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An Ergonomics Study on Posture-Related Discomfort and Occupational-Related Disorders Among Stonecutters of West Bengal, India

Somnath Gangopadhyay
Banibrata Das
Tamal Das
Goutam Ghoshal
Tirthankar Ghosh

University College of Science & Technology, University of Calcutta, Kolkata, India

Stonecutting and setting are important tasks in a construction site. A field study was conducted to assess occupational-related disorders and to conduct ergonomics assessment among stonecutters. The study focused on (a) the duration of work per day, (b) the working environment and working activities and (c) the feeling of discomfort in different parts of the body. A detailed posture analysis was performed with the Ovako working posture analysis system (OWAS). It was observed that stonecutters worked continuously in awkward postures during stonecutting and setting. Consequently, they suffered from discomfort in different parts of their body, specifically in the lower back, knees and shoulders, which mainly prevented them from continuing their work. This study also revealed that stonecutters had to work in congested work areas with a poor level of illumination. The noise level and dust particles emitted during stonecutting activities could affect stonecutters.

stonecutters OWAS posture-related discomfort posture

1. INTRODUCTION

In urban parts of India, stonecutters and setters are mainly involved in stone and marble cutting, and setting them on the floors and walls of single- and multistorey, domestic and commercial buildings. These stone or marble setters are also known as stone grinders, because when building various kinds of buildings, the stone or tile setters grind and cut the tiles, marble and stone. Thus, stonecutting and setting stone on the floor are important parts of the masonry and construction trades.

The construction industry covers a wide range of work, from everyday things like constructing buildings, installing windows to fitting stone on floors. Stonemasons help to restore and repair old buildings, and also cut and shape stone for new buildings. Work-related musculoskeletal disorders (MSD) are common in masonry trades, in which stonemasons suffer from discomfort in the lower back, shoulders and their upper extremities. Stonemason's tenders report a high prevalence of work-related MSD [1].

Stonemasons proved physical overload to be a principal factor responsible for occupational diseases. The physical overload is associated with prevalent manual tasks, frequent monotonous movements, lifting and manual handling of heavy loads during the working shift, uncomfortable working postures, which lead to occupational disorders [2].

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Correspondence and requests for offprints should be sent to Banibrata Das, 100 Biplabi Ganesh Ghosh Sarani, Bhadrakali, DT-Hooghly, PIN-712232, West Bengal, India. E-mail: <aamibani@yahoo.com>.

The aim of the present investigation was to assess the prevalence of MSD among male stonecutters of West Bengal, India, and also to assess postural strain associated with normal working postures during stonecutting and setting activities. The stonecutters and setters are also exposed to different unfavorable working conditions during cutting and setting stone or marble. In the present study, investigators tried to indentify the different unfavorable working condition of stonecutters.

2. MATERIALS AND METHODS

2.1. Selection of Subjects

There were 60 male experimental subjects (stonecutters) in this study. Sixty male restaurant bearers, not working in awkward postures for prolonged periods, were selected as a control group from the urban sector of West Bengal. The experimental subjects were engaged in different stonecutting and setting activities in the construction site. The experimental subjects (stonecutters and setters) were divided into three groups according to their age (A: 18–30; B: 31–40 and C: 41–52 years old). The control group consisted of physically and mentally healthy individuals mainly involved in different activities like serving tea or coffee and food to customers in a restaurant; they were also classified into three groups according to their age (A: 18–30; B: 31–40 and C: 41–52 years old). Thus, both groups were aged 18–52.

2.2. Physical Parameters

The height and weight of the stonecutters and the control group were measured with a Martin anthropometer (Takei, Japan) and Crown weighing machine (Raymon Surgical, India) respectively. The body surface area (BSA) [3] and the body mass index (BMI) [4] of all the subjects were also computed.

2.3. Questionnaire

A modified Nordic questionnaire was administered to the subjects [5]. The questionnaire consisted of a series of objective questions with multiple-choice responses.

2.4. Worksite

The stonecutters' worksite of was analyzed with an OSHA ergonomics checklist [6]. The checklist helped to assess the worksite with respect to the demands placed on the stonecutters by their jobs.

