A CROSS-SECTIONAL STUDY OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG CONSTRUCTION WORKERS IN BANGLADESH

By

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December 2019

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DECLARATION

This is to certify that the thesis work entitled "*A Cross-sectional Study of Work-Related Musculoskeletal Disorders among Construction Workers in Bangladesh*" has been carried out by *Md. Sumon Rahman* in the Department of *Mechanical Engineering*, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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ABSTRACT

The construction activities are closely associated with many occupational injuries. Work-related musculoskeletal disorders (WMSDs) are the most common occupational injuries faced by construction workers. WMSDs refer to a set of painful illnesses of human body muscles, tendons, nerves, ligaments, joints, etc. The construction workers also face injuries from the work site accidents. Most of the accident occurs in the construction site by falling objects on the worker's body, workers fall from the height, electrocution, etc.. The workers feel pain in different body parts, sometimes become partial or permanent disable due to worksite accidents. There are many factors associated with the occupational injuries. Different researchers from different countries have studied the work-related musculoskeletal disorders of construction workers. As far, I know, no researchers have studied these types of disorders on Bangladeshi construction workers. Keeping this view in mind, the study investigated the work-related musculoskeletal disorders and accidental injuries among the Bangladeshi construction workers. This study also tried to find out the factors associated with Work-related musculoskeletal disorders (WMSDs). For this purpose, a cross-sectional study was conducted through a structured and Modified Nordic Questionnaire. The structured questionnaire contained the socio-demographic characteristics, the physical risk factors, environmental risk factors, and the equipment risk factors. The Modified-Standardized Nordic Questionnaire (MNDQ) is used to identify the musculoskeletal pains on different body parts over the previous year. All the questionnaires were two categories as an open-end and yes/no. In this study, a total of 450 (362 males and 88 females) construction workers aged between 18 to 65 years old were taken from the different construction sites at Jashore, Khulna and Satkhira, Bangladesh. Their main activities were mixing sand and cement, ironwork, lifting and carrying mortar, bricklaying, plastering, concrete laying and tiles fitting. The results found that overall 70.2% of workers reported that they had suffered at least one body part injury over the last 12 months. Among the nine body parts, lower back (49.80%) was the highest suffered body part and a thigh (9.60%) was the lowest suffered part. It is found the occurrences of work-related musculoskeletal disorders (WMSDs) were associated with socio-demographic characteristics such as gender, age, work experiences, working time, and working types. To minimize the work-related musculoskeletal disorders workers suggested to provide safety aid (26.70%),

provide proper training and education (19.50%), to design hand tools in ergonomically (24.90%), ensuring good working environment (26.40%), and proper use of the personal protective equipment (21.80%). Most of the workers (32.20%) did not specify how to prevent work-related musculoskeletal disorders.

About 60.70% of the participant experienced with accidents during their work in the construction site. Most of the accidents occurred by the falling objects on the worker's body (19.10%), workers fall from the height (25.30%), electrocution (3.30%) respectively. Based on the data most of the workers (29.80%) injured in different body regions due to the worksite accidents. The workers also identified the causes of accidents such as personal negligence, lack of work experience, improper use of PPE (Personal Protective Equipment), absence of a good working environment, the overload of work, and lack of safety facilities. Above all-causes, the lack of safety facilities (42.80%) reported as the highest reason behind the accidents. It is found from this study that the prevalence of work-related musculoskeletal disorders and accidental injuries among the Bangladeshi construction workers are high. Finally, the author had made some recommendations for both workers and management of the construction sites.

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NOMENCLATURES

Symbol	Description
WMSDs	Work-related Musculoskeletal Disorders
MSDs	Musculoskeletal Disorders
BDT	Bangladeshi Taka
SD	Standard Deviation
REBA	Rapid Entire Body Assessment
PPE	Personal Protective Equipment
BMI	Body Mass Index
MNDQ	Modified-Standardized Nordic Questionnaire
SPSS	Statistical Package for the Social Sciences

CHAPTER -I

INTRODUCTION

1.1 General

The construction industry plays an important role for country development. Most of the construction activities are manual labor incentives. These activities include lifting, carrying (muddy slurry, cement, and tiles), bricklaying, plastering, ironing and structuring, concrete layering, etc. The workers perform these jobs in a hazardous environment. Thus, the construction sector has been recognized as one of the most and hazardous industry in the world [1]. Often the workers execute the tasks by twisting body parts, forceful exertions, and awkward body postures, continuous body movements, which run to fatigues, work-related musculoskeletal disorders (WMSDs), injuries and finally permanent disability. Among these problems, Work-related Musculoskeletal Disorders (WMSDs) is one of the greatest occupational health problems among construction workers.

1.2 Musculoskeletal Disorders (MSDs)

Musculoskeletal Disorders (MSDs) are the most common health problems among the construction workers as well as other workers. These problems are known as injuries or pain in the various body parts like tendons, muscles, ligaments, blood vessels, nerves, body limb, back, neck, etc.. The main causes of Musculoskeletal Disorders are working in awkward and static postures, repetitively body movement, exposure to forces and vibration. Heavy loads handling also causes to Musculoskeletal Disorders (MSDs). The intensity of musculoskeletal disorders (MSDs) among construction workers is increasing day by day. Musculoskeletal Disorders among construction workers affect on following body parts like hand, shoulders, neck, arms, wrist, and legs [2]. Musculoskeletal Disorders (MSDs) have a long-term impact on both workers and management. Musculoskeletal Disorders (MSDs) harm the workers both physically and financially. The workers lose the ability to do the work [3]. They lose income and spend money for treatment and rehabilitation purposes. It also increases the worker’s absenteeism. Musculoskeletal Disorders also increase the worker's compensation and production cost for the management.

1.3 Work-related Musculoskeletal Disorders (WMSDs)

Work-related musculoskeletal disorders (WMSDs) refer to as musculoskeletal disorders due to work-related features [4]. On the other words, Work-related musculoskeletal disorders (WMSDs) are defined as a set of painful illnesses of human body muscles, tendons, nerves, ligaments, joints, etc. The examples of Work Related-Musculoskeletal Disorders are tension neck syndrome, carpal tunnel syndrome, thoracic outlet syndrome, Carpal tunnel syndrome, etc. The prolonged restricted posture causes tension neck syndrome [5]. The causes of thoracic outlet syndrome are the continued shoulder flexion, prolonging arms above shoulder height, carrying loads on the shoulder for a long time [5]. The World Health Organization (WHO) has used the term Work-related musculoskeletal disorders (WMSDs) to specify the multi-factorial scientific cause of a disease. Where, the work performance and environment are two significant factors to create this disease. The manual handling of heavy loads and repetitive work causes those types of injuries [6]. In general, workers use different body organs to perform the works. Therefore, most affected body parts are the wrists, elbows, neck, shoulders, legs, hips, ankles, and feet.

1.4 Work-related Musculoskeletal Disorder (WMSDs) among Construction Workers

Most of the construction activities in Bangladesh are handled by manual labors. The worker performs these tasks by continual repetitive body movement, force exertion those are lead to Work-related Musculoskeletal Disorders. Construction sectors are one of the most hazardous and unsafe workplaces. In the construction sites, the amount of hazardous is more than 8 times risky than other manufacturing industries [7]. In general, construction work needs to expose of awkward postures, lifting and carrying of heavy loads, manual handling of weighty materials, repeated bending, twisting of the body, and working over shoulder height, working under knee level, static position for a long period. The workers do all these activities in a difficult environment. Therefore, Work-related Musculoskeletal Disorders (WMSDs) are common health problems in construction workers [7]. The most affected body regions are the neck, shoulders, back, elbows, wrists, thighs, knee, and ankles. Work-related Musculoskeletal Disorders lead the workers in temporary or permanent disability. Workers lose the quality of life by WMSDs. Work-related Musculoskeletal Disorders increase work absenteeism, obstacles to perform the job, job rotation, treatment cost, compensation cost, training cost, etc.. It also reduces the worker’s productivities and working time. There are several risk factors associated with Work-related Musculoskeletal Disorders among the construction workers.

1.5 Risk factors associated with Work-related Musculoskeletal Disorders (WMSDs)

The risk factors are the activities or environments that cause injuries or pains of the human body. There are several risk factors associated with Work-related Musculoskeletal Disorders among the construction workers. The risk factors that contribute to Work-related Musculoskeletal Disorders (WMSDs) in construction workers are socio-demographic factors, task factors, physical factors, environmental factors, equipment factors, accidental factors, etc.. The mentioned risk factors also divided into different sub-factors as follows:

1.5.1 Socio-demographic factors

The term Socio-demographic is the combination of sociological and demographic characteristics of the people. It includes gender, age, body mass index, educational status, marital status, working hours, race, etc.. These characteristics play an important role in health outcomes. It also plays a part in the precision in interoceptive tasks. In this study, following socio-demographic factors are considered:

Gender of the workers

Gender is a factor that related to Work-related Musculoskeletal Disorders (WMSDs). The injuries rates among female workers are higher over male workers [8]. The study showed that women were more suffer from wrists and hand pain in addition to hip and thigh pain over men. The women were more exposed Musculoskeletal Disorders (MSDs) during carrying the heavy workloads and raising arms above shoulder height [9].

Age of the workers

Researchers found that age of construction workers is statistically significant *(P= 0.001*)* with the Work-related Musculoskeletal Disorders (WMSDs). The young workers can use the equipment and machine ergonomically [10]. Therefore, the prevalence of WMSDs is lower among younger workers than older. Other hands, the incidence rate of Work-related Musculoskeletal Disorders (WMSDs) increased due to the increasing of age [7].

