Assessment Into Injuries Related With Sand Shoveling Work

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Abstract

Shoveling with conventional spades has some level of hazards attached. This study assessed work-related injuries associated with sand Shoveling in Nigeria sand mines work stations. The goal was to identify the risk factors of associated injuries among workers involve in manual handling of the materials. A non-probabilistic sampling techniques was used to assess 115 workers on the job. Scooping rate, scooping length, shovel weight, throw height, throwing distance, break time among others, were measured and compared with the literature standards. A questionnaire and Numeric Rating Scale (NRS) was used to collect data from the subjects. More than 72% of all task variables deviated from the recommended. The measured shovel handle average height (0.98±0.18 m) was shorter than the users' average chest height (1.21±0.14 m). The sand Shoveling task was characterized with ceaseless/lengthy scooping period, high speed throwing motion, awkward lifting and use of inappropriate shovels. Shoulder and Low Back Pains (LBP) were the commonest injuries. The study noted inadequate information on the significance of right use of shovel. It therefore suggested need for relevant ergonomics trainings among the group of workers.

Keywords (12 font)
Injury, Sand, Severity, Shoveling, Workers, Ergonomic

1. Introduction

Shoveling is a task, a form of manual handling, involving transferring loose material from one place to another using purpose-built hand tools called shovel or spade (Bridger et al., 1997). Shoveling with conventional spades has some level of hazards attached. According to CPA(2009), Shoveling can be made even more difficult by the weather.

Back and neck pain, as consequences of poor Shoveling techniques, were reported by ICC (2014) because it places too much stress on the body's muscles and joints. In handling a shovel, the right size that works with workers' body is recommended to be used while hands are kept at least 0.305 meters (12 inches) apart. This provides better leverage and makes it easier to lift and toss. It was recommended that a worker takes break to avoid injuries and other health concerns as overworking puts undue stress on heart and wears out muscles, leading to injuries.

To help eliminate risks associated with manual tasks, such as Shoveling, engineering improvements including redesigning techniques, replacing tools and administrative improvements such as observing how different workers perform the same tasks to get ideas from improving work practices, were some of the steps highlighted by HREHS (2011) and Adeyemi et al., (2013a). According to CCOHS (1999), proper Shoveling techniques include keeping feet wide apart and placing front foot close to shovel (Figure 1a) , shifting weight to rear foot and keeping load close to body (Figure 1b), turning feet in direction of throw (Figure 1c).

Training programs will therefore go a long way toward increasing safety awareness among workers who perform Shoveling jobs. Training and education ensure that workers are sufficiently informed about ergonomics risk factors at their worksites so they are better able to participate actively in their own protection. A good ergonomics training program will teach employees how to properly use tools as well as the correct way to perform the tasks (OSHA, 2000; Adeyemi et al., 2013b).

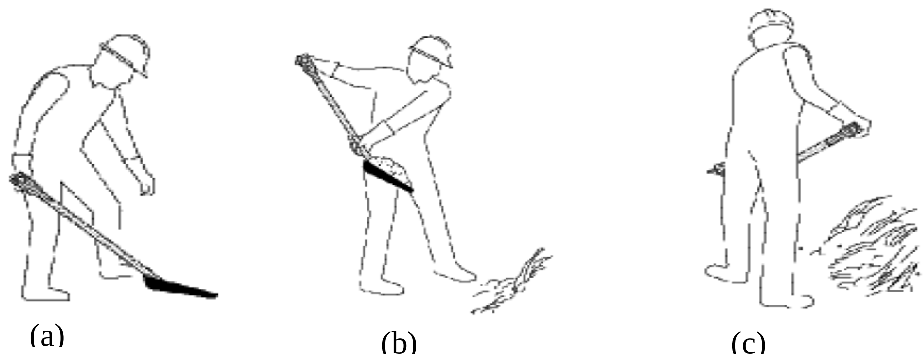

Figure 1. Proper Shoveling techniques (a) keeping feet wide apart and placing front foot close to shovel (b) shifting weight to rear foot and keeping load close to body (c) turning feet in direction of throw

