Relation Between Long Term Adoption of Awkward Posture and Work Related Musculo Skeletal Disorders in Pickaxe and Spade Users in China clay mine

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ABSTRACT

Work-related musculoskeletal disorders (WRMSDs) and discomfort rating at different body segments have multifactorial etiology. Literature review evident that gradual onset of WRMSDs and discomfort rating are linked not only with adoption of awkward postures but to duration also.The present study was aimed to correlate the prevalence of lower back disorder, waist disorder and discomfort rating of pickaxe and spade users in china clay mine with postural stress during performing mine tasks.The study was carried out on 180 male china clay mine workers (25 yrs -35 yrs age) of different china clay mines of Birbhum district of West Bengal (India). The workers were performing different types of mine tasks. Lower back disorder, waist disorder and discomfort rating were evaluated by questionnaire method. The postural stresses were studied by direct observation method as well as Ovako Working posture Analysis System (OWAS) employing video-photography.The china clay mine workers were affected in different body segments during work. High prevalence of lower back disorder (>75%), waist disorder (>82%) and severe (6.6) to very severe (>7.2) discomfort rating was predominant in spade and pickaxe users. It was also observed that the frequency of occurrence of disorders in the workers doing pickaxe and spade operation was significantly higher than workers performing all mine tasks ($P<0.001$). Results of postural analysis revealed that china clay mine workers had adopted forward bending and twisting postures for prolonged duration. Analysis of the bent posture shown that the workers performing pickaxe and spade operation had higher (<100°) and moderate (>100° and <120°) degree of bending for a longer duration of time (37.30% and 53.22 % of total duration of work respectively). The rate of major posture change was also higher during those operations. Postural analysis by OWAS method indicated that posture adopted was distinctly harmful and the risk of MSD was significant (action category 3) in the above mentioned tasks. Occurrence of lower back disorder, waist disorder and high discomfort rating among the pickaxe and spade users in china clay mine might be due to adopting long term awkward posture including bend and twist posture along with frequent posture changes.

Key words: Lower Back Disorders, Waist disorders, Discomfort rating, Postural stress, China clay mine

INTRODUCTION

Mining remains an ancient occupation, long recognized as being arduous and liable to injury and disease. Historically, it is viewed as an inherently high-risk industry. It is also an important industrial sector in many parts of India and world. Though substantial progress has been made in the management of occupational health hazards, still there remains some room for further

reduction of risk and risk factors. The lifecycle of mining consists of exploration, mine development, mine operation, decommissioning and land rehabilitation. Earlier studies as well as changing demography in the mining industry have highlighted the need for a comprehensive study programme to be implemented in the mining industry and the issues are anthropometry, workstation design, functional work capacity, work shift cycles, chronic occupational and other diseases as these are some of the important factors affecting the health and safety of miners.

Work related musculo skeletal disorders (WRMSDs) and discomfort rating are common in workers engaged in physical activities. It is highly prevalent among the workers of manually operated industry. The common risks factors associated with mining tasks include forceful exertions [11], awkward postures [17] frequent postural change [34], whole body and segmental vibration [16, 34]. Research has shown that an ergonomics process that identifies risk factors, devises solutions to reduce MSDs and evaluates the effectiveness of the solutions can lower worker exposure to risk factors and MSDs and improve productivity.

Investigations suggested that bending and twisting of back awkwardly and working in same position for longer duration were both significantly associated with prevalence of low back disorder [12, 28, 29, 31]. Other groups of scientist reported that, there is significant association of awkward postures with back pain [4]. Some researchers indexing long term bend posture is the cause of lumbo-spinal strain and intense physical work [2]. Lower back disorder was associated with longer working hours, flexion and trunk rotation.

Large quantities of china clay (popularly known as Kaolin) are mined and traded internationally. There are about 55 countries around the world who have mined China clay [42]. In 2002 India produced 710 Kilo tonnes of processed and saleable china clay [42], which has now been increased to 1291.7 Kilo tonnes (Indian Bureau of Mines, Govt of India, 2010), where as the world production is 30,600 Kilo tonnes (US Geological Survey, Clays, 2010). In India, china clay found in different states like, West Bengal, Rajasthan, Kerala, Tamilnadu, Orissa etc. In West Bengal, Birbhum, Bankura, and Purulia districts are the good reserve sources of kaolin mineral.

