Level)

b) Appropriate Light (≥Recommended Level)

vii. **Presence of Humidity:** The presence of Humidity in the Marble Industry while cutting marble slabs into tiles was categorized as follows

a) 33-37%

b) 38-41%

c) 42-46%

viii. **Existing Temperature:** The existing Temperature in the Marble Industry while cutting marble slabs into tiles was categorized for the present as follows

a) 33-35 ^{o}C

b) 36-38 ^{o}C

c) 39-41 ^{o}C

ix. **Physiological cost of work:** It referred to the amount of energy (human) consumed by the respondents while cutting Marble tiles. The data were categorized as follows:

a) Very Light (< 5.0 kj/min)

b) Light (5.1 - 7.5 kj/min)

c) Moderately Heavy (7.6 – 10.0 kj/min)

d) Heavy (10.1 – 12.5 kj/min)

e) Very Heavy (12.6 – 15.0

f) Extremely Heavy (> 15.0)

x. **Perceived Fatigue:** The fatigue experienced by the respondents was categorized as follows:

a) Severe Fatigue

b) Less Fatigue

3.10.3 Coding: The process by which observations recorded in the course of social research – typically in a social survey questionnaire – are transformed from raw data into categories and classifications, which then become the subject of quantitative data analysis. Coding involves the act of measurement, for in classifying answers to a question, one is trying to measure the underlying social variable which the survey question intends to tap (Jupp, 2006). Code numbers were given to each answer followed by the information from the interview schedule and observation sheet. Coding key was made then referred to the statistician for approval and guidance. The codes were then transferred on a coding sheet.

3.10.4 Tabulation: The numerical data that forms the results of a content analysis are most conveniently presented in tabular form. A separate table is produced for each case based on the coding schedule, with the columns listing the codes filled in. When the results of all the cases are tabulated, the frequency of the occurrence of the different codes throughout all the cases can then be counted (Walliman, 2011). The data were transferred from coding sheet into a tabular form to give a clear picture of findings to facilitate the analysis of data. The tabulation was done with the help of computer in an Microsoft Excel Sheet 2010. The coded data of the present research were tabulated to arrive at tables that were required for describing and analyzingthe data.

3.10.5 Statistical Analysis: According to MacDonald & Headlam (2009), Statistical analysis is a mathematical method of interrogating data. This is done by looking for relationships between different sets of data. There are two types of statistics:

• Descriptive statistics: numerical summaries of samples (what was observed);

• Inferential / Relational statistics: from samples of populations (what could have been or will be observed).

The data were analyzed employing descriptive as well as relational statistics.

Descriptive statistics: The data were presented in frequencies, percentage, mean and standard deviation.

Relational statistics: Analysis of Variance, t test, Co efficient of Correlation and chi square were carried out to test the hypotheses postulated for the study.

Table 5: Relational statistics applied to test the Hypotheses

Tests	Independent Variables	Dependent Variables
(ANOVA) F-test	• Age (in Years) • Years of Working Experience and • Perceived Health Status	• Perceived Musculoskeletal Pain experienced by the respondents
		• Physiological Cost of Work of the respondents
		• Perceived Fatigue experienced by the respondents.
t-test	• Environment of the Workplace (Noise Level and Presence of Light)	• Perceived Musculoskeletal Pain experienced by the respondents
		• Physiological Cost of Work of the respondents.
		• Perceived Fatigue experienced by the respondents.
Chi Square	• Physiological Cost of Work of the respondents.	• Perceived Fatigue experienced by the respondents.
		• Perceived Musculoskeletal Pain experienced by the respondents
(co-relation of coefficient**) r-test**	• Perceived Musculoskeletal Pain	• Perceived Fatigue experienced by the respondents.

3.11 Ergonomic Intervention Programme

One of the objectives of the present research was the development of ergonomic intervention programme for the selected owners and marble cutting workers to improve the environment of the workplace and maintaining appropriate work postures during the work. The proposed Ergonomic intervention programme was channelized to include providing sensitization

and awareness among the Marble Cutting Workers regarding protection during work and maintaining postures at work.

Out of the 220 marble cutting workers from 70 industries surveyed only two of them agreed for the intervention and giving their valuable time to the researcher. One of the reasons for not getting permission for conducting the educational programme was that due to pandemic situation most of the labourers had gone to their hometown and thus the marble cutting workstation was not functional in few of the industries.

3.11.1 Development of the Ergonomic Intervention Programme

The Ergonomic Intervention Programme was developed as follows:

a) Posters were developed and designed for the workers in English and translated with the help of Hindi language experts as they did not have a command on English. The findings of the study revealed that the respondents were educated and could read and write, but not in English Language. The posters consisted of information stressing upon the maintaining proper posture, benefits of protective aids for better productivity and less injuries.

b) The Content regarding the **Ergonomic Intervention Programme** was developed based on the review of literature collected. The Intervention Programme was made on the basis of the consultation of experts from the Department of Family and Community Resource Management, Ergonomics and physiotherapists.

3.11.4 Administration of Ergonomic Intervention Programme

The selected owners and marble cutting workers were contacted by the researcher as gathering them was not feasible due to the Covid-19 situation and social distancing norms. Each industry owner was briefed and sensitized on the importance of implementing training programme for maintaining proper posture, providing protective aids namely earplugs, hand gloves, protective boots. The content of the posters was explained by the researcher via telephonic conversation and were displayed at key points of the marble cutting workstation. The researcher also had provided details of the online and offline sellers of the protective aids to the owners of the industry along

with the detailed price list and description. The information regarding the sellers included links in case of online seller and address, phone number and price of each protective aids that must be provided to the marble cutting workers.

The researcher had requested the industry owners for implementing the intervention programme. Two industry owners agreed to implement and cooperate with the researcher. The researcher faced a lot of resistance against implementing the suggestions as they opined that the work of their industry will be hindered. Ten marble cutting workers were identified by the researcher. The protective aids namely er plugs, safety shoes and safety gloves were donated by the researcher. The workers were requested to implement the guidelines for 7 days to see if they experience any changes or solutions to the problems as reported by them. Timely and effective feedback was taken by the researcher via telephonic conversations as travelling was not possible by the researcher. The feedback was taken via telephonic conversation on the 8th day with the aid of a feedback form developed by the researcher. The feedback form was prepared in Hindi language for the ease of understanding of the respondents.

The details of the protective aids provided by the researcher are as follows:

Ear Plugs (Plate 6)

Item Weight	21 Grams
Noise Reducing Rating	29 decibels
Other features	Corded for convenience and to prevent loss of earplugs Smooth, dirt resistant surface for hygiene Comfortable for a wide range of ear canal sizes

Safety Shoes (Plate 7)

Features	Rubberized for flexibility and durability Gumboots providing highest level of safety & comfort Puncture and Tear Resistant

Safety Gloves (Plate 8)

Features Nitrile coating, Cut resistant

Left Right Hand specific

Plate 6: Ear plugs provided by the researcher to the workers for Intervention Programme

Plate 7: Safety Shoes provided by the researcher to the workers for Intervention Programme

Plate 8: Safety gloves provided by the researcher to the workers for Intervention Programme