Musculoskeletal Pain and Postural Discomfort experienced by the Marble cutting workers in the Marble Industry

SYNOPSIS

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INTRODUCTION

Marble are rock formations formed by nature. These are formed naturally by enormous pressure under the earth. Marbles were used in decorating and sculpturing right from the moment civilization was born. These are time tested for their natural beauty. Ancient buildings and monuments made of natural stones during early civilization still stand erect narrating the beauty and durability of natural stones. Modern people want to make their home stand out of the rest and they used natural stones for their floors and walls to bring about eternal beauty[1].

Building constructions using marble is popular in India and the Taj Mahal one of the seven Wonders of the World was constructed using pure white marble stones. This uniqueness of natural stones has made people want for more use of natural stones[1].

Scenario of Marble Industry- in India

The Indian marble is available in a wide range of shades and colors, the marble, granite and other stones are exported and have gained popularity in the international markets. This is mainly due to the quality of marble cut, quality of marble surface finish and crack free pieces. Marble deposits are widespread in India across different states like Rajasthan, Gujarat, Madhya Pradesh, Haryana, and Andhra Pradesh. Gujarat produces some very fine marble followed by Madhya Pradesh. Rajasthan is the main depository of marble which accounts for over 90 per cent of total marble production in India [1100 m tons]. Newer varieties of marble are being developed in Bihar, Jammu & Kashmir, Maharashtra, Sikkim, Uttar Pradesh and Bengal[2].

The marble industry in Rajasthan has flourished after 1980's as indicated by continuous increase in production, number of leases and revenue. The marble production which was only 17620 tones in 1950 has been increased to 4278.630 thousand tonnes (243 times) and revenue from Rs. 1,17,880/- to Rs. 5,55,177.551 thousand (470 times) in 1999-2000. At present, a total of 3243 leases and 840 quarry licenses are in existence. Such a drastic change in marble scenario during this half century of independence, has generated job opportunities manifold. A large number of persons are engaged in marble

mining and marble based industries. This has uplifted the socio-economic status of the people working in marble mines associated with marble industries[3].

Kishangarh Marble

Kishangarh is a tehsil of Ajmer district in Rajasthan. It is biggest marble mandi of Asia. The Kishangarh marble area is developed by Kishangarh marble association. More than 9000 marble selling units are situated in the market with an investment of Rs. 5000 crore (approx). This sector has employed near about fifty thousand direct & indirect labours. There are 32 Granite enterprises having capital investment of Rs 16 crore & 385 persons have been employed. Other main enterprises are of marble cutting & crazy with an investment of Rs. 15.30 crore & also around 1995 persons have been employed in marble edge cutting units[4].

Marble production process

The production of marble passes through several stages. The first stage of production is exploration and identification of a quarry location, followed by extraction of marble from the quarries, thereafter lifting and transportation, inventory management and finally cutting the stone into slabs and tiles. The left over slabs of marble are further utilized depending on the size of slab. Some of the slabs are made into tiles, some of them are cut into small pieces for making the decorative items used in residences and commercial purposes. Polishing of the slabs takes place after cutting, and finally, they are distributed to end users.

Workers in Marble Cutting

When a certain order is placed, the raw stone block is transported to the factory to be cut as demanded either into tiles or slabs of various thickness (usually 2 cm or 4 cm). Stone-cutting is a lengthy process that can take more than a continuous 12-16 hours of operation, depending on the model of the cutting machine as well as the status of its diamond wire or diamond blades (Kandil and Selim, 2013).

Despite of technological development for lifting bulky marbles and cutting them, the role of a human being cannot be denied. The findings of the pilot

study conducted by the researcher at Kishangarh tehsil, Ajmer district, Rajasthan found that the laborer is required at every step of marble production demanding awkward postures and standing for long period of time. The marble cutting machine on which the small slabs are cut into the required shape for making tiles requires the worker to adjust the marble on the machine and hold it till the blade cuts the marble through. Sometimes these slabs weigh from 100 kg to 150 kg.

Musculoskeletal Pain among Workers of Marble Industry

Workplace and work related risk factors, which often overlap, typically involve poor work method, inadequate work stations and hand tools and high production demands. The biomechanics factors for work related upper limb disorders include repetitive and sustained mechanical forces. Vibrations and cold environment also accelerate the development of work related upper limb disorders.

Work related injuries present a major public health problem resulting in serious social and economic consequences. Small and medium- scale industries employed about 80 per cent of the workforce and contribute over 90 per cent of all developing countries.

Stone or marble cutters generally adopted different types of posture for prolonged periods during specific operation like cutting and setting stone or marble. Awkward and static working postures could be the two factors that might contribute most to musculoskeletal disorders symptoms among the workers in marble industry. Although disorders of the musculoskeletal system are more prevalent among experienced construction workers, this study indicated that musculoskeletal disorders symptoms were present among young construction workers (Gandopadhyay et. al., 2010).