2.5. Working Environment

The stonecutters' working environment was assessed. The wet bulb globe temperature (WBGT) index was calculated [7]. Mean globe temperature, and wet and dry bulb temperatures were recorded. The formula for calculating the WBGT index for indoor conditions is

$$WBGT_{indoor} = 0.7 \bullet NWB + 0.3 \bullet GT,$$

where NWB—natural wet bulb and GT—globe temperature. Relative humidity was also estimated from a psychometric chart developed by Weksler Instrument (USA) [8]. A sound level meter manufactured by Lutron Electronics Enterprise (Taiwan) was used; it was kept 4 m from the source of sound and 1 m above the ground to record the noise level generated during stonecutting.

The illumination level of the different areas in two worksites (indoor and outdoor) was also measured. A Lux meter (Lutron) was used.

2.6. Stonecutters' Work Activities

At the beginning of their work, stonecutters measured the dimensions of the marble or stone tiles with a measuring tape so they would fit the dimensions of the floor. The second step was to cut the stone or marble with a small portable machine in an awkward posture for a prolonged period. In the last phase of the process these tiles were set according to the size of the floor of the building.

2.7. Analysis of Working Posture

The different working postures of the marble setters were analyzed with the Ovako working posture analysis system (OWAS) [9] and digital

photography (Sony Handycam 360X, Japan). Later stick diagrams were drawn from frozen-frame video recordings and eventually they were analyzed. The most frequent postures adopted by the workers were considered.

2.8. Measurement of Peak Expiratory Flow Rate (PEFR)

Measurement of PEFR was done with a Wright's mini peak flow meter (Clement Clarke, UK). Prior to recording, the use of the instrument was repeatedly demonstrated and explained. The PEFR test was performed in a standing position with the peak flow meter held horizontally. The subjects were asked to take the deepest breath possible and then to blow as hard and as quickly as possible. The highest of the three ratings was recorded.

2.9. Statistical Analysis

Student's *t* test was performed between the two groups of workers to find out whether there was any significant difference between the PEFR of the experimental and the control groups. A two-tail χ^2 test of independence was used to determine whether a test item had any significant association with the response (feeling of discomfort or no feeling of discomfort). The computed χ^2 values were then compared with critical χ^2 values for the chosen level of significance ($p < .05$) [10].

3. RESULTS

Table 1 shows the mean values of age and physical parameters (height, weight, BSA and BMI) of the stonecutters and the control group.

TABLE 1. Physical Characteristics of Stonecutters (*n* = 60) and the Control Group (*n* = 60)

	Stonecutters		Control Group		
Characteristics	***M***	***SD***	***M***	***SD***	***t***
Age (years)	33.9	10.56	34.2	10.28	0.13
Height (cm)	160.4	5.00	159.63	5.78	0.80
Weight (kg)	52.0	10.34	50.93	12.29	0.93
BSA (m^2)	1.58233	1.59	1.56153	1.93	0.63
BMI (kg/m^2)	20.1	3.37	19.8	3.79	0.46

Notes. BSA—body surface area, BMI—body mass index. No values are statistically significant.

The present investigation showed that stonecutters had to work in unfavorable working conditions. The average value of the indoor WBGT index of the worksite was 31.9 °C, with a relative humidity of 59%. The average noise level was 110 dB(*A*) during stone or marble cutting. Moreover, the heavy stone dust emitted could affect stonecutters. As the stonecutters were generally from lower socioeconomic groups, to earn more money, sometimes they worked at night in poor illumination conditions (*M* 14.29 lx).

Table 2 shows the mean duration of work per day (7.8 h) and the number of working days in a week. Table 3 illustrates the mean number of working days per week per age group, with days frequently lost due to discomfort in different parts of the body. Table 4 compares the number of stonecutters, who had to perform many manual tasks in different awkward postures for prolonged periods, with the number of control subjects experiencing discomfort.

TABLE 2. Mean Duration of Work per Day and Average Number of Working Days per Week

	Work per Day (h)		Working Days
Type of Work	***M***	***SD***	**per Week**
Stonecutting	3.7	0.44	7
Stone setting	4.1	0.50	7

TABLE 3. Average Number of Working Days and Average Number of Working Days Lost by Different Age Groups of Stonecutters

Age Group	Average Number of Working Days per Week	Average Number of Working Days Lost per Week
A	6	1
B	5	2
C	4	3

Notes. A—18–30 years old, B—31–40 years old, C—41–52 years old.