Database for the number of workers involved nationally or internationally in china clay mining is not currently available, but it may be said that several thousands of workers are engaged. There are four different mine tasks viz. crowbar operation, pickaxe operation, spade users cum basket loading-lifting and head carrying. Of these the workers of pickaxe operation and spade operation are required to use long adoption of awkward posture.

In India, studies of occupational health stresses in miners are scanty. No studies have been found upon the workers of china clay mine. Very few studies are sporadic on coal miners [8, 32, 38] and other occupations [26].

The present study aimed to correlate the prevalence of lower back disorder, waist disorder

and discomfort rating of pickaxe and spade users in china clay mine with postural stress during performing mine tasks.

METHODS

Site and subject: The study was carried out on 180 male china clay mine workers (25 yrs - 35 yrs age) of different china clay mines of Birbhum district of West Bengal (India). All of them volunteered for the study. None of them have any past history of injury. All mines are manually operated open cast mine having depths of 90-100 feet. The study was approved by the institutional human ethical committee.

Task Performed: Pickaxe operators break the large kaolin lump using pickaxe by repeated forceful stroke, and convert them into the size suitable for loading into the basket. They were also required for clearing of cutting base. The China clay (small pieces) is then loaded into the basket for transportation to the disposal site. This task is performed by spade operators. Generally they loaded the basket using spade. The fully loaded basket is manually lifted to the head carrier. The lifting task is performed by the joint effort of spade operator and base carrier. Thus spade operators perform two tasks - basket loading and lifting.

Evaluation of WRMSD: WRMSDs which were caused in pickaxe operation and spade operation cum basket loading-lifting mine tasks were studied by questionnaire method using modified 'Nordic' questionnaire [23].

Evaluation of Discomfort Rating: Quantification of discomfort level of china clay mine workers was studied to assess the degree of discomfort or pain in different body segment. A 10 point Borg's scale was used for this purpose which was graded from Grade 0 (no pain) to Grade 10 (very severe pain) [6]. The subjects were asked to point out the segments which experience discomfort or pain while performing tasks. The intensity of pain was expressed in words by the workers and those words were rated on the scale.

Evaluation of Postural Stress: The postural stress was evaluated by direct observation method employing video-photography and also by use of postural analysis tool viz. Ovako Working postural Analysis System [18]. The duration of adopting different working postures and frequency of major postural changes during working hours was studied carefully. The workers in the china clay mine had to adopt different postures. Bend posture was further evaluated through subdividing it in Low bend (>120°), Moderate bend (100° to 120°) and Sharp bend (<100°). The degree of bend was assessed by measuring hip angle using goniometer.

RESULTS

According to OSHA, "work-related MSDs currently account for one third of all occupational injuries and illness reported to the Bureau of Labour Statistics (BLS) by employers every year. In the present study the prevalence of Lower back disorder (LBD) and Waist disorder of the male china clay mine workers was evaluated and the results are given in Table 1. There

are different types of mine tasks. Most of the workers were assigned for a specific mine task but a group of workers were engaged in all the mine tasks on rotational basis. The latter workers were considered as a separate group during expressing the occurrence of WRMSD. The results revealed that both LBD and waist disorders were highly prevalent in both spade operation and pickaxe operation but significantly less prevalent ($P<0.001$) among the workers performed all mine tasks.

LBD and waist disorders of these two groups were also studied in different working hours of work shift and the results have been presented in Fig. 1 and 2. The result revealed that the occurrence of MSDs in these two body segments were low during first hour of work shift followed by gradual increase with the increase of working hours. In some cases it reached maximum level within 3rd working hour and for others within 4th working hour. Disorders were also reported after 2 hours of end of work.