Postural Discomfort

Posture is a static state - 'A position of the body' or an arrested movement' The bones hold the body, the joints link the bones, the muscles move the bones around the joints and the nerves facilitate control of the whole. The key to good posture is correct joint alignment, but muscle activity, balance and nerves should also be considered[5].

The posture analysis of stone cutters of West Bengal revealed that stonecutters worked continuously in awkward postures during stonecutting and stone setting activities. Consequently, they suffered from discomfort in different parts of their body, specifically in the lower back, knees and shoulders. Due to this feeling of discomfort stonecutters were affected when continuing their work. This study also showed that stonecutters felt maximum discomfort during sleep at night and a large proportion also felt discomfort throughout the day (Gandopadhyay et. al., 2010). Dhar et.al. (2007) and Ghosh et. al. (2010) conducted the posture analysis of goldsmiths which showed that one-half of the respondents were normal. Among the other respondents postures like protruded neck with rounded shoulder, only Protruded neck, drooping posture and forwarded posture were found to be more prominent.

Environment of the Workplace

The environmental factors include noise, illumination, humidity and temperature which affects the workers' performance and health.

a. Light and its effect on work

A study by Nemecek and Grandjean (1975) in open plan offices showed that a very high level of illumination is often unsuitable in practice. Levels above 1000 lx increase the risk of troublesome reflections, deep shadows and excessive contrasts. In the study 23 per cent of 519 employees reported that they were disturbed by either reflection. This study also observed that employees preferred illuminance levels between 400 and 850 lx (Kroemer and Grandjean, 1997). The work performed by the marble cutters needs the workstations to be adequately illuminated since it requires the worker to work with blades. Poorly illuminated workstations may increase the error of the worker as well as add to the risk of working on the marble cutting workstations.

b. Noise and its effect on work

Effects of noise exposure was studied by various researchers Singh et al (2009) on forging units (SSI) of different sizes in Northern India in Punjab. Harger and Barbosa (2005) in their study on effects on hearing due to the

occupational noise exposure of marble industry workers in the federal District of Brazil found slightly less than half respondents had abnormal audiograms. Among the hearing loss, the predominant cause was found to be Noise Induced hearing Loss, followed by incipient noise induced hearing loss. Atmaca et. al. (2005) also explored the effects of noise on workers working in concrete traverse, cement, iron and steel and textile factories.

Noise impairs performance and output. A decline in performance may be attributed to certain kinds of jobs requiring skill and dexterity. Many studies have shown that a level of noise above 90 db, discontinuous or unexpected can impair mental performance. Noise has negative effects on jobs requiring skill, learning dexterity and high levels to impair mental performance (Khan, 2010).

c. Temperature and its effect on work

the productivity is maintained upto about 28^{o}C and then begins to drop. At about 30^{o}C productivity is around 90 per cent of prestress levels. The rate of decline in productivity continues to increase so that at about 34^{o}C, productivity is only 50 per cent of prestress level (Sanders and McCormick,2013). Extremely hot conditions can lead to serious health dangers. (Kromer and Grandjean, 1997).

d. Vibration

Mechanical vibration arises from a wide variety of processes and operations performed in industry, mining and construction, forestry and agriculture and public utilities. Hand transmitted vibration occurs when the vibration enters the body through hands e.g in various work processes where rotating or percussive power tools or vibrating work pieces are held by the hands or fingers. The human response to vibration depends mainly on the magnitude, frequency and direction of the vibration signal. Vibration seriously affects visual perception and psychomotor performance of the worker. Simultaneously it also has derogatory effects on musculator, with circulatory, respiratory and nervous systems on the worker (Grandjean, 1997). Workers who operate on vibrating hand tools develop peripheral nerve disorder and white fingers. Exposure to large amounts of vibration in a localized area, such

as the user's hand over a prolonged period of time might increase the risk of chronic disorders of the muscles, nerves, and tendons (Khan, 2010). The marble cutters have to place their hands till the marble slab is cut through on the marble cutting workstation which may produce vibrations and lead to hand arm vibration.

Role of Physiological cost of work

The analysis of physiological cost of work plays a pivotal role in the process of carrying out ergonomic evaluations of any job. The objective of applying ergonomic principles in work analysis is to maintain a balance between the work and the physical capacity of the worker. If the physiological cost of the work is less the worker is underutilized and there is a productivity loss hence the balance between the two is needed. (Singh, 2013). Determining the physiological cost of work of the marble cutters would assist in utilizing their work productivity efficiently. Thus, a need was felt to find out the physiological cost of work of the marble cutters.