Triangular or round blades shovel with long handles is advised to be used for sand while square blades with short handles for coarse-grained materials such as gravel. Ideally, the handle of shovel should come up to the user's chest in order to reduce forward bending that may stress the lower back muscles. Table1 summarised tasks variables guidelines in Shoveling, as designed by CCOHS (1999), to avoid fatigue and injuries.
Several studies were carried out in Snow Shoveling where authors reported soft tissue injuries as the most common among all reported injuries (Véronique, et al., 2004; Ryan,et al., 2013; Kaj, 2014). UV (2011) also mentioned back strains as frequent injuries with heart attacks, back strain and injury as well as muscle soreness as by products of snow Shoveling.

Table 1. Guidelines in Shoveling to avoid fatigue and injury.

Parameters	**Optimal Condition**
Rate	15 scoops per minute
Length of time	No longer than 15 minutes
Shovel load for high rate	The total weight should not exceed 5-7 kg
Throw Height	Not exceed 1.3 meters
Throwing Distance	Around 1 metre
Posture Shovel handle	Turn feet in direction of throw The shovel handle should come up to the user's chest

(Source: CCOHS, 1999).

However studies on other manual tasks involving the use of shovel are very uncommon unlike that of Snow shoveling. This study therefore attempted to conduct ergonomics evaluation of sand shoveling among workers in sand mine locations in South-Western Nigeria. The objectives are to determine the:

a) degree of task variables compliant with the literature recommendations
b) type and ergonomics risk factors of common Shoveling-related injury among the group of workers,
c) region(s) of the body mostly affected, and
d) relationship between workers' age and years of working experiences, to the severity of Shoveling-related injuries.

2. Materials and Methods

The study involved workers who manually scoop sands and tossed into trucks with the use of shovel. Six sand mining locations were selected for the study where large numbers of the group of workers were assessable. A non-probabilistic sampling technique was used to select 115 workers which were later reduced to 70 physically healthy workers who had spend at least 2years on the current job. Consents of all potential volunteers to have all procedures performed were received orally, because majority of them were not literate, after they were informed that their participation in the study were voluntarily. The purpose of the study and the confidentiality of the information provided were emphasized. Two extra trained personnel were used to assist in data recording to avoid parallax when taking readings.

2.1 Shoveling tasks variable measurements

Methods adopted to measure task variables are stated below:

a) Rate of scooping: Tasks were observed as carried out. Numbers of scoops made by each subject was counted within a space of one minute using a stopwatch.
b) Length of scooping time: Time spent (seconds) in scooping before brake was measured using a stopwatch.
c) Length of Shovel: Length of shovel from its handle to the blade was measured using a meter rule.
d) Subject chest height: Chest height of each subject was measured standing from the foot to the height of breast bone with the use of a meter rule.
e) Shovel load: Shovel weight plus load weight (kg) was measured randomly four times for each subject using a digital weighing scale and the average value was computed.
f) Throw height: The vertical throw height of the load (m) was measured from the origin (ground) to the destination (truck height) using a meter rule.
g) Throwing distance: The horizontal distance (m) of the load from the origin to the destination was measured using a meter rule.
h. Feet direction at throw: Feet positioning of each subject, with respect to the direction of throw, was noted randomly in five observations for each round of 15 minutes.
i. Break time (seconds): Total rest time observed by each subject within one hour was measured using stopwatch.

Measurements were recorded to the nearest tenth of a centimeter. All instruments were inspected before the commencement of measurement to ensure accuracy.

The following are the descriptions of tools used for the measurements:

Tape rule: A flexible tape rule made of latex material and calibrated in centimetre with a measuring range of 150 cm.

Weighing scale: A weighing scale with a flat platform for objects to stand upright. The maximum capacity of the scale was 120kg.