Table 1: Prevalence (%) of occurrence of Lower back and Waist disorder in China clay mine workers during performing Pickaxe and Spade operation mine tasks

Affected parts of the body	Prevalence of Lower back disorder (%)	Prevalence of Waist disorder (%)
Pickaxe Operation (n=23)	78.26	82.61
Spade Operation/Basket Loading-Lifting (n=42)	83.33	88.1
Workers performed all mine tasks (n=38) (%)	26.32	31.58

* $P<0.001$, ($\chi 2$-test performed w.r.t. workers performed all mine tasks)

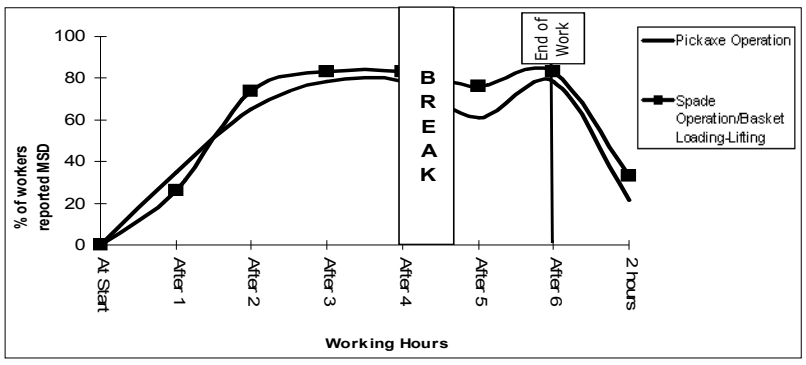


Fig 1: Percentage (%) of workers of Pickaxe and Spade operation mine tasks reported feeling of discomfort / pain in lower back in different working hours

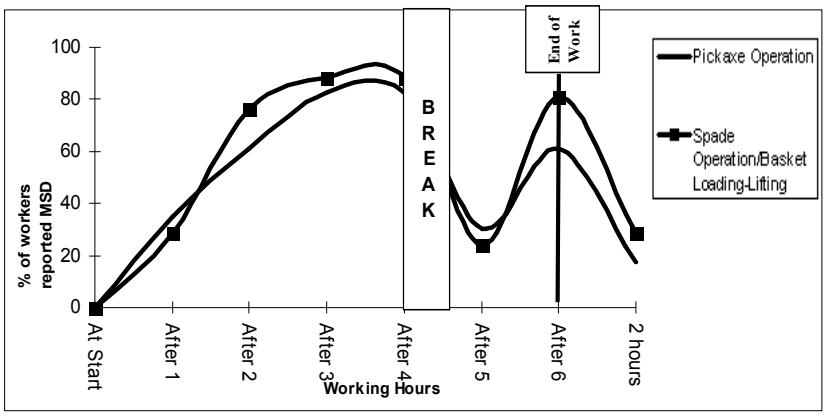


Fig 2: Percentage (%) of workers of Pickaxe and Spade operation mine tasks reported feeling of discomfort / pain in waist in different working hours

Quantification of discomfort level were studied to assess the degree of perceived exertion using 10 point scale and according to the degree of severity, the perceived rating of discomfort score of the 10-point scale were divided into three subgroups, i.e.

i) Mild pain : Grade 1 to $\leq$4.

ii) Moderate to Severe pain : Grade >4 to $\leq$7 and

iii) Very severe pain : Grade >7 to 10

The workers of pickaxe and spade users, as well as workers performing all mine tasks on rotation basis were evaluated and the results obtained are presented in Table 2. The results showed that the workers engaged in pickaxe and spade operation cum basket loading-lifting were reported to suffer from different degrees of perceived exertion. The most affected segments were lower back and waist region. It was revealed that highest degree of severity of pain (very severe >7) was observed in waist region of both spade operators and pickaxe operators. Severe degree of discomfort (>4 to =7) was observed in lower back in both these groups. But the workers performed all mine tasks shows mild degree of discomfort.

Table 2: The perceived Discomfort rating of Pickaxe and spade operation workers (in a 10 point scale)

Body Segments	Spade Operation /Basket Loading-Lifting n=42	Pickaxe Operation n=23	Workers performed all mine tasks n=38
Lower Back	6.69	6.65	2.69
Waist	7.26	7.22	3.08

Mildpain (1 to $\leq$4), Moderate to Severe (>4 to $\leq$7) and Very Severe pain (>7)

A comparative study of reported severe and very severe discomfort rating has been worked out and the results are presented in Fig 3. The results revealed that percentages of workers expressed very severe rating of discomfort was higher than that of severe rating in all task groups.