TABLE 4. The Feeling of Discomfort Among Stonecutters (*n* = 60) and the Control Group (*n* = 60)

Subjects	Subjects With Discomfort (%)
Stonecutters	53 (88)
Control group	3 (5)

Further analysis of the questionnaire revealed that an alarming proportion of the subjects

suffered from occupation-related discomfort mostly affecting the lower back (97%), knees (85%) and shoulders (77%) (Table 5). The questionnaire study also showed that in the experimental group (stonecutters) 67% of the subjects experienced discomfort in the hands and 58% of the subjects suffered from discomfort in the wrists. The extreme parts of the upper extremities, i.e., the hands were found to be the affected parts of the experimental subjects' bodies. The upper back and legs also affected the experimental group. Forty-seven percent of the subjects felt discomfort in the upper back and 43% of the experimental group felt discomfort in the legs.

Table 6 shows that statistically significant feeling of discomfort was found in all groups of stonecutters and in the control group in the shoulders, lower back and knees. So, it was clear that the shoulders, lower back and knees were the regions of the body which mainly affected most stonecutters. It was also observed that, among the

TABLE 5. The Feeling of Discomfort in Different Body Parts Among Stonecutters and the Control Group

Subjects	Age Group	*n*	Neck	Shoulders	Wrists	Elbows	Hands	Upper Back	Lower Back	Knees	Feet	Legs
Stonecutters	A	25	0	15 (60)	10 (40)	0	12 (48)	0	23 (92)	16 (64)	0	3 (12)
	B	15	8 (53)	11 (73)	7 (70)	3 (30)	8 (53)	9 (60)	15 (100)	15 (100)	2 (13)	6 (40)
	C	20	11 (55)	20 (100)	18 (90)	9 (45)	20 (100)	19 (95)	20 (100)	20 (100)	15 (75)	17 (85)
Control group	A	25	0	1 (4)	0	0	2 (8)	0	3 (12)	2 (8)	0	0
	B	15	1 (7)	1 (7)	0	0	0	2 (13)	4 (27)	3 (20)	0	0
	C	20	2 (10)	0	1 (5)	0	0	2 (10)	3 (15)	3 (15)	0	0

Notes. A—18–30 years old, B—31–40 years old, C—41–52 years old. Percentage of total number of subjects in parentheses.

TABLE 6. Association of the Feeling of Discomfort and No Discomfort Among Stonecutters and the Control Group in Different Age Groups

Body Parts	Age Group	Subjects	Subjects With No Discomfort	Subjects With Discomfort	Total a+b	c+d	*N*	b+d	a+c	χ^2	Significance
Neck	A	stonecutters	25 (b)	0 (a)	25	25	50	50	0	0	*ns*
		control group	25 (d)	0 (c)							
	B	stonecutters	7 (b)	8 (a)	15	15	30	21	9	7.77	*ns*
		control group	14 (d)	1 (c)							
	C	stonecutters	9 (b)	11 (a)	20	20	40	27	13	10.28	*ns*
		control group	18 (d)	2 (c)							
Shoulder	A	stonecutters	10 (b)	15 (a)	25	25	50	34	16	18.01	$p < .001$
		control group	24 (d)	1 (c)							
	B	stonecutters	4 (b)	11 (a)	15	15	30	18	12	13.88	$p < .001$
		control group	14 (d)	1 (c)							
	C	stonecutters	0 (b)	20 (a)	20	2200	40	20	20	40.00	$p < .001$
		control group	20 (d)	0 (c)							
Wrists	A	stonecutters	15 (b)	10 (a)	25	25	50	40	10	2.00	*ns*
		control group	25 (d)	0 (c)							
	B	stonecutters	8 (b)	7 (a)	15	15	30	23	7	9.13	*ns*
		control group	15 (d)	0 (c)							
	C	stonecutters	2 (b)	18 (a)	20	20	40	21	19	28.97	$p < .001$
		control group	19 (d)	1 (c)							

Notes. A—18–30 years old, B—31–40 years old, C—41–52 years old; a, b, c, d—cells.