Justification

Marble Industry in Kishangarh district comprises of many Marble industries. The industries have employed several daily wages, permanent and contractual employees. The Marble Industry in today's era is emerging as an important industry for the construction agencies. The marble cutting workers are designated to cut the marble slabs into tiles as per the customer's demands and needs. Thus, for achieving such a task, the workers have to manipulate their postures in the space available resulting in changes in the posture. The environment of the workplace such as light, noise, noise, temperature and humidity also affect the worker's capacity. The workstation is located under an open shed thus the temperature and humidity directly affect the marble cutting workers' while working. The protective aids that must be provided for completing the task without any injuries are also not provided in most of the industries.

Stone quarrying, cutting and masonry is one of the many industries which involve moderate to heavy manual work. Due to the nature of manual work and use of tools, stonecutting job may potentially cause work-related upper

limb musculoskeletal disorders.

The review of literature highlighted that work-related musculoskeletal disorders/ occupational disorders have been investigated and reported for workers from various sectors in India. These include computer operators / keyboard users, goldsmiths, stone carvers and workers from sand core making, mining and weaving industry (Gandopadhyay et.el., 2010, Dasgupta and Harrison, 1996, Ghosh et. al., 2010, Nag et. al., 2010,Silvian et. al., 2011Talwar et. al., 2011 and Dhar et al. 2007). There are very few studies been conducted on marble cutters within and outside India (Gangopadhyay, et. al., 2010 Mukhopadhyay and Srivastava, 2010, Bovenzi, 1994, Harger and Barbosa, 2005).

The review of literature further revealed that the postural analysis of stone cutters was conducted by Gandopadhyay et. al. (2010) in West Bengal. The environmental factors were studied by Singh (2009), Talwar et. al. (2009), Ghosh et. al. (2010) on forging industry, computer professionals and goldsmiths respectively.

The anthropometric data of the marble cutters involved in marble industry, their working environment, physiological cost of work, their posture analysis and occupational related disorders experienced by them is yet to be explored. Thus, the present study is conceptualized. The findings of the study will be helpful in making the owners of the marble industries aware about the existing working environment of their industry. The findings will also be helpful for them as well as the marble cutters in the industry as it will help them review their postures and adopt the improved ones to reduce occupational disorders.

Statement of Problem

The present research aims to assess the musculoskeletal pain and postural discomfort experienced by the marble cutting workers in the marble industry.

Objectives of the Study

1. To gather the demographic profile perceived Health Status, anthropometric data of the marble cutting workers in the marble industry and workstation dimensions.
2. To study the musculoskeletal pain as perceived by the respondents.
3. To analyze the postural discomfort experienced by the respondents while carrying out their work.
4. To assess the environment of the workplace of the respondents.
5. To determine the physiological cost of the work carried by the respondents and fatigue as perceived by them.
6. To organize an ergonomic intervention programme for the selected owners and marble cutters of the marble industry for
   a) improving their work environment,
   b) maintaining appropriate work posture during their work.

Hypotheses for the Study

1. The Perceived Musculoskeletal Pain experienced by the respondents will vary with the Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace (Noise and Light)).
2. The Physiological Cost of Work of the respondents will vary with their Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace(Noise and Light)).
3. The Perceived Fatigue experienced by the respondents will vary with the Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace (Noise and Light)).
4. There is an association between Physiological Cost of Work and Perceived Fatigue experienced by the respondents.
5. There is an association between Physiological Cost of Work and Perceived Musculoskeletal Pain.
6. There is an association between Perceived Fatigue and Perceived Musculoskeletal Pain.

Delimitations of the Study

1. The present research was limited to the marble cutters involved in cutting of marble tiles and small pieces of marbles in the marble industry.
2. The present study was limited to the respondents having a minimum work experience of 2 years in marble cutting.
3. The present research was limited to the healthy workers those who were not suffering from any chronic or acute disease.

REVIEW OF LITERATURE

The review chapter was divided into two parts viz. Theoretical Orientation and Empirical studies regarding Musculoskeletal Pain and Postural Discomfort experienced by the Marble cutting workers in the Marble Industry

Theoretical Orientation: It covered the topics such as Types of Marbles, Production of Marble in World, Asia, India and Rajasthan, Processing of Marble, Method of Marble Processing, Marble Tile Cutting, Uses of Marble, Types of Machines used in Marble Industry, Musculoskeletal Pain, Posture and Environment of the Workplace,