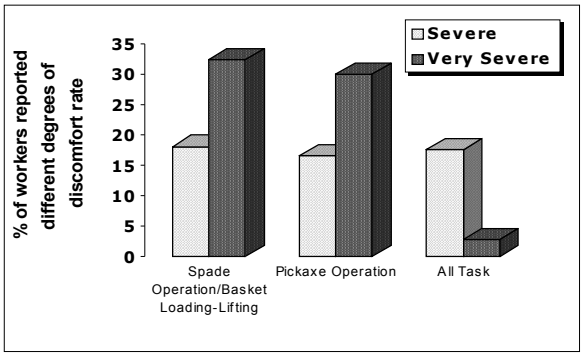


Fig 3: Percentage of workers perceived discomfort rating (severe and very severe)

It is evident that gradual onset of WRMSDs and discomfort rating are linked with the physical risk factors including awkward postures, repetitiveness, high force [1, 10]. Not only poor work posture, prolonged tasks [35] have also been found to have positive relationship with high discomfort score. There are many researcher studies on working postures by using different methods based on a postural classification. The direct observation method was proved to be a good method for studying work postures when there was requirement of whole body movement. The validity of visual observation to assess posture in a laboratory-simulated material-handling task [25] was established. However, continuous direct observation of individual workers was not only very laborious and expensive but was likely to lead to changes in working patterns and habits on the part of those being observed. Furthermore, minor changes in forward or lateral adjustments of the relative position of loads to the axis of the body were unnoticed.

In the present investigation, the analysis was made by direct observation method employing video-photographic technique and applying postural analysis tool (OWAS method). The advantage of using video recording method is that the observer has much time to look at the observed postures. Besides, the observer can also easily and effectively be used in recalling the actual work situation [19] Videotaping and posture analysis (OWAS) from a monitor have been validated in other studies too [40].

Table 3 shows the postural pattern of china clay mine workers during performing their tasks. The results revealed that the workers adopted bend, twisted bend, erect and walking postures of which bend as well as erect and walking postures were the dominating postures. In case of pickaxe and spade operation, bend posture was dominated. The workers were also used to adopt twisted bend in a significant amount of time.

Table 3: Mean ± SD and (percentage) of working time (in min) in different postures adopted by the china clay mine workers during performing different mine tasks.

Mine jobs	Different postures adopted				Total Work Period
	Bend	Twist Bend	Twist Erect	Erect and walking	
Pickaxe Operation (n=20)	231.11 ±5.02 (72.95%)	60.01 ±1.23 (18.94%)	6.80 ±0.38 (2.15%)	18.89 ±0.49 (5.96%)	316.81 ±6.59
Spade Op./Basket loading-Lifting (n=24)	87.93 ±6.31 (28.93%)	90.42 ±14.48 (29.75%)	7.05 ±0.34 (2.32%)	118.58 ±5.14 (39.00%)	303.98 ±23.94
All mine jobs (n=90)	140.29 ±100.77 (45.03%)	44.99 ±35.37 (14.44%)	6.74 ±5.20 (2.16%)	119.54 ±16.64 (38.37%)	311.56 ±16.49

The bend posture was further evaluated on the basis of the degree of bending, which was measured by hip angle and the results have been presented in Table 4. From the results it was noted that the workers engaged in spade operation adopted sharp bend posture (Bend <100°) for an appreciable time (45% of total duration of bend posture). The moderate degree of bending (Bend between 100°-120°) was also adopted in spade operation (45%) followed by pickaxe operation (31%). Combining moderate and sharp bend posture (i. e., less than 120°), the workers performing these two mine tasks (spade operation and pickaxe operation) adopted bend posture for a remarkable time. They had also to adopt twist posture as mentioned earlier in this section.

Table 4: Mean ± SD and (percentage) of working time (in min) in different bent postures adopted by the china clay mine workers during performing different mine tasks.