Body Mass Index (BMI)

Body mass index is the ratio of weight and square height of a person. For adults, the ideal BMI range is 18.5-24.9. A BMI of below 18.5 indicates underweight and a range in 25-29.9 indicates overweight. Another hand a Body mass index (BMI) of 30 or above considers as obese [11]. Obesity, as well as overweight, is also considering an individual risk factor for some MSDs [8].

The study showed the BMI of the construction workers was an association with Work-related Musculoskeletal Disorders (WMSDs) [10].

Working experiences

The workers who have high work experiences for a specific task maintain the same posture for several years. These postures may natural or awkward (twisting, bending, tension, etc.). The long-term execute the postures contribute to develop the Work-related Musculoskeletal Disorders (WMSDs) [8]. Researchers [3] reported the years of work experience were responsible for developing Work-related Musculoskeletal Disorders in construction workers.

Working hours

Working hours per day plays an important role in workers' health. Work in abnormal working position for long hour's causes to work-related musculoskeletal disorders. Akter et al reported that daily working hours are lead to development the Musculoskeletal Disorders (MSDs) [12].

Education Level

Educated persons are more conscious about their health than illiterate persons are. Educated workers can easily receive working technique and training. Therefore, illiteracy may cause some MSDs. Researchers showed their study 84.2% of the total construction workers are having low education. They found that educational qualifications are statistically significant *(P=0.023*)* with work-related musculoskeletal disorders among the construction workers in Nigeria [10].

1.5.2 Tasks factors

Most of the construction tasks are frequently involved with manual material handling activities. These tasks are mixing sand and cement, lifting and carrying materials, bricklaying, plastering, ironworks, concrete lying, tiles fitting, etc.. Workers have executed the tasks by twisting, bending and work in bad postures. They also work in exerting forces and strained for a long time. Consequently, construction tasks consider as risk factors for work-related musculoskeletal disorders. The selected activities are:

Mixing sand and cement

The mixture of sand and cement used as a binder in construction trade especially for plastering and bricklaying tasks. The mixture of sand, a binder, and water is called mortar. To make these mixture workers need to twist and bend the body. These types of body posture contribute to

develop the muscles disorder on the shoulder, upper arm, wrist, thighs, lower back, and upper back [13].

Lifting and carrying materials

Lifting and carrying materials to the work location are one of the common task in the construction trade. To lift the materials from below knee level body need to bend. The workers also carry the material to the work location need to the body twist, awkward position and repetitive. These postures lead to pain in the upper arm, shoulders, wrists, neck and lower back [13].

Bricklaying

Generally, bricklaying is the placing and lays the brick into the work location to make a wall. Workers pick up the bricks and mortar from lower positions. They bend down to pick up the bricks and straighten up to lay the bricks on the work location. The continuing working below the knee level in awkward position causes body discomfort. Most of the affected body parts of bricklayers are lower back, knee, shoulders, and wrist upper back. Researchers' showed that, among the 36.6% of the total bricklayers reported that they suffer from work-related musculoskeletal disorders during their work time [10].

Plastering

Plastering is the laying the mortar on the wall, floor, and roof. To perform this work, the workers need to move the body upper level and downwards continuously. Workers bend and twist the body to lift the mortar from below knee level to above shoulder height or to reach the overhead position. Repetition of this postures leads to MSDs symptom on the shoulder, upper arm, neck, and knee of the workers. A study showed 92% of floor and wall plastering workers were felt body discomfort [14].

Ironworks

The ironworkers make a structure of the rod or steel for building column, beam, and roof. They also place and sheltered these structures by reinforcing concrete. Ironworkers generally work outside in open sky and several weather conditions. They straight and bend the rod in strictly awkward positions within restricted places or from kneeling positions. Ironworkers frequently lift and carry heavy weight loads from floor to work locations. They use heavy vibrating tools and equipment that can cause discomfort. They also apply high force on the rod to make the

structures while in fixed positions. The most commonly affected body parts by work-related musculoskeletal disorders are back, hand, shoulders, knees, and fingers [15].

Concrete laying

Workers lay or pouring the concrete into the structure to build floors, roofs walls, etc.. They perform heavy manual materials handling tasks. It includes lifting, carrying, climbing, bending, kneeling in awkward positions. During summer, workers perform work in a hot environment, which leads to a risk of different heat-related problems. The following body parts as back, knee, wrist, shoulders, and feet are associated with work-related musculoskeletal disorders (WMSDs) [15]. The authors found that, about 94% of the concrete worker reported they had pain in the back region [14].

Tiles fitting

Tiles fitting in building construction refer to the thin plates or elements used to cover the surfaces as floors walls and roofs. Workers fit the tiles on the floors by sitting and static position. They also bend and twist their body during the wall's tiles fitting. These repetitive body movements cause to WMSDs in the body. The common body parts associated with work-related musculoskeletal disorders (WMSDs) is wrist, knee, lower back, shoulder. Workers also used tiles cutting machine to get proper shapes. The vibration and sound from the cutting machine also contribute to MSDs and hearing loss.

Other tasks

In the construction trades, other types of tasks are pilling, pipefittings, carpenter, electricity, painting, etc.. These activities are also responsible for work-related musculoskeletal disorders (WMSDs) in the workers body. Therefore, in this study, author considered only the above-mentioned tasks.

1.5.3 Physical factors

In this study, physical factors considered as the different types of body postures and the types of loads. The following factors have taken those causes to work-related musculoskeletal disorders among the construction workers.

Awkward working posture

Posture denotes to the position of the different body parts. On the other hands, awkward working posture refers the body positioning outside normal and a relaxed range motion. Awkward posture includes the following body positioning as repeated or prolonged reaching, twisting, bending, working at below knee height, squatting, working at over shoulders height, holding something in fixed positions for long period [16]. Working process and workplace environment contribute to making the awkward postures. Most of the construction workers perform the tasks with the awkward posture that associate with various injuries.

Static posture

Static posture generally means the performance of the task from a fixed position for a long time. Thus, Static posture is not relaxed to keep the body position without adjustment for a long period. On the other hand, execution the tasks in one outside of natural position called static loading [16]. Therefore, static posture leads to work-related musculoskeletal disorders (WMSDs) in the worker's body.

Repeated work

Repeated works define as performing the similar motion of a task without taking any rest or break. In repeated motion, workers perform a task by using both large muscles and small muscles repeatedly with little chance for rest or recovery. The repetition work leads the workers at a higher risk of injuries combining with other risk factors as excessive forces and awkward body posture [16].

Heavy load

Heavy load refers to the large quantity of loads. Workers impose excessive forces to handle heavy loads. Frequently body needs to bend, twist and kneeling to lift, carry, climb and place the heavy load to work location. Therefore, heavy or bulky loads execute work-related injuries.

High work stress

High work stress refers to the workers have excessive heaviness or other types of request engaged on them at work. In this case, stress is a state, not a sickness. Therefore, prolonged and too excessive stresses develop both physical and mental illness. Due to the demand of construction trades workers perform the task for daylong. However, high work stress may cause a

significant illness among the workers. It also increases the sickness absence, job turnover and creates more error [8].

1.5.4 Environmental factors

The environmental factors are known as characteristics in an environment that influence on workers performances. In this study, the following environmental factors in construction sectors are considered to know the effect of MSDs on the worker's body. It includes air temperature, noise from the engine, machine and equipment, first aids facilities, bad working layout, and safety facilities.

Air temperature

The workers perform most of the Construction works in the open sky. Therefore, the air temperature both hot and cold plays a negative effect on workers performance. It also decreases the worker's efficiency and productivity. Hot temperature often exposed to heat stress. Extreme heat stress causes various health problems and lower efficiency. It can also lead to heat pains, heat fatigue, and heat stroke, which may lead to death. On the other hands, extreme cold temperature leads the thermal discomfort. Cold temperature reduces the core temperature of the body. As a result, workers suffer from various cold-related diseases as narrow the blood vessels, decline sensitivity, extremity pain, ventricular fibrillation, etc..

Noise from the engine, machine and equipment

Noise is unwanted sound, especially one that is loud or unfriendly or that cause disturbance to hear. In the construction section, sound from the engine during pilling and machine during rod or tiles cutting become more annoying to hear. Noise effects on workers performance and productivity. It also causes hearing loss and disturbs with verbal communication.

First aid facilities

First aid means the first and instant support given to any person suffering from either a slight or serious illness or injury. The aims of first aid are to give the initial treatment a person obtains after an injury, accident or when a person becomes ill at work. On the other hands, first aid facilities deal with detecting all the dangers and risks in the work environment that can lead to injury or harm to the health of people at the workstation [17]. The construction sectors are identified most of the hazardous zone than other industries. Therefore, First aid facilities are

more essential for this industry. Due to lack of first aids facilities illness or injuries, pains become worse. Finally, the workers may also die.

Bad working layout

Layout refers to the arrangement all the equipment, supplies, procedures and personnel in the space that can be utilised at supreme efficiency. The construction industry needs facilities as heavy material handling as well as heavy equipment to perform construction activities. The bad working layout of construction industry relates the inadequate space in construction sites, material places in the wrong location, machinery and equipment wrongly positioned. This type of working layout plays an effect on the workers' productivity and frequently leads to injuries.