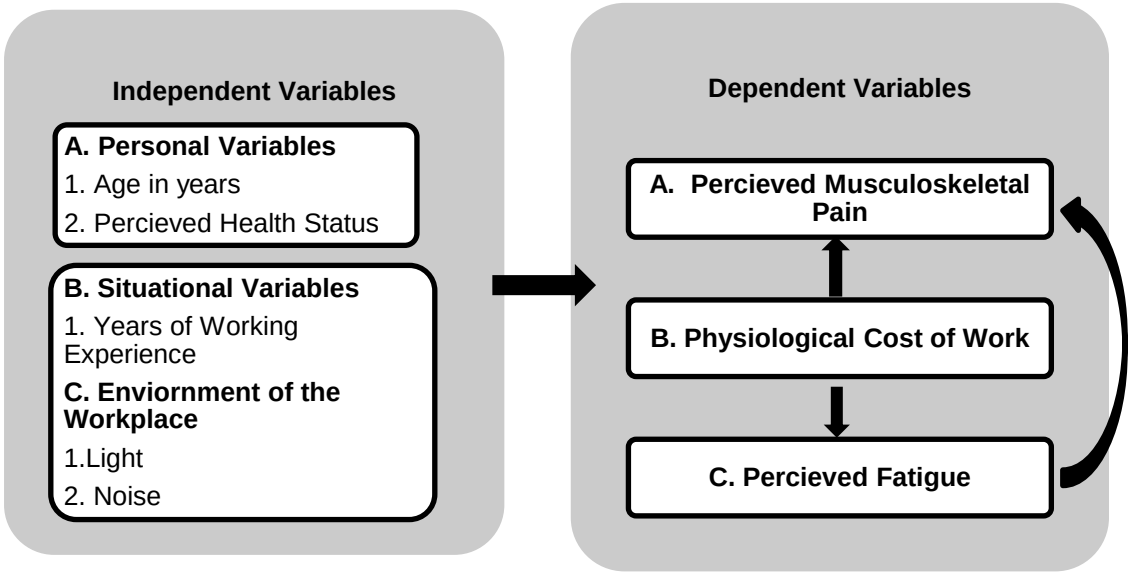
Empirical studies: This subsection consisted of researches conducted in India and abroad on topics such as:

- Marble cutting machines
- Environment of the Workplace,
- Musculoskeletal Discomfort and Postural Discomfort,
- Physiological Cost of Work and
- Fatigue .

METHODOLOGY

The present investigation was a descriptive research. There were three sets of variables selected for the present study viz. Independent, Intervening and Dependent (Figure 1). The present study was conducted in an International hub of marble i.e. Kishangarh Tehsil of Ajmer district of Rajasthan, India. The unit of enquiry for the present study were the workers involved in cutting of tiles of marble from left over marble slabs.

Figure 1: The Schematic framework showing the Hypothetical Relationship between the Variables considered for the present study is as follows:



Sampling Size and Sampling Procedure: The sample comprised of 220 marble cutting workers working on the marble tile cutting workstation. The respondents for the present study were healthy and did not suffer from any chronic or acute diseases at the time of data collection as reported by them. The care was taken to select the workers who came regularly and did the work of cutting marble tiles. The workers aged above 50 years were also excluded from the sample to avoid bias. The respondents selected for the study had minimum two years of experience and above.

Sampling and Selection Procedure

The sample was selected through multistage criteria:

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

ii. In the second stage, 400 Marble Industries were randomly selected. The selected Marble Industries were requested to send data regarding the number of Marble tile workstations installed in their respective industries. The data revealed that 250 industries had Marble tile workstations installed. Majority of the industries had two marble tile cutting workstations, only few had three marble tile cutting workstations. The researcher thus approached the 250 industries for permission of data collection out of which only 70 industries having 2-3 marble tile 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 which agreed to co-operate comprising of the number of workers working at the marble tile cutting workstation were prepared by the researcher to select the respondents.

iv. In the last stage, 220 respondents were selected purposively who were healthy and had an experience of 2 years and above in the same in cutting tiles from marble slabs.

Construction of Tool

- **Selection and Development of Tool**

An Interview schedule was resorted to gather the demographic data, perceived musculoskeletal pain and perceived fatigue of the respondents for the present study.

The Observation Sheet served as a recording device for collecting information regarding Postural Discomfort, Anthropometry, Dimensions of the Workstation, Environment of the workplace and Physiological Workload.

- **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.

- **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 data of the Respondents

This section comprised of questions regarding background information of the respondents such as their Age, Educational Qualification, Employment Status of the Worker, Work Experience, Handedness, Working Hours, and Perceived Health Status.

Section II – Anthropometric data and Workstation Dimensions

This section dealt with the detailed Anthropometric data of the workers i.e. their Body 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 Length, Width and Breadth of the Workstation was also recorded in this section. The second section was meant to collect information on the anthropometric data of the respondents which will be utilized while suggesting the redesigning of workstation for marble tile cutting.

Sections III - 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, repetition of motions of the respondents. Scores were assigned to each awkward body posture of neck, trunk and leg.

Section IV - Perceived Musculoskeletal Pain

This section of the schedule was meant to elicit information on Musculoskeletal Pain perceived 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 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. An enquiry was also made in identifying whether pain interferes in daily activities of the respondents or not.