Different mine tasks	Different Bent Postures			Total Bent Time
	Low Bend (>120°)	Moderate Bend (100-120°)	Sharp Bend (<100°)	
Pickaxe Operation (n=20)	172.95±3.50 (59.41%)	91.20±1.86 (31.33%)	26.97±0.83 (9.26%)	291.12 ±5.95
Spade Operation /Basket loading-Lifting (n=24)	16.58±1.90 (9.30%)	80.98±9.44 (45.40%)	80.79±9.03 (45.30%)	178.35 ±20.32

Frequent posture change is a common occurrence in mine tasks. The rate of major posture changes by the workers of china clay mine tasks was noted and the results have been presented in Table 5. The results revealed that the rates of hourly postural changes were found to be very high in pickaxe operation (326 times/hour) and moderately high in spade operation (146 times/hour). There is a significant difference (P<0.001) in posture change rate between these two groups.

Table 5: Number (Mean ±SD) of posture changes in different hours in china clay mine tasks

Tasks	1st hr.	2nd hr.	3rd hr	4th hr.	5th hr.	6th hr.	Average Postural Change rate/day
Pickaxe Operation (n=20)	330.68 ±0.45	326.31 ±0.44	323.99 ±0.45	321.82 ±0.43	Food Break	327.51 ±0.45	326.06* ±0.44
Spade Op. /Basket loading-Lifting (n=24)	151.24 ±9.45	146.12 ±9.46	143.44 ±9.45	141.41 ±9.40		148.08 ±9.46	146.06 ±9.44

P<0.001; t test performed to find out the significance difference between two groups.

Multiple ergonomic tools have been designed and tested to estimate risk levels for WRMSDs in a wide variety of industries. The Ovako Working Posture Analysis System (OWAS) is one such ergonomic assessment tool used for over 30 years to estimate risk of MSDs [21]. It has been shown to be an effective method for analyzing jobs and estimating the risk of injury in many different types of industries [15, 24]. The versatility of its posture coding components provides applicability to most working postures.

In the present investigation, the postures of pickaxe and spade operation mine tasks were analyzed. Each of the tasks was divided into different phases or components. Thus pickaxe operation was divided into 5 components and spade operation/basket loading-lifting was divided into 7 components as shown in Fig 4 & 5. By applying OWAS method work postures were categorized into different action categories (AC). In a particular phase of a china clay mine task, there were more than one action categories, but the dominating action category was taken into account. By this method each phase of both these mine tasks were analyzed.

There are 4 different action categories.

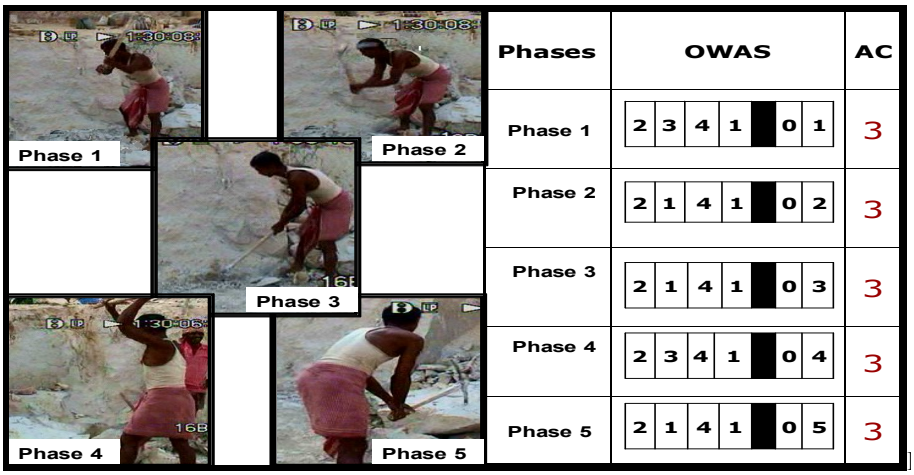
(i) AC 1 = Normal posture, no action required and no increased risk for MSD.

(ii) AC 2 = Posture is slightly harmful, actions to change postures should be taken in the near future, workers exposed are at increased risk for MSD.

(iii) AC 3 = Posture is distinctly harmful, actions to change postures should be taken as soon as possible, risk of MSD is significant.

(iv) AC 4 = Posture is extremely harmful, actions to correct postures should be taken immediately, injury is imminent.