TABLE 6. (*continued*)

Body Parts	Age Group	Subjects	Subjects With No Discomfort	Subjects With Discomfort	Total a+b	c+d	*N*	b+d	a+c	χ^2	Significance
Elbows	A	stonecutters	25 (b)	0 (a)	25	25	50	50	0	0	*ns*
		control group	25 (d)	0 (c)							
	B	stonecutters	12 (b)	3 (a)	15	15	30	27	3	3.33	*ns*
		control group	15 (d)	0 (c)							
	C	stonecutters	11 (b)	9 (a)	20	20	40	31	9	11.61	$p < .001$
		control group	20 (d)	0 (c)							
Hands	A	stonecutters	13 (b)	12 (a)	25	25	50	36	14	9.92	*ns*
		control group	23 (d)	2 (c)							
	B	stonecutters	7 (b)	8 (a)	15	15	30	22	8	10.90	$p < .001$
		control group	15 (d)	0 (c)							
	C	stonecutters	0 (b)	20 (a)	20	20	40	20	20	40.00	$p < .001$
		control group	20 (d)	0 (c)							
Upper back	A	stonecutters	25 (b)	0 (a)	25	25	50	50	0	0	*ns*
		control group	25 (d)	0 (c)							
	B	stonecutters	6 (b)	9 (a)	15	15	30	19	11	7.03	*ns*
		control group	13 (d)	(2 c)							
	C	stonecutters	1 (b)	19 (a)	20	20	40	19	21	28.97	$p < .001$
		control group	18 (d)	(2 c)							
Lower back	A	stonecutters	2 (b)	23 (a)	25	25	50	24	26	32.05	$p < .001$
		control group	22 (d)	3 (c)							
	B	stonecutters	0(b)	15 (a)	15	15	30	11	19	17.36	$p < .001$
		control group	11 (d)	4 (c)							
	C	stonecutters	0 (b)	20(a)	20	20	40	17	23	29.56	$p < .001$
		control group	17 (d)	3 (c)							
Knee	A	stonecutters	9(b)	16 (a)	25	25	50	32	18	17.01	$p < .001$
		control group	23 (d)	2 (c)							
	B	stonecutters	0 (b)	15 (a)	15	15	30	12	18	20.00	$p < .001$
		control group	12 (d)	3 (c)							
	C	stonecutters	0 (b)	20 (a)	20	20	40	17	23	29.56	$p < .001$
		control group	17 (d)	3 (c)							
Feet	A	stonecutters	25 (b)	0 (a)	25	25	50	50	0	0	*ns*
		control group	25 (d)	(c)							
	B	stonecutters	13 (b)	3 (a)	15	15	30	28	2	2.14	*ns*
		control group	15 (d)	0 (c)							
	C	stonecutters	5 (b)	15 (a)	20	20	40	25	15	24.00	$p < .001$
		control group	20 (d)	0 (c)							
Legs	A	stonecutters	22 (b)	3 (a)	25	25	50	47	3	3.19	*ns*
		control group	25 (d)	0 (c)							
	B	stonecutters	9 (b)	6 (a)	15	15	30	24	6	7.50	*ns*
		control group	15 (d)	0 (c)							
	C	stonecutters	3 (b)	17 (a)	20	20	40	23	17	29.56	$p < .001$
		control group	20 (d)	0 (c)							

Notes. A—18–30 years old, B—31–40 years old, C—41–52 years old; a, b, c, d—cells.

entire group, group C (41–52 years old) of the experimental subjects experienced statistically significant discomfort compared to the control group in all body parts except the neck (Table 6).

TABLE 7. Feeling of Discomfort Experienced at Different Times by the Stonecutters (n = 60)

			Discomfort			
Age Group	n	Subjects Affected	At Work	After Work	During Sleep	24 h After Work
A	25	18 (72)	0	2 (11)	11 (61)	5 (28)
B	15	15 (100)	1 (7)	3 (20)	8 (53)	3 (20)
C	20	20 (100)	2 (10)	3 (15)	10 (50)	5 (25)

Notes. A—18–30 years old, B—31–40 years old, C—41–52 years old. Percentage of the total number of subjects in parentheses.