Safety facilities

Due to hazardous situations, health and safety are particularly important in construction industries. The employers reported in 2015/16 that, slips, trips, and falls caused a large percentage of accidents on the construction spot [18]. Lac of safety facilities can lead to a vast loss in working hours and mean that workers are hopeless within their work locations. However, many construction workers also injured during lifting, climbing, and handling or falling from a height. In UK the portion of construction workers who suffer from a work-related injury and work related sickness are 3% and 4% respectively [18].

1.5.5 Equipment related factors

Due to high physical work demand and manual handling, tasks in construction industry workers used different types of equipment and machinery. The bad working tools and equipment and the characteristics of machineries can lead to various injuries. The most of the equipment and machine-related hazards in the construction industry are vibration (from the engine, machine, and equipment), excessive force need to operate the equipment, unfitted design of hand tools, and equipment, PPE (Personal Protective Equipment).

Vibration

Vibration is the movement or oscillation of the body in one fix point. The uses of power tools or equipment create vibration. The construction workers use different types of power and motorized equipment that cases to vibration. Whole-body vibration can also vibrate during working with heavy machinery and vehicles. The authors revealed about 63% of workers commonly exposed

to vibration at construction trades [19]. Vibration experience is also associated with different types of injuries. It may include as hand-arm vibration syndrome, which damages the nerve and blood vessels [8].

Excessive force need to operate the equipment

Force is the amount of physical exertion required to execute a task or to control of equipment or tools. The excessive force that a worker applies on an object that, consider a risk factor. Workers impose high force to perform the construction activities like lifting, lowering, climbing, carrying, pushing or pulling and griping the objects. Through excessive force, the body muscles are contracting much harder than normal. This can lead to fatigue, injuries or pain and stress on the muscles, tendons, and joints. It also causes injuries on following body parts like shoulders, neck, low back, wrist, and hand.

Unfitted design of hand tools and equipment

Generally, hand tools and equipment are non-powered tools. The most common hand tools used in the construction industry are hammers, float, head pan, hoe, and putty knife, spade, trowel and so on. Proper designed hand tools and equipment help to work easy. When the workers use hand tools and equipment incorrectly then it carriage a safety risk. The design and situation of tools can emphasize any discomfort and lead to more symptoms that are serious or other injuries. Workers use hand tool every day and maximum forget to take precautions for safety. Thus, they are frequently suffering from tools related injuries [20].

PPE (Personal Protective Equipment)

PPE (Personal Protective Equipment) is equipment that will protect the wearer against health or safety risks on the workplaces**.** It can include as goggles, safety helmets, gloves, eye protector, safety footwear, clothing, etc.. It reduces employee exposure to hazards and risks to an acceptable level [21]. Due to a high-risk site in construction, workers may suffer a vast of injuries as well as death. Only proper use of PPE can reduce or eliminate the most type of danger and injury in the workplace.

1.6 Accident related injuries

Accidental injury refers to an injury that is the outcome of an unexpected and unfortunate catastrophe. The most common accident occurs in the construction site due to fall the workers from the height, falling objects on the worker's body, electrocution, slip and falls, scaffolding

accidents, power tool, and machinery, ladder accidents, etc.. The accidents in the construction site cause a number of severe injuries. Frequently workplace accidents cause to workers death. The accident also causes injuries, partial or permanent disability to the workers. Some of the accidental injuries among construction workers are broken or fractured bones, burns from fires or electrocutions, cuts from the machinery or tools, shoulder, knee or ankle pain, spinal cord damages from falls, brain injuries, etc. Among all the most of the accidents are caused by workers negligence, unsafe workplaces, wrong use of tools and equipment, and lack of sufficient protective precautions.

1.7 Background of the study

As a developing country, the construction industries and high-rise buildings in Bangladesh are increasing day by day. According to the construction workers Union and Real Estate and Housing Association of Bangladesh (REHAB), about 3.5 million people work in the construction industry of Bangladesh [22]. As reported by the International Labor Organization (ILO) about 24,500 workers died each year in Bangladesh due to work-related diseases in all sectors. It also estimated that approximately 8 million workers faced work-related injuries. Among them construction workers are more than 40% [23]. Bangladesh Occupational Safety, Health, and Environment Foundation (OSHE) reported in 2018 that, number of workplaces death and injuries are 898 and 314 in several sectors in Bangladesh. Among them, 163 died in the construction sector, and 262 became injuries [24]. Based on the evidence construction workers in Bangladesh are working in a hazardous and risky environment. Based on the Bureau of Labor Statistics, approximately 150,000 construction workers are becoming injures due to accidents per year [25].

The frequencies of work-related musculoskeletal disorders (WMSDs) among the construction workers in neighboring countries of Bangladesh are shown in table-1. Among the mentioned countries, Malaysian construction workers (80.1%) are most sufferers from WMSDs. On the other hand, the workers (41%) of the Hong Kong are the least suffer from WMSDs.

The documentation on work-related musculoskeletal disorders (WMSDs) among the construction workers in Bangladesh is rare. It may present in the literature but unfortunately, the author did not find in the electronic databases.

Table 1: The frequencies of WMSDs among construction workers in neighboring countries of Bangladesh

Authors	Country	Frequency of WMSDs
Nirmala C.J, and Dharaneesh Prasad, S [26]	India	48.57%
Ahmad Alghadir and Shahnawaz Anwer [3]	Saudi Arabia	48.5%
Ullah et al [27]	Pakistan	81.3%
Jazari et al [28]	Iran	53.3%
Wen Yi and Albert Chan [29]	Hong Kong	41%
Muhamed et al [30]	Malaysia	80.17%
Thin N. N. A et al [31]	Thailand	53.4%

1.8 Thesis objectives

It is evident from the literature review, most of the researchers conducted several cross-sectional studies to evaluate the occurrences of work-related musculoskeletal disorders among construction workers. Those studies evaluated the various risk factors that lead to musculoskeletal disorders among the workers. However, there is a lack of studies, which evaluate the ways to remove or reduce the work-related musculoskeletal disorders (WMSDs) and accidental injuries from construction workers. This study will help to identify the ways and agents those are responsible for the occupational and accidental injuries among the construction workers. Therefore, the main objectives of this study are as follow:

i. To evaluate the prevalence of work-related musculoskeletal disorders among the construction workers in Jashore, Khulna, and Satkhira, Bangladesh.
ii. To investigate the factors, which are responsible for those injuries
iii. To identify the ways to minimize the work-related musculoskeletal disorders (WMSDs) and accidental injuries from construction workers.

1.9 Limitations of this study

This cross-sectional study has some limitations. The study conducted only the construction workers at Jashore, Khulna, and Satkhira, Bangladesh. The workers selected only in building constructions trades and their tasks were mixing cement and sand, lifting and carrying the load, bricklaying, plastering, iron-related work, concrete laying, and few others trades. These participants might not be working other works along with the construction's tasks. Author did not ask the contributors about any previous medical/surgical history that could cause MSDs. The duration and intensity of the pain did not find out.

1.10 Thesis outlines

The thesis is structured as follows: Chapter II presents the literature review related to work-related musculoskeletal disorders among construction workers in the different site and places. Chapter III describes the research methodology. The results and discussions are presented in chapter IV. In chapter, V shows the conclusions and recommendations.

CHAPTER –II

LITERATURE REVIEW

2.1 Literature Review

Maximum construction activities are performed manually. The workers perform these activities by prolonged standing, high repeating, heavy body movements, and irregular body postures. Continuous and lasting exposure to these tasks leads to Work- related Musculoskeletal Disorder. Work-related musculoskeletal disorders (WMSDs) are the impairments of body musculoskeletal systems. Thereby, Work-related musculoskeletal disorders (WMSDs) have become one of the most common health problems among the construction workers [32].

Baba et al conducted a study among 60 male construction workers in Malaysia. Their main daily tasks were housekeeping, plastering, bricklaying, and skim the coating [33]. Their study showed the majority (66.7%) of construction workers reported that they are a high prevalence of musculoskeletal disorders (MSDs). They also reported that the duration of work was significant associations (P = 0.023) with MSDs [33]. Ahmad and Shahnawaz conducted a study on 165 construction workers in Saudi Arabia [3]. They found that 48.5% of the responding workers are experiencing MSDs symptoms. Low back pain (50%) is very high over knee pain (20%) among the responders. They found the average intensity of pain 6.65 during activity and 3.59 during rest time. They also revealed the rest time, work experience, and use of protective equipment act as risk factors.

Chakraborty et al conducted a cross-sectional study on 268 Indian construction workers to evaluate the work-related stress levels, the prevalence of MSDs and Quality of life [34]. They retrieved the data from six categories workers as groups like masons and concrete workers (21.64%), reinforcement (9.7%), carpenters (23.13%), loading-unloading (17.9%), laborers (17.9%) and others (fitters, plumbers, electricians, crane operators, roofers) (9.7%). They found the long working time and high stresses lead to musculoskeletal pain in the body parts. Das et al reported that psychosocial factors such as work style, workload, work stress associated with work-related musculoskeletal disorders (WMSDs) [35].

Jazari et al investigated the work-related injuries among 850 Iranian construction workers. They reported that most of the construction workers are suffering from different types of injuries as

occupational injuries (31%), eye diseases (34.1 %), musculoskeletal disorders (53.3%), and skin diseases (30.1%). They also identified the demographic factors (age, education, experiences, employment status) are significantly associated with work-related injuries [28].