Digital stopwatch: Simply measures and displays the time interval from an arbitrary starting point that began at the instant the stopwatch was started. It measure time interval by using a frequency source. Frequency is the rate of a repetitive event, defined as the number of events or cycles per second (Michael, 2002).

2.2 Personal data collection, job demand and work station assessment

Personal data were collected from participants using well-structured questionnaire for parameters such as, age, years of working experience on the current job, physical and health conditions. Numeric Rating Scale (NRS) was used for assessment of body pain intensity. The tool asks the worker to mention the painful regions of their body as a result of the current job and rate the pain by assigning a numerical value with zero (0) indicating no pain and 10 representing the worst pain (Ellen, 2012; Breivik, 2000).

2.3 Data analysis

The inferential chi-square test for independence between two categorical variables was used to analyze whether variables are independent of each other or not. Calculated Chi-Square statistic values 0.05 level of significance were compared with Chi-Square distribution table values

3.0 Results

One hundred and fifteen (115) workers participated in the study and completed the questionnaire. The study selected 70 workers as sample size who had worked for two years and above on the current job. The statistical information of this category of workers is presented in Table 2. The ages of workers fall into range 14-35 years old. While the average age is 25.7±4.6 year, most of the subjects are 24 years of age. The average working experience of the participants is about 3years, of which there is a minimum and maximum of 2±0.95 and 6±0.95 years respectively on the current job.

Table 2. Statistic of the demographic information for workers studied (N=70)

Descriptions	**Age**	**Years of Working Experience**
Mean	25.7	2.9
Mode	24	2.0
Std. Deviation	4.6	0.95
Minimum	14	2.0
Maximum	35	6.0

Table 3 reports the account of all measured task variables' mean values on the Shoveling task and corresponding literature recommended values. Some deviations of the measured values from recommended values were observed for all variables. The deviations of average measured "Throw height", "Throw distance", "Break time", "Length of Shoveling time" and "Average shovel load" from the recommended were calculated to be 61.5%., 70%, 29.6%, 152% and 39% respectively. The highest deviation was recorded in "Length of Shoveling time". While the recommended Shoveling time was 15minutes, the average recorded value was about 38 minutes with standard deviation of 6.01. Although it was recommended that the length of shovel should extent to the worker's chest the average height of shovel used by the workers was 0.98m while their average chest height was 1.21m. The deviation of this from the recommended value was computed to be 19%. The least notable deviation calculated was 2.7% for the "rate of scooping".

Table 3. Measured Shoveling task variables compared with the literature recommended values (N=70)

Variables	**Measured**	**Rec.**	**Deviation**	**Frequency Categories** ≤No. Rec.	**Frequency Categories** **No. > Rec.**
Rate	15.4±2.18	15	2.7%	30	40
Throw height	2.1±0.2	1.3	61.5%	-	70
Throw Distance	1.7±0.43	1.0	70%	5	65
Ave. Break Time (sec)	105.6±33.9	150	- 29.6%	61	9
Length of Shovel (m)	0.98±0.18				
Chest Height (m)	1.21±0.14		- 19%	19 ≤ (dev 0.1)	51 (dev>0.1)
Length of Time (min)	37.9±6.01	15	152%	-	70
Average Shovel Load (kg)	8.34±1.34	6	39%	5	65
TOTAL				**115**	**305**

Note: dev = deviation, Rec. = Recommended Values, Measured Values are Means ± SD

While 40 of the workers, representing 57.1%, performed the rate of scooping above the recommended values, nearly all the workers lifted more load (8.34±1.34 kg), and delivered same to the destination height (2.1±0.2 m), above the recommended. The average total length of Shoveling time (37.9±6.01 min) was also higher than the recommended time of 15min. Similarly, 65 of the workers (about 93%) threw the shovel load to a destination distance (1.7±0.43 m) farther than the recommended (1.0 m). On the contrary, about 87% of the workers observed their average break period (105.6 ± 33.9 s) less than the recommended (150 s).