It is evident that most workers in the experimental group felt discomfort during sleep at night and a large proportion also felt discomfort throughout the day (Table 7).

In this study the overall average rated perceived exertion (RPE) among the experimental subjects was 6.5. Figure 1 illustrates the average RPE for the three age groups.

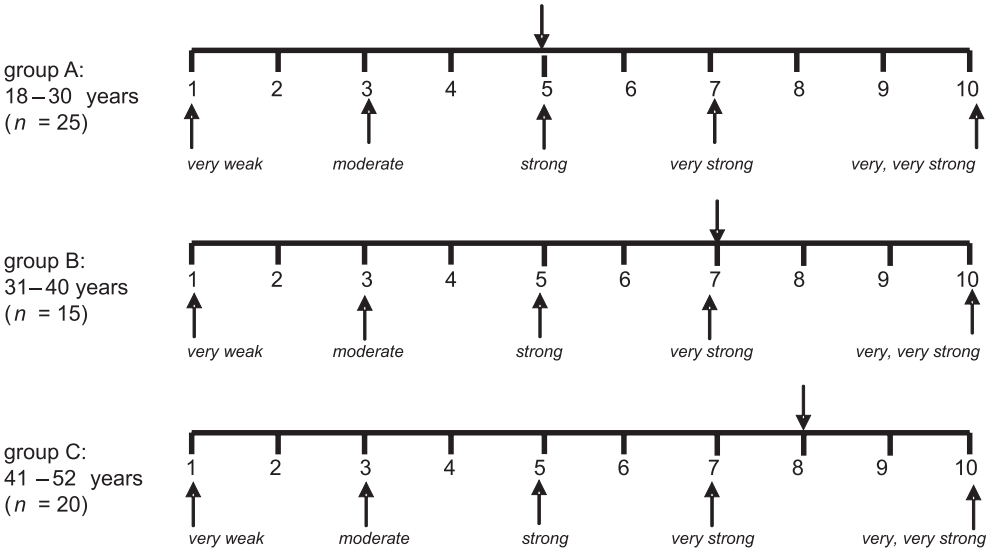


Figure 1. Feeling of discomfort according to Borg's rated perceived exertion (RPE) scale [24]. *Notes.* Computed F ratio = 151.76. As the computed F is higher than critical F for $p < .001$, it is significant at $p < .001$. So there is a significant added variance component (s_a^2) between the 3 age groups.

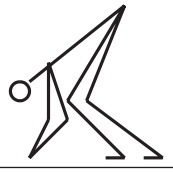
Activity	Posture	Duration	Frequency	Code	Action Category	Remarks
stone & tile cutting	 bent forward, both arms below shoulder level, legs bent forward, weight or force needed >20 kg	average 3.7 h/day	21 times/h	2123	3	corrective measures as soon as possible
stone & tile setting	 back bent forward, both arms below shoulder level, both knees bent, weight or force needed ≤20 kg	average 2.5 h/day	tile setting: 17 times/h stone setting: 11 times/h	2143	3	corrective measures as soon as possible
	 bent forward, both arms below shoulder level, legs bent forward, weight or force needed ≤10 kg	average 1.6 h/day	tile setting: 19 times/h stone setting: 13 times/h	2121	2	corrective measures in near future

Figure 2. Analysis of the stonecutters' working posture.

TABLE 8. Difference in the Peak Expiratory Flow Rate (PEFR) of Stonecutters and the Control Group

			PEFR		
Age Group	Subjects	*n*	*M*	*SD*	*t*
A	stonecutters	25	496	16.49	14.80
	control group	25	567	16.85	
B	stonecutters	15	468	4.00	40.96
	control group	15	536	4.89	
C	stonecutters	20	440	10.00	17.42
	control group	20	509	14.10	

Notes. Only statistically significant differences are reported ($p < .001$). A—18–30 years old, B—31–40 years old, C—41–52 years old.