Wang et al showed work-related musculoskeletal disorders among construction workers in the USA is higher than other industries. The older workers are most sufferers than the youngers. One of the main causes of this injury is overexertion. More than 40% of workers claimed that back is the most affected body region by work-related musculoskeletal disorders [36]. Suzila et al documented some activities that affect on the musculoskeletal disorder among the bricklayers. These activities were mixing and spreading cement mortar, lifting and laying bricks. They observed that bricklaying workers at the construction site suffered hands, shoulders, wrists, thighs, back, and knee pain due to body movement. The main causes behind these pains were twisting the body, work in an awkward posture, and the high repetition [13].

Leung et al reported that most of the construction workers (76.2%) in Taiwan were suffering from musculoskeletal disorders. Among them 47% of workers reported, they had high work-related symptoms at shoulders. Total 43.8% of the workers had neck pain and only 38.1% of workers blamed they had a low back symptom. Construction workplaces have been considered as highly stressful and risk a zone for the workers. As a result, the injury incident rate and stress level among construction workers is high [37].

Paridaa and Kumar identified 30 ergonomic factors that affected on the construction worker's performance in India. These factors were classified under the following three primary categories: (i) human/labor-related factors, (ii) task-related factors and (iii) equipment/tools-related factors based on various age groups and occupations of the construction workers. These factors are responsible for most of the work-related injuries. They suggested implementing the ergonomics interventions in construction sites to minimize the worker's injuries and accidents [38].

Muhammad Shafique and Muhammad Rafiq reported that the construction site is one of the most hazardous places for the workers compared to other industries in Hong Kong. They showed that most of the accidental injuries occurred among construction workers due to fall the person from the height and slip, trip or fall on the same level. Incorporated the effective management with advanced technologies is main causes of these fatalities [39].

Christopher Edet Ekpenyong and Udoinyang Clement Inyang conducted a study among 1200 construction workers in Nigeria. They found the overall prevalence of musculoskeletal disorders were 39.3%. The workers reported that they suffered from different body parts as neck (48.2%), trunk (25.3%), lower body (26.5%) and 36.85% for the multiple body locations. Meanwhile, the reasons as physical factors (41.6%) founded the greatest risk; followed by psychosocial (29.5%) and individual (28.9%) factors are associated with the MSDs [10].

Saedpanah et al selected total 150 of construction workers from three tasks as wall plastering, bricklaying, and concrete lying. They found 92% of wall plastering workers suffered from back pain. Shoulders pain (84%) was the second-highest symptoms over hand, neck, leg, and wrists pain. Most of the bricklaying workers (83%) suffered from back pain over shoulders, neck, hand, elbows pain. The concrete laying workers (94%) also reported they had back pain. They concluded that excessive forces, vibration, contact stress and working time are associated with these work-related musculoskeletal problems [40]. The construction activities also causes to ergonomic risk and injuries among the workers. These activities are carrying the loads, repetitive body movement, work in awkward positions and contact stress vibration [41].

Rahman et al and Hossain et al studied in two-difference cross-sectional study and showed types of works are statistically significant with MSDs [12, and 45]. Researchers found that working in the wrong posture and repetition of body movement are associated with body pain among the workers [12, 16 and 47]. Ratri Parida and Pradip KumarRay reported that static posture and high workload effect on performance of the construction workers in India [38].

Romuald et al reported that good working environment, personal protective equipment, teamwork, use of mechanical aids, job rotation, daily exercise, fitting hand tools, proper training and technique, awareness about physical health and safety play an important role in controlling the musculoskeletal injuries among the construction workers [42]. Based on the Occupational Safety and Health Administration (OSHA), fall from the height, struck by the objects, electrocutions and caught by an object are considered as the main causes of the accident in the construction industry [43]. Muhammad Shafique and Muhammad Rafiq revealed similar results among Hong Kong construction workers [39].

Vikram et al conducted a study to evaluate the postural risk level among building construction workers in India. In this study, they used Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) as ergonomic tools to assess the awkward posture. They found

the REBA score 11 and 13 for brickwork and plastering work. They also found RULA score 7 for both bricklaying work and plastering work. From these evidences, it can be conclude that, workers at building construction work in awkward postures and in a high-risk zone [44].

Researchers found an average REBA score as 9.25 for sawmill workers in Bangladesh. They also reported the REBA score for carrying and lifting tasks as 10 and 11 [45]. Vikram and Devalkar analyzed the various activities on building construction by REBA. They found all the particular tasks were at the high-risk level and recommended to changes the posture. They also reported the REBA score for bricklaying and plastering were 11 and 12 respectively [44]. Hari and Apsari applied REBA to analysis the posture of Indonesian construction workers. They found REBA score for cement mixing and tiles fitting as 8 and 11 respectively. Based on REBA risk level sheet, which is high and very high-risk zone separately. Consequence the workers need the change the posture as much as possible [46]. Kathiravan and Gunarani revealed the poor body posture as risk factors for Work-Related Musculoskeletal Disorder among Indian construction workers. They reported 85% of workers (construction) are in medium risk zone and 15% of workers are in high-risk zone based on REBA sheet. They also appeared with the concreters are the highest risk of MSD over masonry and material handling workers. On the other hand, plastering workers were in the lowest risk zone [47].

CHAPTER –III

RESEARCH METHODOLOGY

3.1 General

To fulfill the objectives of this study, a cross-sectional survey study has been conducted with 450 construction workers from different construction sites at Jashore, Khulna, and Satkhira, Bangladesh. A cross-sectional study refers to analyze the data from a population or sample within a specific point of time. All variables remain the same over the study period. The following steps (figure-1) have performed to meet the objectives of this study.

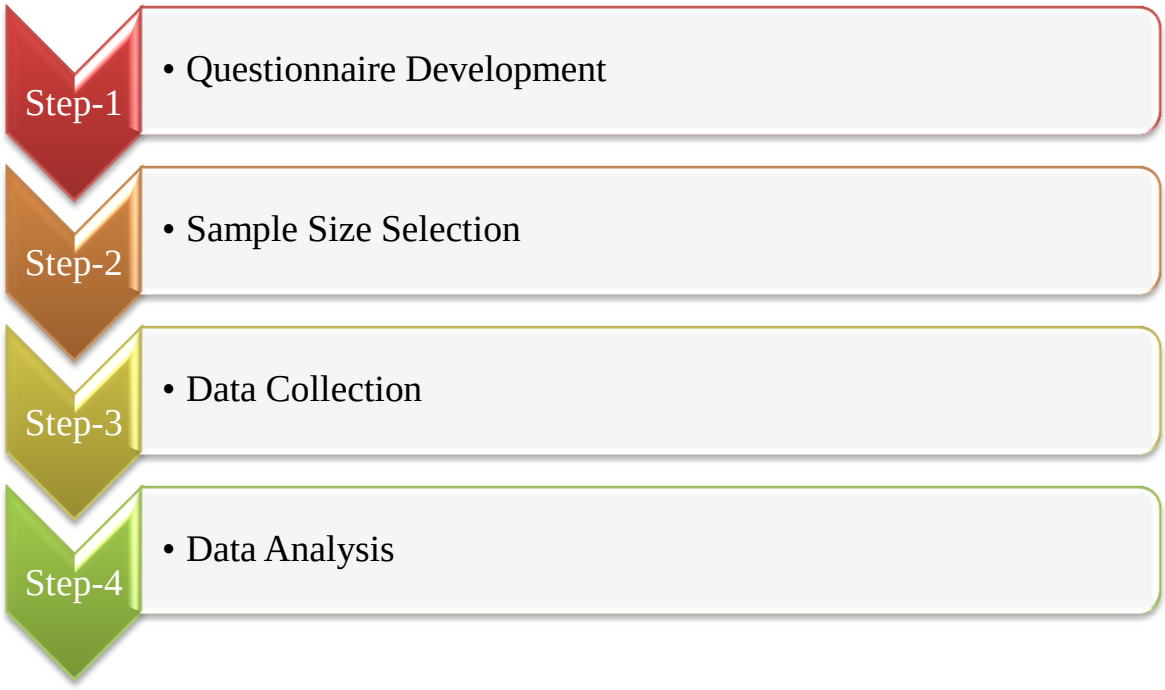

Figure 1: Methodology flowchart.

Step -1: Questionnaire development

Keeping in mind the objectives of the study, the author made a primary survey and informal discussion with some workers in order to develop a final questionnaire with variables of interest. Based on the primary survey and knowledge gathered from the workers a set of questionnaire were prepared. Before making the final Questionnaires, a pilot test conducted in some construction sites. All the questionnaires are two categories viz open-end and yes/no type. This pilot test was helpful to find the gaps and to locate faulty questions and statements in the final survey. Based on the results from pilot test necessary additions, alterations and adjustments were

made in the final questionnaire. The Modified-Standardized Nordic Questionnaire (MNDQ) also adjusted with the final survey questionnaires (Appendix–I). The Standardized Nordic Questionnaire is a set of questions, those analyses the musculoskeletal injuries from the ergonomic point of view. It uses to assess the nature and severity of work-related musculoskeletal injuries through either self-reported or face to face interviews. Besides, the Modified-Standardized Nordic Questionnaire (MNDQ) is used to identify the musculoskeletal pains over the previous year [48]. This questionnaire helps to identify the musculoskeletal problem among the nine body parts (wrist, hand, elbows, shoulders, neck, upper back, lower back, knee, and ankles).