3.1 Shoveling-related injuries prevalence among workers

Shoulder pain was reported as the most prevalent work-related pain among the workers (Table 4). 55 workers, representing 78.6% of the respondents, reported this discomfort. 58.2% of these workers are in the age bracket of 24years and above. And the majority (45.7%) of which are on their second year on the current job. LBP was reported as the second most prevalent disorder. 52 workers, representing 72.2% of the respondents reported disorder in the lower back region of their body. In a similar trend 82.7% of these workers were above 24 years of age while 69.2% of them have spent more than 2years on the current job. For those who reported "Palm pain" (61.4% of the workers), majority of them (62.8%) have not spent more than 2years on the current job and are either 24years of age or lower.

Out of total of 249 responses from 12 different pain descriptions, those who were above age 24 were mostly affected (59.8%), majority (56.6%)of which had not spent more than 2years on the current job.

Among the workers who were affected by one disorder or the other, 48 of them representing 68.6% have had reasons to miss their work schedule at one time or the other in the past one month because of the reported pain. Most of the affected workers fall among those who were older than 24 years of age (52.1%) and had spent more than 2years (64.6%) on the current job.

The number of workers who reported pain at the " base of thumb" (45.7%) were almost the same with those who complained of hip/upper legs pain (44.3%) except that while the former had majority (53.1%) within the age bracket of 24years or lower, those who were above 24years of age were mostly (51.6%) affected by the latter. However for the two reported disorders, those who were in their second year on the current job (87.5% and 54.8% respectively) were mostly affected. Other notable reported pains were "Upper back pain", "Elbow/forearms pain" and "Neck pain" by 18.6%, 14.3% and 7.1% respectively.

Table 4. Reported health outcome by age and working experience categories for participated workers

Reported Variables	**Total Response**	**Age Categories (Years)**		**Working Exp. Categories (Years)**	
		≤24	**> 24**	**= 2**	**> 2**
Neck Pain (NP)	5	2	3	2	3
Lower Back Pain (LBP)	52	9	43	16	36
Upper Back Pain (LBP)	13	6	7	5	8
Hip/upper Legs Pain (H/ULP)	31	15	16	17	14
Knees/Lower Legs Pain (K/LLP)	1	1	-	1	-
Ankles/Feet Pain (A/FP)	3	-	3	3	-
Shoulder Pain (SP)	55	19	36	32	23
Elbow/Forearms Pain (E/FP)	10	4	6	6	4
Wrist/Hands Pain (W/HP)	2	1	1	2	-
Fingers Pain (FP)	2	2	-	2	-
Palm Pain (PP)	43	24	19	27	16
Pain at the base of thumb	32	17	15	28	4
TOTAL	**249**	**100**	**149**	**141**	**108**
Workers missed work scheduled due to pain in the last one months	48	23	25	17	31

3.2 Pain severity assessment with NRS tool

The observed the severity of pain among the group of workers is shown in Table 5, 32 workers representing 61.5% of those who reported LBP experienced moderate pain in the affected body region while 30.8% of them reported severe suffering from it. About 66% of those who reported shoulder pains were experienced moderate pain with 23.6% of them complained of severe condition. In the case of reported "Palm pain", 55.8%, 34.9% and 9.3% of the affected workers reported mild, moderate and sever pains respectively. Majority of the workers who reported "base of thumb" pain had suffered from mild (59.5%) and moderate (40.6%) pains. Nearly all workers who complained of Hip/upper Legs pains experienced mild pain (90.3%) with no reported severe cases.

Table 5. Summary report of workers' self rated pain severity using 10-point NRS one-dimensional pain intensity scale with 0 indicating no pain and 10 representing the worst possible pain.