An analysis of the stonecutters' working postures revealed that most working postures were highly risky and corrective measures were required as soon as possible (as indicated by OWAS) (Figure 2). The stonecutters frequently adopted those types of working postures; consequently, they often suffered from discomfort especially in their upper extremities and the lower back.

Table 8 compares the peak expiratory flow rate (PEFR) of the experimental group (stonecutters) and the control group. It is evident that the mean values of PEFR of stonecutters were lower than those of the control group and that PEFR differed significantly ($p < .01$) among both groups.

4. DISCUSSION

The prevalence of occupational health hazards has been reported as high among people of India. In this study it is evident that stonecutters and the control group had no significant relationship in terms of age, height, weight, BSA or BMI. So, in this study both groups of subjects were standardized in terms of age, height, weight, BSA and BMI. The result of the study also revealed that the stonecutters (experimental group) were engaged in rigorous hand-intensive jobs for many years, whereas the control group was not involved in such type of work.

From the observation of the working conditions of the unorganized sector, it was evident that the experimental subjects (stonecutters) had to work in a congested and poorly illuminated (14.29 lx) work area because most of the working areas were inside the house, where the illumination level was insufficient. Not only that, the noise level during cutting the stone or marble in the working area was also very high (110 dB(*A*)) which could affect the stonecutters (experimental subjects).

This study revealed that stonecutters and setters suffered from discomfort in different parts of the body, especially in the lower back, knees and upper extremities. This result was mainly supported by Goldsheyder, Nordin, Weiner, et al. [11]. According to them, mason's tenders experienced a high prevalence of lower back pain (LBP). They also added that LBP constituted a major problem in construction trades. According to Pope, back and lower limb disorders occurred disproportionately frequently among construction trades [12].

This study revealed that stonecutters and setters felt discomfort in their knees due kneeling for prolonged periods. Jensen, Mikkelsen, Loft, et al. support this result [13]. According to Jensen et al., prevalence of knee disorders in some occupations was possibly related to kneeling working postures [13]. Jensen also stated that the prevalence of self-reported knee-complaints were positively associated with the amount of knee-straining work [14]. Knee complaints among floor layers predicted exclusion from the trade [15].

This study can be attributed to their working in an awkward and knelling posture for a prolonged period of time with a repetitiveness of the work among stonecutters and setters. This result corroborated the studies of Garg [16], Gangopadhyay, Ray, Das, et al. [17] and Gangopadhyay, Das, Das, et al. [18]. According to Garg, severe discomfort or pain was due to heavy spinal loading and repetitive movement

of body parts over an extended period [16]. The feeling of discomfort (pain) in different parts of the body among the workers may be due to their prolonged working hours and repetitiveness of the work; which may lead to MSD [17]. Gangopadhyay et al. also showed previously that continuous bending posture, led workers to suffer from acute pain and discomfort for a long period of time, which mainly led to severe pain and MSD [18]. Sturmer, Luessenhoop, Neth, et al. also concluded that repetitive strain in forced positions during long periods was a risk factor for lower back disorder [19].

This study also showed that group A (18–30 years old) of both groups suffered less discomfort than the other groups of the study (Table 6). This research mainly revealed that group C (41–52 years old) suffered most from discomfort in different parts of the body. This study also indicates that group C (41–52 years old) of the experimental subjects had a significant change in the feeling of discomfort compared with group C (41–52 years old) of the control group in all parts of the body (except the neck). This may be due to the fact that the experimental subjects of this age (group C) could not minimize the forces exerted during stonecutting and setting activities in that particular posture. Moreover, the length of the time that the posture was held by group C subjects was also a causative factor of the feeling of discomfort. This result was supported by Rosecrance, Pórszász, Cook, et al., according to whom work in a static, awkward posture was a causative factor for MSD [20]. They also added that MSD was more prevalent among experienced construction workers.

This study also showed that the shoulders, knees and lower back were the regions in which significant changes were observed in the feeling of discomfort between entire groups (A, B and C) of both experimental and control groups (Table 6). This mainly indicates that during stonecutting, the shoulders are most affected due to the vibration of portable stonecutting machines. Ludewig and Borstad also concluded that repetitive or sustained elevated shoulder postures were identified as a significant risk factor for occupationally-related shoulder MSD [21]. The stonecutters' lower back and knees were also seriously affected due to prolonged and awkward posture during work. This result corroborates the work of Merlino, Rosecrance, Anton, et al.; according to them the lower back was the site most commonly reported for job-related musculoskeletal symptoms [22].