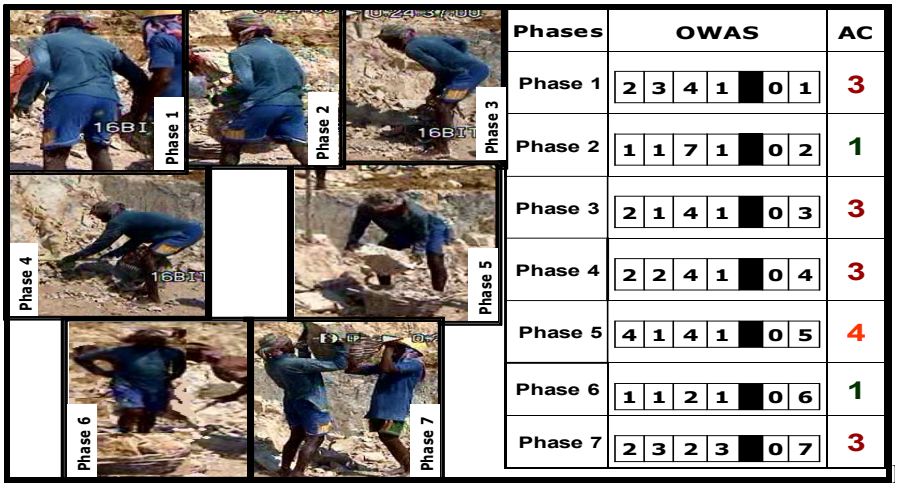
The AC was also found to be varied in different subjects of the same operation. The percentage of occurrence of ACs in different mine tasks had been analyzed. From the analysed results it would be possible to suggest the required correction of the posture.



Phases	OWAS	AC
Phase 1	2 3 4 1 0 1	3
Phase 2	2 1 4 1 0 2	3
Phase 3	2 1 4 1 0 3	3
Phase 4	2 3 4 1 0 4	3
Phase 5	2 1 4 1 0 5	3

Fig 4: Assessment of Posture by using OWAS code and determining action category in Pickaxe operation

The summary of OWAS analysis of mine operations were presented in Table 6 and it was noted that there was no AC 4 except for spade operation (with little percentage, 14.29%). On the other hand most of the components of both these mine tasks had dominating AC3, indicating the awkward posture, need correction as soon as possible; otherwise risk of WRMSD is significant.



Phases	OWAS	AC
Phase 1	2 3 4 1 0 1	3
Phase 2	1 1 7 1 0 2	1
Phase 3	2 1 4 1 0 3	3
Phase 4	2 2 4 1 0 4	3
Phase 5	4 1 4 1 0 5	4
Phase 6	1 1 2 1 0 6	1
Phase 7	2 3 2 3 0 7	3

Fig 5: Posture assessment by OWAS code and determination of action category in Spade operation (including Basket lifting)

Table 6: Percentage distribution of workers working postures in different action categories in different mine task

Mine Tasks	Action categories				Dominating categories
	1	2	3	4	
Pickaxe Operation (n=25)	0	0	100	0	3
Spade Operation/ Basket Loading-Lifting (n=25)	28.57	0	57.14	14.29	3

1=Normal Posture, 2=Slightly Harmful, 3=Distinctly Harmful, 4=Strictly Harmful

DISCUSSION

Physical demands at work remain a leading cause of work-related injuries in industrialized countries. The higher prevalence of WRMSD at different segment of the body might be due to use of significant force, carrying heavy weights, repetitive movements and longer duration of exposure [5]. Any injuries or disorders are multifactorial in nature and none of the risk factors appears to work independently. Not only repetitive movement, but work in awkward postures can be harmful when movements extend tissues beyond the normal range of motion, causing a tear or strain.

The results in Table 1 revealed that, both the LBD and waist disorders were highly prevalent on both pickaxe operation and spade operation cum basket loading lifting mine tasks. The discomfort rating was also found very high (Table 2). The workers of these two tasks group thus suffering from severe or very severe degrees of pain. The workers affected might be due to several risk factors ranging from awkward posture to load to duration of task and also frequency of postural changes. The workers of these two mine tasks require adoption of bend posture for long time (Table 3) including low degree of bend (Table 4) and some time twisting of trunk also. Thus spinal bend and rotation may cause occurrence of both LBD and waist disorder.