Section V – Data on the Working Environment of the Respondents

This section focused on the information on the working environment of the marble tile cutting workers which included amount of light available in the working area, the temperature, humidity, vibration, noise produced by the marble tile cutting workstation. This section also gathered information regarding the preferred level of light at the workstation to get an insight of the comfort and preference regarding Light of the respondents.

Section 3 focused on the Assessment of the Working Environment through PMA Ergonomic Checklist, ISO (9001: 2000). The PMA (Precision Metalforming Association) along with the association of OSHA (Occupational Safety and Health Administration) had developed a checklist to identify and assess about the potential safety issues in the plant. The checklist comprised of collecting data regarding the provision of training for managing posture, repetition, stress and vibration. The checklist also covered the stress experienced at various body parts and to check the provision of protective aids while working namely gloves, ear plugs for the respondents. The responses in this section were collected in Affirmative and Non Affirmative responses of the respondents were collected in this section.

Section VI - This section dealt with information on physiological cost of work of the marble tile 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 Indian Council

of Medical Research (ICMR, 1969) and National Institute of Occupational Safety and Health (NIOSH, USA, ISO-28996, 2006).

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, easy to administer tool that measures an individual's level of fatigue during their usual daily activities over the past week. The items are scored as follows: 4=Not At All; 3=A Little Bit; 2=Somewhat; 1=Quite A Bit; 0=Very Much, EXCEPT items #7 and #8 which are reversed scored. The statements from 1-13 are negative except 7 and 8 statement. Score range 0-52. (Webster et al., 2003). It covers Four primary quality of life domains are covered in the general measure: Physical Well-Being (PWB; 7-items), Social/Family Well-Being (SWB; 7-items), Emotional Well-Being (EWB; 6-items); and Functional Well-Being (FWB; 7-items). In a 2007 study, (Chandran et al., 2007) the FACIT Fatigue Scale was found to have high internal validity (Cronbach's alpha = 0.96) and high Test-Retest reliability (ICC = 0.95).

Content Validity of the Tool

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. A consensus of 80% among the judges was taken as a yardstick for inclusion of the statement in the final tool.

Data Collection

The survey research method suited the research objectives of the present study.

- **Data collection regarding Anthropometric Measurements**

The anthropometric measurements of the respondents were taken with the help of a non-elastic measuring tape and a weighing scale. The weight of the respondents was taken by asking them to stand straight on the weighing scale bare foot and with light weight clothes without any

gears to note the correct weight.

- **Data collection regarding Environment of the Workplace**

The data regarding working environment was of the marble cutting work station was collected through

i. Dimensions of Workstation: The metallic measuring tape was used to note down the length, breadth and height of the platform on which the cutting of marble pieces were taking placed. The noting of the measurements was taken on an observation sheet by the researcher personally.

ii. The intensity of Light at the Marble Tile Cutting Workstation was measured with Lux meter (Model: Digital Lux Meter indi 6171). The Lux Meter was placed at the location of the marble tile cutting workstation. The average reading regarding light was taken by the noise meter at the same time subsequently one after another on an observation sheet by the researcher personally.

iii. The Temperature and Humidity of the Marble Tile Cutting Workstation was measured with Thermometer with Hygrometer (Eurolab Hygrometer Model number 412 ATH). The researcher recorded three readings at the same time subsequently of the temperature and humidity and then an average Temperature and Humidity were calculated.

iv. The Level of Noise produced by the Marble Tile Cutting Workstation was measured with the help of Noise meter (Model: Lutron SL-4001) he Noise Meter was placed near the working station. The average reading regarding noise was taken by the noise meter at the same time subsequently one after another on an observation sheet by the researcher personally.

v. The Vibration produced by the Marble Tile Cutting Workstation was measured with the help of Vibrometer. The researcher

identified the areas on machines where the workers most come in contact to those areas were measured using vibrometer VIB 6.142R - VIBXpert II VIB 5.310. The areas of the Marble Tile Cutting Workstation where the vibration was measured are the Pulley, the Marble slab away from the marble Cutter, on the Wooden bar of the Counter, on the floor.

- **Data collection regarding Perceived Musculoskeletal Pain**

The data regarding perceived musculoskeletal pain were collected by asking the respondents about the exact points of the pain experienced by them on the exact body parts depicted on a Body Map shown to them. The various body movements such has rotating of neck, moving wrist up and down were demonstrated to each respondent for their correct responses.

- **Data collection regarding Postural Discomfort**

The respondents who were found to have more musculoskeletal pain were selected. The video recording of selected 50 respondents while working were recorded for detailed Ergonomic Postural Analysis. On an average the video recording for one respondents was of 15 minutes.

- **Data collection regarding Physiological cost of work**

The Heart Rate Monitor (Omron Heart Rate Monitor HEM 6161 Model) was used to measure the heart rate stresses during the activity. Based on the records of heart rate monitor, total cardiac cost of work (TCCW) and energy expenditure for the activities, inferences were drawn by using the formula.