Description of Pain	**No Pain**		**Mild Pain (1-3)**		**Moderate Pain (4-6)**		**Sever Pain (7-10)**	
		%.	**g**	**%.**	**Freq.**	**%.**	**q.**	**%.**
Low Back	Nil	Nil	4	7.7	32	61.5	16	30.8
Shoulder	Nil	Nil	6	10.9	36	65.5	13	23.6
Palm	Nil	Nil	24	55.8	15	34.9	4	9.3
base of thumb	Nil	Nil	19	59.4	13	40.6	4	12.5
Hip/upper Legs	Nil	Nil	28	90.3	3	9.7	-	-

However, Hip/upper legs region of the affected workers' body has the highest (90.3%) reported mild pains (Figure 2). Shoulder region recorded highest moderate pain while LBP ranked highest among the severe pain reported categories. \

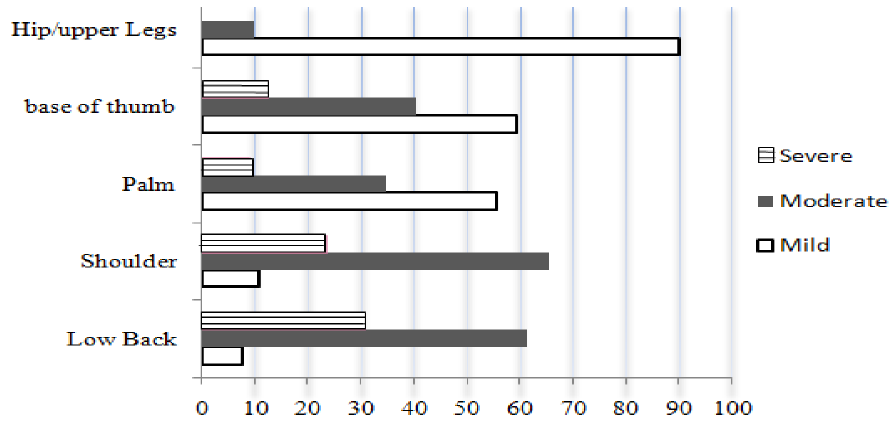

Figure 2. Percentages outcome of workers' Shoveling-related pain severity using NRS pain intensity scale .

3.3 Chi-Square tests for independence

3.3.1 Effects of age on pain severity

The result in Table 6 provides a statistical test for the hypothesis that age of workers and intensity of Shoveling related pains are independent of each other. The smaller Chi-Square statistics values and their larger corresponding table values indicate that it is very likely that these two variables are independent of each other. Thus, it can be concluded that there is no relationship between a worker's age and pain severity in any of the reported body region.

Table 6: Chi-Square tests results for independence between workers' age and body regions pain severity

	Lower Back	**Shoulder**	**Palm**	**Thumb Base**	Hip/upper Legs
X^2	12.92	7.69	6.33	9.57	5.52
Df	7	7	6	7	3
Table value	14.07	14.07	12.59	14.07	7.82
Opinions	Accept H_o	Accept H_o	Accept H_o	Accept H_o	Accept H_o

3.4 Discussion

The study revealed that those workers who were above 24 years were mostly affected by the various disorders reported. This is in agreement with the epidemiological survey report which suggested that pain tolerance decreased with increasing age (Tsang et al., 2008). The younger ones among the group of workers might probably be able to tolerate the discomforts relative to the task more than the elderly ones. It was evident that those who reported pains among the older ages were mostly of those who were in the second year on the sand Shoveling job. Those who had spent more than 2years might be accustomed to some of the discomforts in their body regions. Among the study participants, only 18.6% were above 30 years. This apparently shows that as workers advanced in age they quit the job for the younger ones who seems to have a better endurance level to cope with the job. The severity of pains was anyway reported more with LBP than any other. However this study noted that age or working experiences of the workers cannot be used to predict the intensity of Shoveling-related pains in any of their body regions. Hence any age group and/or with their year of working experience may be affected by any of the severity categories of pain related to the task.