The final survey questionnaire had four sections. The first part included socio-demographic characteristics such as gender, age, experiences, working hours, smoking habits, body mass index (BMI), educational level, marital status, monthly income, types of work. The second part included musculoskeletal disorders related information of nine body parts of the workers. A photo sketch of the human body delivered to identify the affected area (Appendix –II). The third part included the different risk factors related to physical factors (awkward working posture, static posture, repeated work, heavy load, high work stress,) environmental factors (air temperature, noise from the engine, machine and equipment, first aids facilities, bad working layout, safety facilities), equipment factors (vibration, excessive force, fitness of hand tools and equipment, Personal Protective Equipment). The fourth part contained questions related to the effect of accidents and causes of the accidents. At last, the data were collected through the finalized version of questionnaires.

Step-2: Sample size selection

An acceptable sample size is very important for a cross-sectional study. It is also helpful to find a good accuracy outcome [49]. Keeping this in mind, in this cross-sectional study, a total of 450 construction workers were selected randomly from the different construction sites at southern region of Bangladesh such as Jashore, Satkhira and Khulna (Figure-2).

Figure 2: Data collection sites (Jashore, Khulna, and Satkhira).

Therefore, the following simple selection formula was selected to find the sample size of this study [50].

$$N = \frac{Z^2 * P * (1-P)}{C^2} \quad \text{.....} \quad (1)$$

Where N is the expected sample size, Z is the statistic corresponding to the level of confidence, P is percentage picking a choice, expressed as decimal and C is precision (confidence interval). The level of confidence (LC) denotes the probability that the mean value places in the stated interval. On the other hand, the confidence interval (CI) is the margin of error. This is the plus or minus number that is often reported with an estimated proportion [51].

With the 95% level of confidence (LC), 50% is picking a choice and 5% confidence interval (CI) the sample size was 384.16. Here the value of statistics (Z) with a 95% level of confidence is 1.96. To facilitate the subcategory analysis and for the convenience of data collection, 450 individual worker was selected in the study.

Step-3: Data collection

In this study, face-to-face interview (Appenix -III) was conducted on construction workers to collect the data using the questionnaire form. The interviews were done individually in their worksite. The time take for interview was between 15 to 20 minutes. Videos of different types of

work were also taken to analysis the body movement and different working posture of the interviewed workers. The interviews and videos were taken with permission of the project managers as well as from the contractors of different construction sites. Snapshots of critical body postures were taken from the video. These snapshots were used to analyze the body posture. The Ergo Fellow version-6 was used to analyze those snapshots. The author collected the data during the worker's free time within 8 am to 6 pm at the construction sites.

Step-4: Data analysis

Keeping the objectives in mind, the author performed two types of analysis, which included as Statistical analysis and Posture analysis.

Statistical Analysis

A statistical analysis has made to find out the relation between worker's body injuries and different types of risk factors. For this purpose, descriptive analysis of socio-demographic information has performed as maximum; minimum; mean and standard deviation for continuous variables. Frequencies and percentages were derived for categorical variables. To find out the relation between various risk factors and musculoskeletal discomforts, a chi-square (x^2**)** test has performed. Generally, the chi-square test has been used to identify the relationships between categorical variables and the depended variable. In the chi-square test, the null hypothesis is that there are no relationship presents on the categorical variables. In statistics chi-square value is calculated based on equation 2.

$$X^2 = \sum \frac{(V_o - V_e)^2}{V_e} \quad \ldots\ldots (2)$$

Here, X^2 = Chi-square calculation value, V_o = means observe value and V_e = means expected value.

In this study, work-related musculoskeletal disorders and various risk factors have considered as depended variable and independent variables respectively.

All analyses have performed through SPSS (Statistical Package for the Social Sciences) version 25. In SPSS, the output of the chi-square test is considered as Pearson chi-square. The Chi-square distribution compares the actual value against a critical value. In statistics, degrees of freedom (DF) play an important role. It indicates how the number of independent values varies in an investigation without changing any restraints. For the chi-square, the equation number 3 is used to calculate the degrees of freedom.

$$DF = (r - 1) * (c - 1) \ldots\ldots (3)$$

Here, DF = Degrees of freedom, r = number of rows, and c = number of column.
However, in SPSS provide a P-value to simplify the test. The P-value less than 0.05 with 95% level of confidence consider the chi-square statistics. The P-value less than 0.01 with 99% level of confidence also consider the chi-square statistics. It may indecate that the variables are dependent on each other and there is a statistical association between them [52].

Posture analysis

Work in natural posture is one of the main ergonomics principles. Awkward working postures have considered as risk factors for work-related musculoskeletal disorders. It leads to fatigue, injuries, and stress on musculoskeletal systems. To find the postural risk level among the construction workers the Rapid Entire Body Assessment (REBA) worksheet has been used. The Rapid Entire Body Assessment (REBA) [53] is an ergonomic tool which is used to assess the postural risk level of various critical tasks of a job. In Rapid Entire Body Assessment (REBA) worksheet, the human body is divided into two groups as group A (Trunk, Neck, and Legs) and group B (Upper Arms, Lower Arms, and Wrists) postures for left and right (Appendix-IV). A score is assigned for group A by adding table-A score and the Load/Force score. The load/force score is chosen as zero for load < 5 kgs, 1 for load is between 5-10 kgs, and 2 for load more than 10 kgs. On the other hand, a score is assigned for group B by adding table B and the Coupling score for each hand. The coupling score is selected as zero for well design handle, 1 for acceptable but not ideal, 2 for poor designed, 3 for not acceptable but possible to hold. The score for table C is calculated by combining the score A and score B. Finally, the REBA is calculated by adding activity score with score C (figure-3). The activity score assigns as 1 for the static position, 2 for repeating the body in a small range, 3 for rapid change the body posture. Lastly, the posture factors are assessed as a score to each region for each task. The degrees of risk associate with REBA scores have shown in table-2.

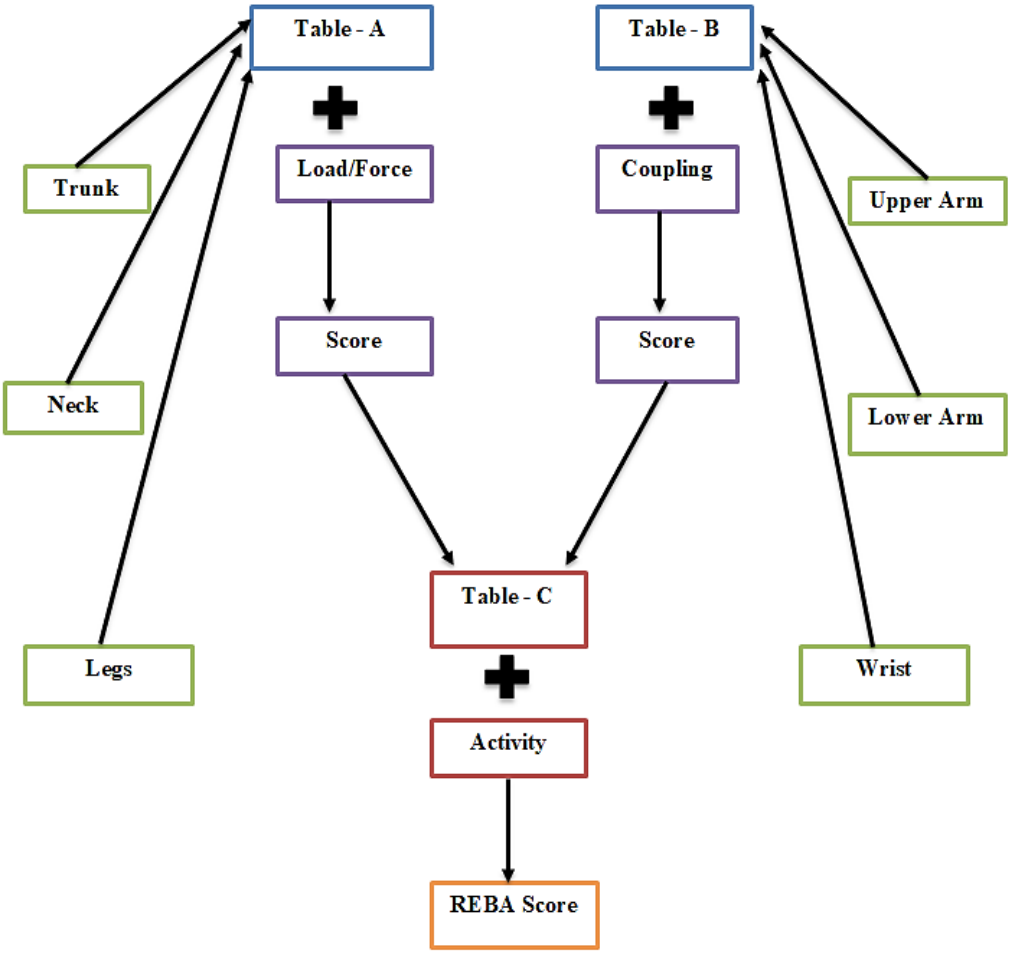

Figure 3: REBA score assessment chart.

Table 2: REBA score and associated risk level.