Stone or marble grinders generally adopted different types of posture for prolonged periods during specific operation like cutting and setting stone or marble. Awkward and static working postures were the two factors that contributed most to MSD symptoms. Although disorders of the musculoskeletal system are more prevalent among experienced construction workers, this study indicated that MSD symptoms were present among young construction workers, too [20]. According to Holmström and Engholm, construction workers had higher age-adjusted prevalence of MSD [23].

This study showed that although the workers in the experimental group felt discomfort for 24 h, a greater percentage suffered during sleep at night than during and after work. Thus, it can be assumed that stonecutters's work is extremely intense. As a consequence the feeling of discomfort not only prevails during work but it also persists during the rest periods and up to the whole day.

According to Borg, RPE is an overall integrated configuration of the signals, perceptions and experiences of the body while enduring physical strain [24]. It is not a measure of responses for individual body segments, but rather a subjective judgment about the task and its effects on the body as a whole [25]. Our results on the RPE scale showed that the intensity of discomfort was highest among group C (41–52 years old) (Figure 1). The reason behind this may be that during stonecutting the subjects in this group could not manage the highly repetitive, extended and forceful exertion with a heavy tool. Not only that, during stone setting activities, the aged subjects had to carry heavy stones with both hands and set them on the floor in an awkward posture for a long period.

An analysis of the stonecutters' postures revealed that postures used for stonecutting

and first stone setting activities required some correction as soon as possible, as indicated by OWAS action categories (Figure 2). The workers adopted awkward postures at work, and they often suffered from musculoskeletal complaints and LBP. Thus it was evident that by remaining in awkward postures for prolonged periods, they suffered from discomfort affecting different body parts. This result corroborates the studies of Gangopadhyay, Das, Das, et al. [26] and Gangopadhyay, Das, Ghoshal, et al. [27]. According to Gangopadhyay et al. severe pain and MSD in different parts of the body mainly occur due to constant bending in an awkward and stressful posture for a prolonged period [26, 27]. This result corroborates the studies of Chaffin and Andersson [28] and Leskinen [29]. According to them the amount and quality of forward-bent working postures influenced the compressive forces on the vertebral discs and the erector spinae muscles. Postures, especially severe flexion or lateral twist and bending, were found to be significantly related to LBP [30]. Posture and the location and weight of a load affect the moment of force required in the lumber region, which in turn affects muscle loading and compressive forces on the internal vertebral disc [28, 31]. Thus, this study found that stonecutters were mainly associated with awkward postures which could lead to MSD.

Table 8 also shows that the experimental group (stonecutters) had a lower PEFR than the control group. This result corroborates the studies of Das and Gangopadhyay [32] and Debray, Chattopadhyay, Maity, et al. [33]. They also stated that PEFR was markedly decreased in stonecutters compared to their control groups of healthy subjects. This study was supported by Onizuka, Tanabe, Nakayama, et al. [34]. According to their research, chronic asthma was reported among stonecutters and setters. Yingratanasuk, Seixas, Barnhart, et al. stated in their research that decreased lung function was observed among stonecutters [35].

These studies have some limitations. In this study we were unable to record the workers' initial health status; actually those workers were unorganized. So, there was no possibility to record their health status before they began work.

5. CONCLUSION

From this study it can be concluded that stonecutters work in unfavorable working conditions with a high level of sound (M 110 dB(A)), sometimes at night with a poor average illumination level (M 14.29 lx), with an average indoor WBGT index value of 31.9 °C and with a relative humidity 59%.

A posture analysis 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. Groups B and C of stonecutters were frequently absent 2 and 3 work days per week, respectively. This study also showed that stonecutters felt maximum discomfort during sleep at night and a large proportion also felt discomfort throughout the day. This study also revealed that dust particles emitted during stonecutting could affected lung capacity and thus lower stonecutters' PEFR, whereas the control group remained unaffected.

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