Of all the measurements in the study only 27.4% agreed with the recommended values. This indicates a very high degree of deviation from the expert's advice as related to Shoveling tasks. This might probably be the cause of the

high report of discomforts and level of reported absenteeism of workers from their normal routine work due to injuries.
Among the total reported injuries, lower back and shoulder pains prevalence are on the high side as the weight of the duo is about 43% of the total reported twelve injuries. Meanwhile, CONIAC (1993) mentioned heavy loads and poor postures as the main hazards among construction workers resulting in excessive stress and strain which causes injury to muscles and tendons. The heavy shovel loads coupled with high frequency of scooping and/or improper ergonomics posture adopted by the workers made greater contributions to high reported LBP. Deviation of throw height from the recommended, leading to working with the hands above their comfort level, is one of the major reasons for high level of shoulder pains among the workers.
Most of the shovels used for the task were measured and discovered to be shorter than the recommended length. The handles of most of the shovels used could not come up to the users' chests. The average height of the shovels was 0.98±0.18 m while the average measured anthropometric dimensions of the workers chests was 1.21±0.14 m. The use of wrong sizes of shovels led to forward bending and this resulted to stressing the lower back muscles. The average throw distance was 70% which deviated from the recommended value of 1.0m. Throwing material further than necessary the required distance increased shoulder muscle action which might have led to injury. The shovel loads were lifted from the origin without proper positioning of the body and/or delivered at angles deviated from the workers' natural postures. Most workers preferred quick scooping from sides, so as to load as many truck as possible for an increased daily wages, in lieu of repositioning of body to lift at comfortable posture.
It was reported by Snodgrass and Rivett (2002) that using a hand tool that requires using a forceful grip, holding hand or wrist in an awkward position can result to pain. The thumb joints also are particularly vulnerable to biomechanical overload and work-related injury (Suzanne, 2003). The longer grasping of shovel handle (as evidence in the excessive length of Shoveling time), poor material make of the handle, combined with lengthy period of scooping are some of the leading causes of palm pain reported by the workers. Shapes of the shovel handle, some of which did not allow thumb movement, was one among other factors the cause of the reported thumb pain. There is therefore a need for redesign of shovel to match the anthropometric dimensions of the group of workers.
However extremely high level of continuous length of scooping time, frequent bending and lifting loads above the recommended in awkward postures, contributed to the high reported injuries in the sand Shoveling work. This implies that all the various actions must be given equal attention. It is important to emphasise the need to: (a) use the right sizes of shovel which meet individual anthropometric dimension, (b) reduce the distance in between origin and destination of load by bringing the load as close as possible to the workers and by moving the origin of shovel lift and destination of load closer together could make significant positive change, (c) reduce the weight lifted by workers by ensuring the shovel are not fully loaded at the lifting point, (d) observe adequate recovery time with regular breaks in between Shoveling, (e) adopt the right technique in Shoveling such as positioning the body rightly to reduce awkward posture, and (f) decrease the physiological demands by reducing the frequency rate of lift, is needful. From the foregoing, there is urgent need for ergonomics intervention trainings programmes among the group of sand winning workers. The workers need adequate information on the use of the hand tools and proper techniques of Shoveling to reduce the impact of injuries.

4. Conclusions

The study assessed work-related injuries associated with sand Shoveling in Nigeria sand mines work stations. From the study the average length of scooping time, average shovel load throw distance, average shovel load throw height, average break time in between Shoveling, average rate of scooping and average shovel load had some deviations from the recommended values. The measured shovel handle average length was shorter than the users' average chest height.
The study task was characterised with lengthy period of scooping without intermittent break, high speed throwing motion, frequent forward bending, lifting of shovel loads at awkward postures and use of inappropriate size and type of shovel, leading to high degree of reported Shoveling-related injuries. Shoulder and low back pains were prevalent among the group of workers. Urgent need for required ergonomics intervention and information on the proper technique of Shoveling at reducing the impact of injuries among the group of workers are recommended.

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