REBA Score	Risk Level	Action
1	Negligible	None necessary
2 – 3	Low	May be necessary
4 – 7	Medium	Necessary
8 – 10	High	Necessary soon
11 – 15	Very High	Necessary now

CHAPTER- IV

RESULTS AND DISCUSSIONS

4.1 Socio-demographic information

The general characteristics of participants (N= 450) have shown in table-3. It shows that the mean age of the interviewed workers were 34.20 years (SD = ±11.60). The maximum age of the participant was 65 years. There were no workers less than 18 years. The mean working time was 9.17 hours (SD = ±1.10). It was nearby at standard working hours. According to the International Labor Organization (ILO), the standard daily working hours is eight [54]. The mean body mass index (BMI) was 23.91 kg/m^2 (SD = ±3.04) which indicates that maximum workers were in normal ranged. A BMI of 18.5-24.9 indicates a healthy weight with respect to height. A body mass index (BMI) below 18.5 refers to the underweight. A BMI within 25-29.9 considers as overweight. Finally, a body mass index (BMI) of 30 or above means the obesity with respect to height [55]. Maximum working experience of the participants was 46 years with the mean 11.94 years (SD =± 9.46). The participants had taken who have at least one-year work experience.

Table 3: General characteristics of the workers (N = 450)

Factors	Minimum	Maximum	Mean	SD
Age (Years)	18	65	34.20	±11.60
Working time (Hours)	8	12	9.17	±1.10
Rest time (Hours)	1	2	1.09	±0.24
Work Experience (Years)	1	46	11.94	±9.46
Weight (kg)	44	91	61.44	±8.38
Height (meters)	1.40	1.80	1.60	±0.08
Body Mass Index(kg/m^2)	15.41	33.43	23.91	±3.04
Monthly working days	20	30	27.29	±2.17
Monthly Income (Taka)	6000	24000	12819.02	±38.72.13
Monthly medical cost(Taka)	0	800	269.53	±246.82
Absent Days in a month	0	7	1.93	±1.42

The minimum and maximum working days in a month were 20 and 30 respectively. The respondents' average monthly income was about Bangladeshi Taka (BDT) 12819. The participants spent an average of BDT 269.53 for medications due to MSDs pain. They also remained absent in the works maximum of 7 days (average 1.94) in a month.

A bar chart with mean and standard deviation bars is shown in figure 4. Here, the standard deviation bar is shown at the top of each bar.

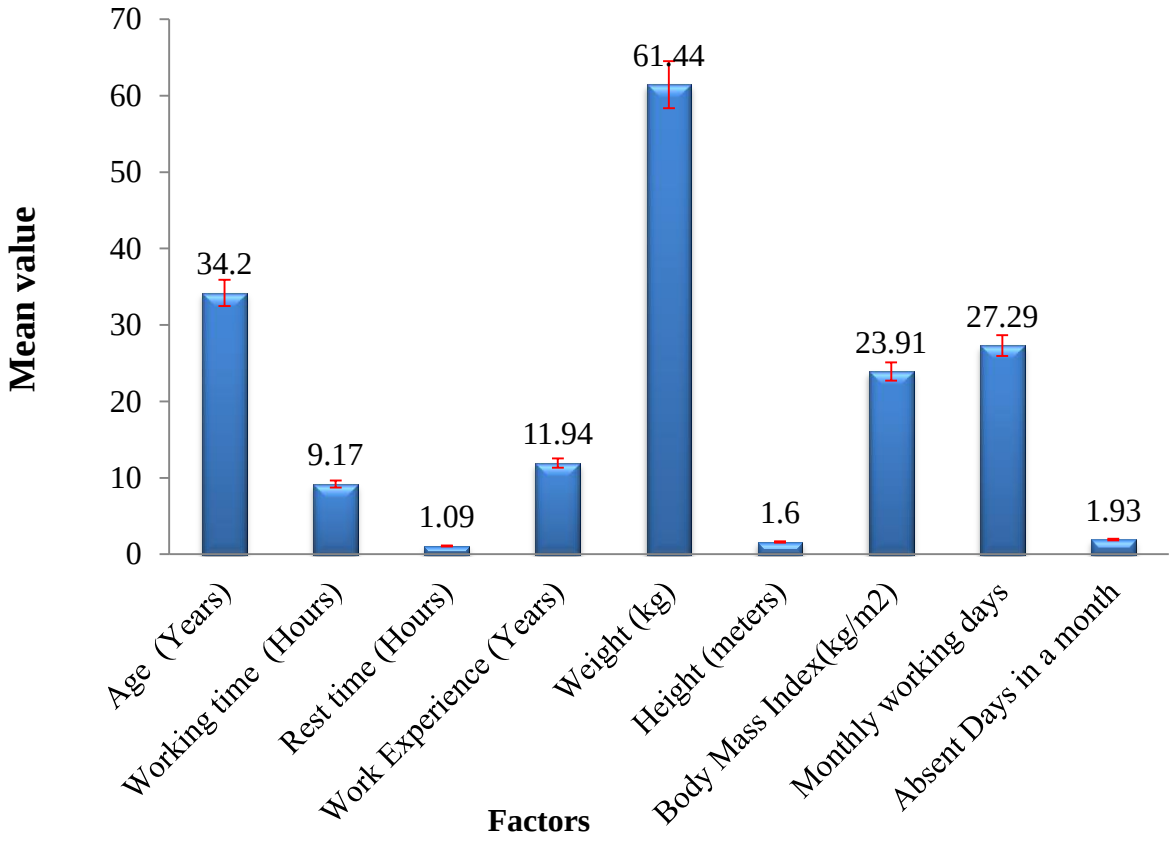

Figure 4: Bar chart with mean and standard deviation of socio-demographic factors.

Table-4 represents the socio-demographic information of the respondents. From the results, it can be found that only 88 (19.6%) responders were female. That is a lot less than male workers (80.4%) were. The maximum 47.9% of workers was age below or equal to 30 years. The age of 22.4%, workers were within 31 to 40 years. The age of 22.4% of workers was in middle-level range as 41-50. Only 7.3% of workers age was >= 51. Majority of the participants (63.3%) were in the normal BMI range. The body mass index (BMI) of over weighted workers was 30.5%. However, only 3.8% of workers were underweighted and 2.4% was obesity. About 53.3% of the participants were a smoker and 46.7% were a non-smoker. Most of the participants 75.1% were married and only 24.9% were unmarried. Majority of the participants (51.1%) had primary

education. About 22.9% of workers had taken secondary level education. About 21.6% of total workers were illiterate. Merely, 4.4% of workers had taken higher education.

Table 4: Socio-demographics information of the participants (N=450)

Back ground Factors		Frequency	Percent
Gender	Male	362	80.4%
	Female	88	19.6%
Age Group	<=30	215	47.9%
	31-40	101	22.4%
	41-50	101	22.4%
	>=51	33	7.3%
BMI Range	<18.5	17	3.8%
	18.5-25	285	63.3%
	25.1-29.99	137	30.5%
	>=30	11	2.4%
Smoker or Non-smoker	Smoker	240	53.3%
	Non-smoker	210	46.7%
Marital Status	Married	338	75.1%
	Unmarried	112	24.9%
Education Level	Illiterate	97	21.6%
	Up to Primary	230	51.1%
	Up to Secondary	103	22.9%
	Above	20	4.4%
Types of works	Mixing Sand and Cement	103	22.9%
	Lifting and Carrying mortar	51	11.3%
	Iron Work	63	14%
	Bricklaying	37	8.2%
	Plastering	43	9.6%
	Concrete Laying	67	14.9%
	Tiles fitting	21	4.7%
	Others	65	14.4%
Work experience (Years)	<=12	279	62.0%
	13-24	116	25.8%
	25-36	48	10.7%
	>=37	7	1.6%
Working Time Category	=<8	89	19.8%
	=>9	361	80.2%

Among the total participants of 103 (22.9%) worked as mixing sand and cement, 51(11.3%) lifting and carrying mortar, 63 (14%) ironwork, 37 (8.2%) bricklaying, 43 (9.6%) plastering, 67(14.9%) concrete laying, 21 (4.7%) tiles fitting, and 65 (14.4%) were performed others works. Maximum 62% of workers had up to 12 years of working experiences. About 25.8% of workers had experiences within 13 to 24 years. There were 10.7% of workers experienced within 25 to

36 years. Only 7 (1.6%) workers had high working experiences as >= 37 years. Most of the participants (80.2%) worked more than 8 hours per day. There was a few, 19.8% of workers worked below or equal eight hours in a day.

The prevalence of musculoskeletal symptoms among the participants represent in table-5. All the body parts are not equally affected due to occupational injuries. Based on the Modified-Nordic questionnaire, the symptoms represent only the nine parts of the body. Among the total participants of 316 (70.2%) reported that they had at least one symptom during last year. On the other hands, 29.8% of workers said that they had no musculoskeletal symptoms during their job life.

Table 5: The prevalence of musculoskeletal symptoms among participants (N =450)

Factors	Opinion	Frequency	Percent
Musculoskeletal Disorders	Yes	316	70.2%
	No	134	29.8%
Neck pain	Yes	81	17.4%
	No	369	82.6%
Shoulder pain	Yes	105	23.3%
	No	345	76.7%
Upper Back pain	Yes	119	25.5%
	No	331	73.5.0%
Elbows pain	Yes	78	17.3%
	No	372	82.7
Wrists pain	Yes	147	32.7%
	No	303	67.3%
Lower Back pain	Yes	224	49.8%
	No	226	50.2%
Thighs pain	Yes	43	9.6%
	No	407	90.4%
Knees pain	Yes	101	22.4%
	No	349	77.6%
Ankles pain	Yes	76	16.9%
	No	374	83.1%

About 17.4% of the participants said that they suffered from neck pain and 82.6% had no pain. Only 23.3% of workers felt pain in shoulders, and 76.7% had no pain in shoulders. About 25.5%

(119) of the participants blamed that they feel upper back pain during work. Almost 73.5% of workers did not suffer from upper back pain. Workers suffered from elbows pain, as 17.3% and 82.7% had no elbows pain. The wrist is one of the most contacted body parts with the work. As a result, 32.7 % of workers felt wrist pain during their work.