The National Research Council (NRC) and Institute of Medicine (2001) reports that there is a clear relationship between back disorders and physical load [30]. Backache is a pathological degeneration of the discs of spinal column which creates mechanical troubles between the vertebrae and to nerve irritations leads to pains [14, 27]. Recent studies have clearly shown multiple hazards related to bending the trunk forward when lifting. Bending forward creates an additional moment about the low back due to the weight of the torso, which the spine muscles must counteract through increased contraction. Spinal tissues have been found to fail much more quickly when this additional load is imposed [9]. In addition, it has recently been found that when spine ligaments get stretched in sustained or repeated forward bending, the spinal muscles (through a feedback mechanism) actually lose strength and are more prone to

spasm [41]. Peng (2006) pointed that as the degeneration process proceeds, fissures or tears in the fibers of the disc start to develop from the inside out. If any of these tears appears, an inflammatory response occurs in the disc, which will lead to the well-known sensation of low back pain [33]. Several opinions are there regarding the etiology of high discomfort rating, LBD and waist disorders. Some believed that prolonged heavy manual work [20, 36], awkward posture [37] is the encouraging factor and others stress on combinations of these risk factors [22]. OWAS analysis of the present study (Table 6) resulted that postures adopted by the workers of both these groups were distinctly harmful, risk of MSD is significant.

The study WRMSD in different working hours (Fig 1 & 2) shoes that there is gradual increase in prevalence rate with the increase of working hours and this effect might be due to impose of gradual cumulative stress on the workers which increase the degree of fatigue with the progress of work. At 5^{th} working hour the percentage of prevalence was reduced followed by further increase at 6^{th} working hour. This might be due to the fact that after completion of 4^{th} work hour the workers took a food break as prescribed by the authority. Disorders were also reported by all the workers in case of performing all mine tasks even after finishing the work, although prevalence rate was decreased.

A results of comparative study (Fig 3) of reported severe and very severe discomfort rating revealed that prevalence of very severe rating of discomfort was higher than that of severe rating in all specific task groups. The workers of different task group performed cyclic and repetitive work. This observation was consistent with the previous study made by Descatha et. al, 2009 [7], in which it was stated that a high degree of repetitiveness in varying use of body parts caused muscle pain and physical discomforts. The results of workers performing all task by rotating the job had lower degree of discomfort rating. So diversified variability may be useful to diminish the discomfort rating [39] of industrial manual workers.

In the present study, rate of hourly postural changes were found to be high (Table 5) in pickaxe operation (326 times/hour) and it was moderately high in spade operation (146 times/hour). There was significant difference ($P<0.001$) between these two task groups. This difference is due to variability in degree of dynamism. The workers performing pickaxe operation were engaged in clay cutting using pickaxe. In each stroke of clay cutting they used to change their posture from erect to bend and vice versa. Besides that, they also changed their posture during doing associated work like breaking of large lump of clay into small pieces suitable for loading to basket. All those might be the cause of higher rate hourly posture change in pickaxe operations in china clay mine. The rate of posture change was dependent on the ratio between static and dynamic components of a task.

Studies suggested that the rate of postural changes was associated with higher prevalence of MSDs, especially the lower back and waist disorders, though these occupational health hazards are multifactorial. According to Granata and Marras, 1999 [13], the rate of change of spinal load (load occurred during postural change) is one of the risk factor for spinal strain and injury, the cause for lower back disorders. So, the results of the present study were in conformity with the study of Granata and Marras.

So above discussion concludes that with several other risk factors, reported pain and discomfort in this study might be due to adoption of long term poor postures and frequent postural changes.

CONCLUSION

So in conclusion it can be stated that the china clay mine workers were suffering from postural stress and this is one of the cause of higher prevalence of WRMSD and high degree of discomfort rating. Ergonomic intervention might be incorporated to reduce the stress. It could be done by arranging training and awareness programs of the workers because proper training and education combined with an ergonomic intervention were found effective [3]. Besides, emphasis should also be given for effectiveness of workplace interventions on work-related outcomes and health outcomes.

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