- **Data Analysis**

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

- **Data Categorization:** The data was categorized to enable the researcher to analyze the data further for statistical application.
- **Coding:** Code numbers were given to each response then the

information from each interview schedule and observation sheet were transferred on a coding sheet.

- **Tabulation:** 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 coded data of the present research were tabulated to arrive at tables that were required for describing the data.

- **Statistical Analysis:** 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 and chi square were carried out to test the hypotheses postulated for the study.

Table 1: Relational statistics applied to test the hypotheses

Test	Variables
(ANOVA) F-test	Personal Variables (Age and Perceived Health Status), Situational Variables (Years of Working Experience and) **with** Perceived Musculoskeletal Pain Physiological Cost of Work Perceived Fatigue
t - test	Environment of the Workplace (Light and Noise) **with** Perceived Musculoskeletal Pain Physiological Cost of Work Perceived Fatigue
Chi Square	Physiological Cost of Work **with** Perceived Fatigue
	Physiological Cost of Work **with** Perceived Musculoskeletal Pain
	Perceived Fatigue **with** Perceived Musculoskeletal Pain.

Ergonomic Intervention Programme

An ergonomic intervention programme is designed for educating the owners of the industry and the marble cutting workers regarding maintaining appropriate posture while working for example while lifting marble, while cutting the marble on the machine and others. Preparation of teaching aids like flash cards, banners and live demonstartion for disseminating information regarding the use of protective aids like ear buds, protective gloves, protective boots etc. is under process.

MAJOR FINDINGS

The findings of the present investigation as obtained after the analysis of the data collected through the survey are described as follows

A. Demographic Profile

- The mean age of the respondents was 36.77 years at the time of data collection.
- The respondents with Primary Education (upto 5th standard) slightly succeeded in percentage (34.09 per cent) as compared to the ones who pursued Secondary Education (upto 10th standard) (32.73 per cent).
- The higher percentage of the respondents (41.36 per cent) had a work experience in the range of 11 – 15 years as compared to 38.18 per cent of the respondents who had total work experience in the range of 5 to 10 years.
- Majority of the respondents (97.27 per cent) were right handed depicting that their right hand was dominant while carrying out any activity.
- The feeling of Physical Wellness in general among the higher percentage of the respondents (57.73 per cent) were found to be “Very Good” ‘before the start of their work’ as compared to “during work” and ‘after their work’. A very minimal percentage of the respondents (4.54 per cent) reported to experience a feeling of their physical wellness as “Poor” during work and after completion of their work.

1. Anthropometric data of the Respondents

- The mean height of the respondents was recorded as 67.09 inches.
- The mean forearm length of the respondents was measured as 16.33 inches.
- Their mean vertical maximum reach was recorded as 63.14 inches and horizontal maximum reach as 23.92 inches.

2. Dimensions of the Workstation

- The height of the workstation was 34.5 inches which was reported to be according to the recommended height as per OSHA. According to OSHA guidelines 2018, for heavy work and demanding downward forces the work height should be 8-15 inches below elbow height. The present workstation was reported to be 13 inches below the (95^{th} percentile was 45.67 inches) elbow height of the respondents. Thus, there were no recommendations in changing the work height of the workstation of the respondents.

- The width of the workstation on which the respondents worked was 43 inches which was designed to fit larger size of marble of 53x30 inches. it was also found to be appropriate according to the large size of the marble.

- The length of the workstation was 77 inches for fitting to the length of the marble and thus aid in smooth running of the machine and less wastage of the marble which was also found to be appropriate as per the size of the marble.

B. Postural Discomfort

Based on the REBA scores obtained by the respondents, it was observed that majority of the respondents (74 per cent) were at high risk of Musculoskeletal Disorder. Very few respondents (14 per cent) were found to be at a very High risk. Thus, an intervention program is designed to impart knowledge regarding maintaining posture and use of protective aids to reduce Musculoskeletal Pain and Postural Discomfort.

C. Perceived Musculoskeletal Pain

The subjective data regarding the perceived musculoskeletal pain in various body parts namely neck, shoulder, arms, elbows, wrists, palms, back, hips, thighs, knees, feet and ankles experienced since the past 7 days and 12 months while performing their task of cutting tiles from the marble slabs are described as follows:

- **Neck**
    - Nearly more than one-tenth of the respondents (14.55 per cent) in movements of their neck while pursuing their task of cutting marbles in the past 7 days depicted that more pain was experienced by the respondents while rotating their neck clockwise and anticlockwise as compared to the other neck movements.
    - More than one-half of the respondents (54.54 per cent) were found to be experiencing musculoskeletal pain while moving their neck upwards in the past 12 months.
- **Shoulder**
    - Pain in the left shoulder was experienced by 14.55 per cent while lifting the marble slab which could be due to inflammation of the shoulder muscles in the past 7 days.
    - Two-third of the respondents (63.64 per cent) experienced pain in the right shoulder while carrying the marble slab and while rotating the shoulder clockwise in the past 12 months.
- **Elbow**
    - Nearly one-tenth of the respondents (10.91 per cent) were found to be experiencing pain in the right elbow while at rest in the past 7 days.
    - More than one-half of the respondents (59.09 per cent) were facing pain while doing supination movement (i.e. while doing a movement of tightening a screw) in the past 12 months.
- **Wrist**
    - One-tenth of the respondents (10.00 per cent) experienced pain while resting in their right wrist in the past 7 days
    - More than one-half of the respondents (53.64 per cent)

experienced pain in the right wrist while rotating it clockwise in the past 12 months.

- **Arms**
    - Slightly less than one-tenth of the respondents (9.09 per cent) experienced pain in their left and right forearms while carrying the marble slab in the past 7 days.
    - Nearly two-third of the respondents (62.27 per cent) experienced pain in their right forearm while carrying the marble slab in the past 12 months.
- **Palms**
    - One-tenth of the respondents (7.27 per cent) experienced pain in their right and left fingers while grasping the marble slab in the past 7 days.
    - Majority of the respondents (68.18 per cent) experienced pain in their right hand fingers while gripping and grasping the marble slab and tile in the past 12 months.
- **Back**
    - One-tenth of the respondents (10 per cent) experienced pain in their upper back and lower back while carrying weight, while bending down and while keeping the marble slab on the surface of the workstation respectively in the past 7 days.
    - Majority of the respondents (86.36 per cent) were found to be experiencing pain in their lower back while keeping the marble on the surface of the workstation and while carrying the marble slab in the past 12 months.
- **Hip**
    - Slightly less than one-tenth of the respondents (7.27 per cent) experienced pain in their right and left side of the hip while sitting

on a chair in the past 7 days.

- Pain in the right side of the hip while sitting on a chair was experienced by 20.91 per cent of the respondents in the past 12 months.

- **Knee**

  - One-tenth of the respondents (10.00 per cent) experienced pain in the left knee while resting in the past 7 days.

  - Slightly less than three-fourth of the respondents (72.73 per cent) were experiencing pain in the right knee while carrying the marble slab in the past 12 months.

- **Thighs**

  - Slightly less than one-tenth of the respondents (8.18 per cent) were found to be experiencing pain while carrying the marble slab on both thighs in the past 7 days.

  - Slightly less than one-half of the respondents (45.45 per cent) were found to be experiencing pain in their right thigh while sitting in squatting position in the past 12 months.

- **Leg**

  - Very few respondents (4.55 per cent) experienced pain in the right leg while carrying the marble slab in the past 7 days.

  - Slightly one-half of the respondents (50.91 per cent) were found to be experiencing pain while carrying the marble slab in their right leg in the past 12 months.

- **Feet**

  - Very few respondents (4.55 per cent) were found to be facing pain while carrying the marble slab in both feet in the past 7 days.

  - Pain in the right feet was experienced by 29.55 per cent while

carrying the marble slab indicating that carrying weight induced pressure on the feet of the workers in the past 12 months.

- **Ankle**

    - Very few respondents (8.18 per cent) of the respondents were found to be experiencing pain in their right ankle while sitting in a squatting position and in left ankle while carrying the weight in the past 7 days.

    - Slightly more than one-half of the workers (54.55 per cent) experienced pain in right ankle while sitting in squatting position in the past 12 months.

- Thus, it can be concluded that the pain in the shoulder of the respondents was highest as perceived by them in the past seven days followed by elbows and back. The analysis of the findings regarding perceived musculoskeletal pain in the past 12 months revealed that back was ranked highest followed by pain in the palms and shoulder of the respondents.

Environment of the Workplace

- The workstation of cutting the marble had natural lighting; the marble cutting machine was placed under a heighted roof (14 feet) and was open from all sides. The working unit had no doors and was an open shed from all four sides.

- Less than two-third of the industries (62.86 per cent) had intensity of light below recommended levels (1000 Lux).

- The lowest measurement of noise produced by the machinery was 93 db and the highest was 112 db. Slightly less than one-half of the industries (44.28 per cent) was found to be producing very high noise (107-112db) while the machine was functioning.

- Majority of the industries (65.71 per cent) had humidity ranging

from 33-37 per cent.

- Nearly two-third of industries (65.71 per cent) were having temperature ranging from 36-38 ^{o}C. The researcher also found that 28.57 per cent of marble cutting industries had temperature ranging from 39–41 ^{o}C. The researcher also observed that the workers used to get exhausted soon due to such high temperatures. Although, the working area gets cool while working since the marble is cut with continuous flow of water, thus aiding in reducing the heat stress. According to Sanders and McCormick (2013) productivity of work is maintained upto 28 ^{o}C and then it begins to drop with the increase of temperature.