Table 6: Socio-demographic factors consequence of Musculoskeletal Disorders (MSDs).

Socio-demographic factors(N=450)	Group	Respondent Musculoskeletal Disorders (%)		Chi-Square value	P-value*
		Yes	No		
Gender	Male	266(73.5%)	96(26.5%)	9.40	0.003**
	Female	50(56.8%)	38(43.2%)		
Age Category	<=30	109(50.7%)	106(49.3%)	82.30	0.00**
	31-40	80(79.2%)	21(20.8%)		
	41-50	94(93.1%)	7(6.9%)		
	>=51	33(100%)	0(0%)		
BMI Category	<18.5	8(47.1%)	9(52.9%)	5.10	0.164
	18.5-25	201(70.5%)	84(29.5%)		
	25.1-29.99	100(73%)	37(27%)		
	>=30	9(81.8%)	2(18.2%)		
Work experience	<=12	158(56.6%)	121(43.4%)	67.10	0.00**
	13-24	103(88.8%)	13(11.2%)		
	25-36	48(100%)	0(0%)		
	>=37	7(100%)	0(00%)		
Working time	<=8	46(51.7%)	43(48.3%)	18.23	0.00*
	>=9	270(74.8%)	91(25.2%)		
Types of work	Mixing Sand and Cement	58(56.3%)	45(43.7%)	19.97	0.006*
	Iron work	46(73%)	17(27%)		
	Lifting and Carrying mortar	40(78.4%)	11(21.6%)		
	Bricklaying	30(78.9%)	8(21.1%)		
	Plastering	37(86%)	6(14%)		
	Concrete laying	43(64.2%)	24(35.8%)		
	Tiles fitting	15(71.4%)	6(28.6%)		
	Others	47(72.3%)	17(27.7%)		
Education level	Illiterate	84(86.6%)	13(13.4%)	4.67	0.159
	Up to Primary	153(65.5%)	77(33.5%)		
	Up to Secondary	67(65%)	36(35%)		
	Above	12(60%)	8(40%)		
Smoking	Smoker	190 (79.2%)	50(20.8%)	0.354	1.872
	Non smoker	126(60%)	84(40%)		
Marital status	Married	266(78.7%)	72(21.3%)	3.35	0.234
	Unmarried	50(46.6%)	62(55.4%)		

Significant at *P**<0.05, *P***<.01*

Most of the workers (49.8%) reported they had pain in the lower back. They also blamed that kneeling is the main reasons behind this pain. On the other hand, 50.2% of workers had no lower back pain. Least of workers (9.6%) suffered from thighs pain. Most of 90.4% of participants had no pain on their thighs. Due to kneeling, 22.4% of workers had suffered from knee pain. On the other hand, 77.6% of workers had no pain on the knees. Most of the workers (83.1%) did not have ankles pain. However, due to work in bare foot 16.9% of workers suffered from ankles pain.

Table 6 shows the socio-demographic factors consequence of musculoskeletal disorders of the construction workers in Bangladesh. Of the total respondent, the 73.5% male and 56.8% female suffered from MSDs. The chi-square and *P*-value for gender group were 9.40 and 0.003** respectively. It indicated that the gender was statistically significant with musculoskeletal disorders, and the level of confidence was 99%. The age interval of every ten years associated with the muscular symptoms. For this case, the P-value (0.00*) in chi-square test was significant with a 99% level of confidence. Most of the workers (100%) who have age above or equal 51 years suffered from muscular pains. The workers of indifferent categories ages strongly associated *(P = 0.00*),* with musculoskeletal disorders in construction workers. In this case, the level of significance was 1%.

The workers of different body mass index (BMI) as underweighted (<18.5), normal weighted (18.5-25), over weighted (25.1-29.9) are obesity (>=30) were not associated with musculoskeletal disorders. Majority of obesity workers (81.8%) reported that they suffered from MSDs. The working experiences of every twelve years were statistically significant with musculoskeletal disorders. With the 99%, level of confidence the chi-square P-value was 0.00**. Working skills and experiences play an important role in workers physical conditions. The workers in several experiences of construction work were statistically significant *(P =0. 00*)* with musculoskeletal disorders. The working hours of below or equal eight hours and equal or above nine hours lead to the worker's musculoskeletal disorders. The chi-square value of two categorical working times was 18.23. The p-value (0.00**) is statistically significant with the 95% level of confidence. The working hours of Bangladeshi construction workers were associated *(P = 0.00**)* with musculoskeletal symptoms.

The workers of several work trades suffered from work-related musculoskeletal disorders. The workers of selected trades were associated with MSDs. The physical movements are not the same for all tasks. The construction works involved different types of materials handling. Thus, the different types of construction works associated with workers physical discomfort. With 5%, level of significance the P-value in chi-square test for work types was 0.006**. In this study, the

results show that the educational qualifications do not effect on workers injuries. Although 86.6% of illiterate workers suffered from work-related musculoskeletal injuries yet it is statistically insignificant (P-value = 0.159) with MSDs. In this study, 53.3% (240) of the total workers had smoking habit. Among them, 190 workers had musculoskeletal symptoms. Although, taking drug cause injuries to health, but the chi-square p-value (0.354) indicates that smoking habits were not significant with musculoskeletal disorders of the workers. Among the total participants, 73.2% (281) of the workers were married. The married (266) and unmarried (50) workers informed that they feel different types of musculoskeletal injuries. The chi-square statistics shows that there is no relation between marital status and work-related musculoskeletal disorders in Bangladeshi construction workers.

4.2 Main causes responsible for Musculoskeletal Disorders (MSDs)

Figure 5 represents the cause and effect diagram that shows main possible causes behind the musculoskeletal disorders. The Cause-and-Effect Diagram is a diagram that helps to identify, sort, and display the possible causes of a specific effect or problem. In a cause and effect diagram, the main problem or issue typically sit in a box on the right edge of the page. A Centre line extends to the left of the main box. The main factors locate the up and down of the centerline within boxes. The sub-factors of the main factor locate in the left or right of the main factors. All the factors (main or sub factors) consider the causes of the problems. The major causes in cause and effect diagram are person, method, machine, materials, and environment [56].

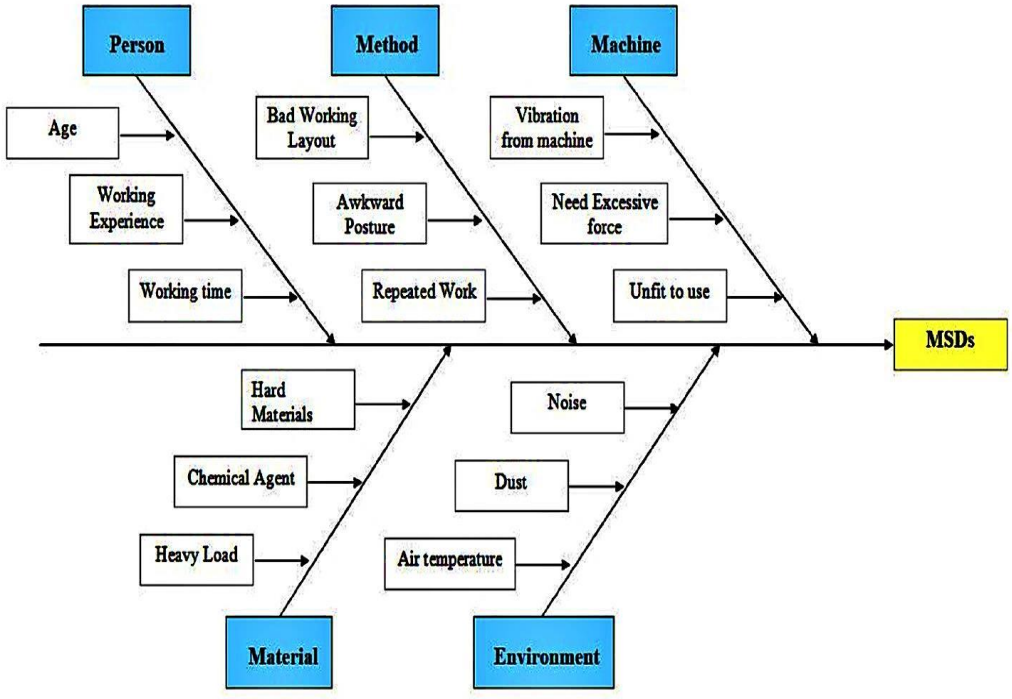

Figure 5: Main causes for MSDs.

Age, working experiences, and gender are the main personal factors for musculoskeletal disorders. Hence, the older construction workers suffer the most. Women are suffering from work-related disorders more than male workers. Bad working layout and process, wrong working posture, and repetition are the main methodological factors of MSDs. Unfit tools and equipment, vibration from the engine or machine, the excessive force to operate the tools and machine are defined as machine-related factors.