- The data of the environment was also collected with the aid of modified checklist on the various ergonomic aspects with the help of modified PMO Ergonomic checklist. There were two aspects covered in this section. The first aspect was related to the training provided to the respondents by the industries. The second aspect was regarding the provision of rest breaks and protective aids provided for hands and excessive noise by the industry to the workers. The findings highlighted that

    - Majority of the respondents were not given any training for vibration (80.91 per cent) and for maintaining posture (72.73 per cent).
    - Slightly less than on-half of the respondents (49.09 per cent) were provided training for repetition of work.
    - Majority of the respondents (76.36 per cent) were provided training concerning the use of tools.
    - Similarly, slightly more than one-half of respondents (59.54 per cent) were found to be trained regarding performing jobs to decrease injuries.
    - Majority of the workers (81.82 per cent) were not provided any rest breaks to relieve stress from repetitive motions.

- Majority of the respondents (90.91 per cent) were not using anything for protecting their hands.

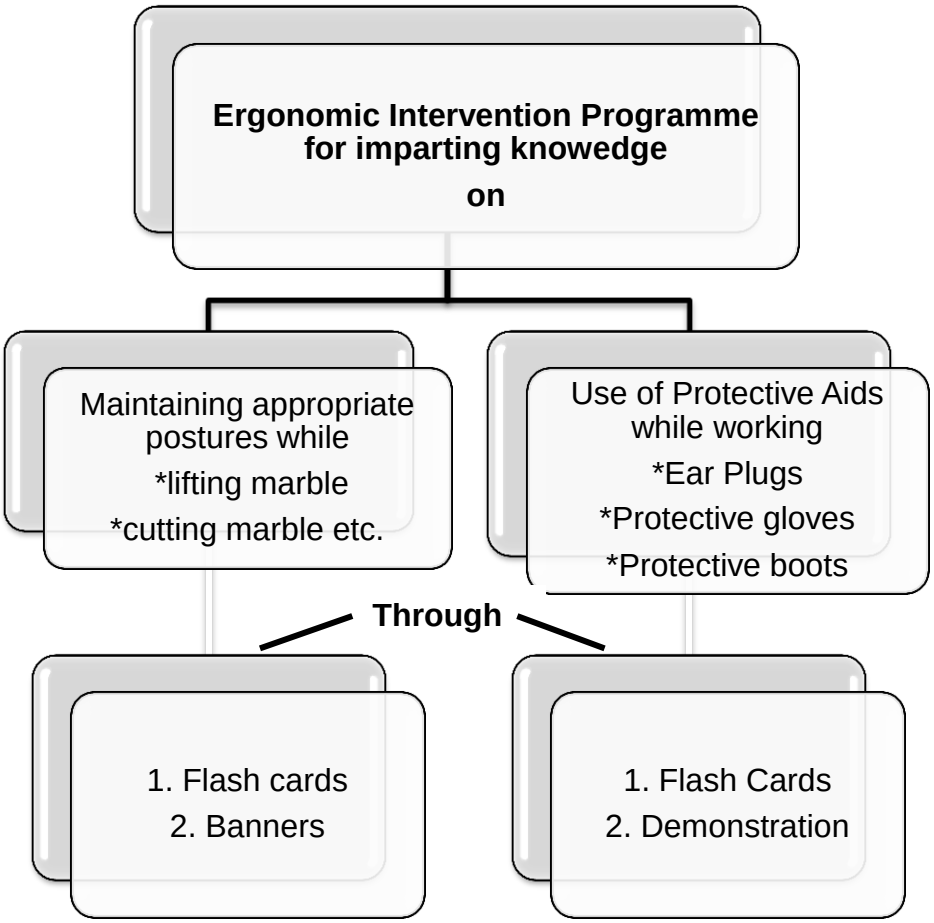
- Thus, it can be concluded that the majority workers did not have appropriate environment to work as they were not provided any training regarding reducing the effect of noise, repetition of work, maintaining appropriate postures. Thus, the intervention programme is designed to impart knowledge regarding maintaining posture and use of protective aids.

Perceived Fatigue and Physiological Workload

- Out of the two categories of Level of Fatigue almost one-half of the respondents (50.45 per cent) were found to be severely fatigued.

- The physiological workload of slightly less than two-third of the respondents (61.82 per cent) was found to be moderately heavy while performing their task. The physiological workload was recorded heavy of 34.54 per cent respondents whereas very few respondents (3.64 per cent) physiological workload was found to be as light for the task performed by them. This could be that their muscles are accustomed for the task.

INTERVENTION PROGRAMME



HYPOTHESES

The findings of hypotheses will be discussed in the thesis at the time of submission.

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