Table 7: Risk factors related information (N=450)

Main Factors	Sub factors	Opinion	Frequency	Percent
Physical factors	Awkward Working Posture	Yes	226	50.2%
		No	224	49.8%
	Static Working Posture	Yes	170	37.8%
		No	280	62.2%
	Repeated Work	Yes	152	33.8%
		No	298	66.2%
	Heavy Load	Yes	107	23.8%
		No	343	76.2%
	High Work stress	Yes	60	13.3%
		No	390	86.7%
Environmental factors	Air Temperature	Yes	246	54.7%
		No	204	45.3%
	Noise from the engine, machine and equipment	Yes	45	10%
		No	405	90%
	First aids facilities	Yes	160	35.6%
		No	290	64.4%
	Bad working layout	Yes	174	38.7%
		No	276	61.3%
	Safety facilities	Yes	112	24.9%
		No	338	75.1%
Equipment factors	Vibration from the engine, machine and equipment	Yes	48	10.7%
		No	402	89.3%
	Excessive force	Yes	231	51.3%
		No	219	48.7%
	Fitness of hand tools and equipment	Yes	185	41.1%
		No	265	58.9%
	PPE(Personal Protective Equipment)	Yes	160	35.6%
		No	290	64.4%

The materials of heavy loaded, handle the hard and chemical materials in the construction sectors are lead to work-related muscular symptoms. High or low air temperature, dusty noise environment causes a significant effect on musculoskeletal disorders. Table 7 represents the occurrence of different factors that are responsible for work-related musculoskeletal disorders among the construction workers. In this study, various factors have categorized into three main domains such as physical factors, environmental factors, and equipment factors. The main domain factors are also divided into sub-domain factors.

All data of table 7 have been explained in detail through the figures 5, 6 and 7. Figure 6 shows that the various physical factors associated with the participant's MSDs. The highest 50.20% of workers blamed that most of the time they need to perform the work in abnormal postures. These are known as awkward working posture and lead to various musculoskeletal pains. The workers (37.80%) reported that they work in the same position for a long time. It includes standing, sitting, kneeling, etc. known as static working posture and causes to discomfort. About 33.80% of workers said that they do the work with the same motion repetitively for long periods. Therefore, they put stress on joints, muscles, and tendons that lead to injuries. Due to the fixed time for construction of projects, workers need to do the work for daylong. This high work stress (13.30% reported) also causes musculoskeletal injuries. In construction trades, workers carry the heavy weighted materials to work locations. It includes rod, sand, cement, mason, tiles, etc.. The workers (23.80%) told the heavy material handling lead to workers physical discomfort.

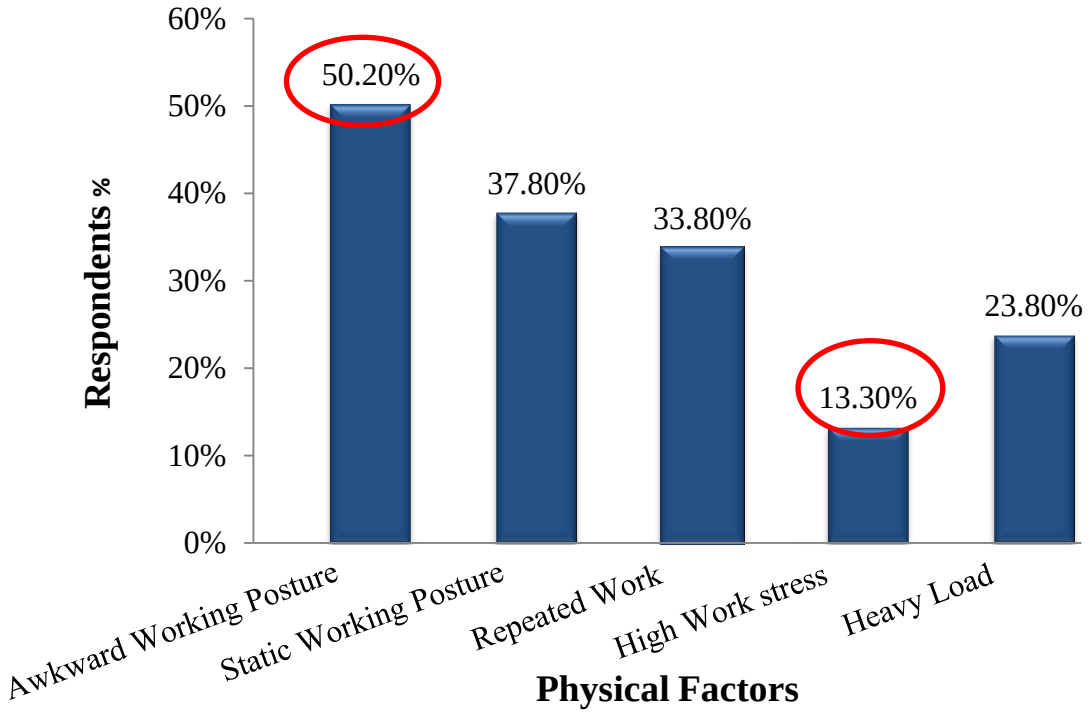

Figure 6: Physical factors associated with participant's respond.

Figure 7 shows the various environmental factors associated with the participant's responds. Most of the workers (54.70%) accused that air temperature in summer is highly associated with MSDs. High temperature causes various types of heat-related injuries. These are hit stroke, rash and death. A few workers (10%) reported they feel hearing problems during construction work. High sound coming from the engine during pilling and concrete mixing makes the workers hearing problem. The tiles and rod cutter machine also produce high sound. This type of high sound makes noise. The noise damages the auditory nerve and decreases the worker's efficiency. The aims of the first aid are to give the initial treatment a person obtains after an injury, accident or when a person becomes ill at work. In the absence of first aid, facilities may lead a person toward death. Finding shows, that worker (35.60%) suffered from musculoskeletal symptom due to absence of sufficient first aid facilities. The bad working layout of construction industry denotes the inadequate space in construction sites, material places in the wrong location, located the machinery and equipment in wrong places.

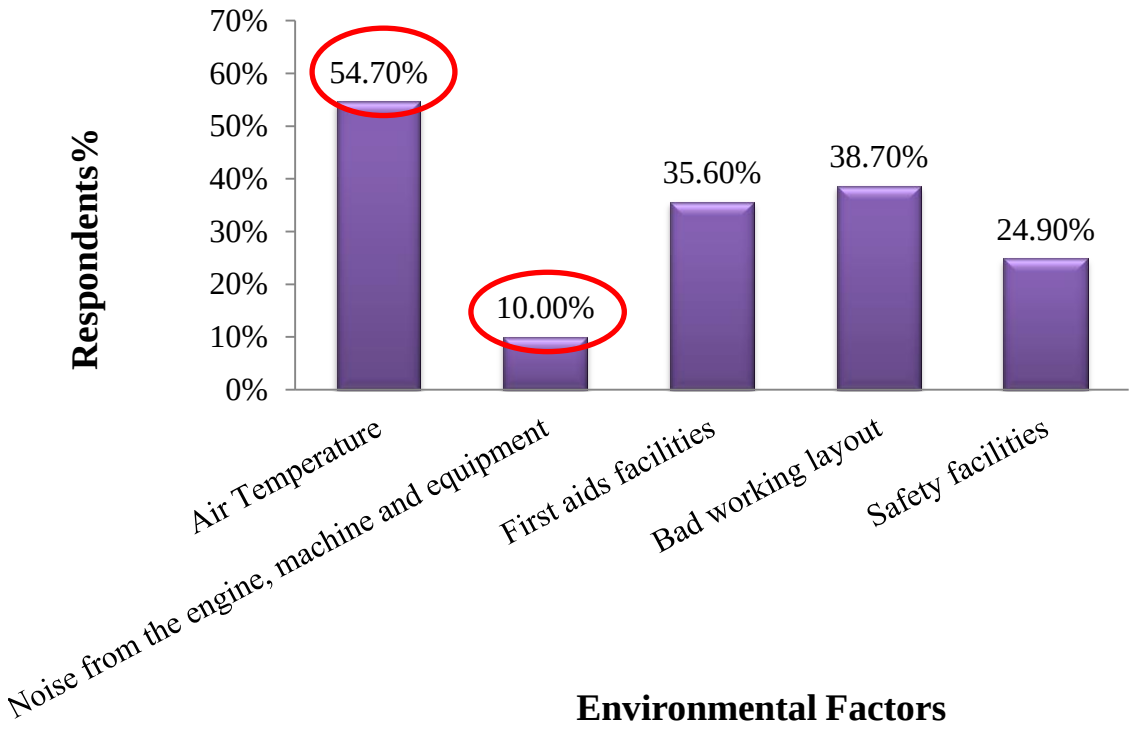

Figure 7: Environmental factors associated with participant's respond.

This type of working layout hampers the workers' (38.70% reported) productivity and causes injuries. As hazardous condition, safety facilities are very essential in construction sectors. Lack of safety facilities can lead to a vast loss in working hours and injuries. The workers (24.90%)

reported that they feel musculoskeletal disorders due to not having safety facilities in their workplaces.

Figure 8 describes the various equipment related factors associated with the participant's responds. Total 51% of workers reported that excessive force to operate the equipment and machine is responsible for MSDs. In the construction trades, workers exposed force during lifting, rod bending concrete laying and so one. This causes physical discomfort. Workers (10.70%) of this study reported that they feel musculoskeletal pain for vibration. This vibration induces during rod and tiles cutting, concrete laying and wall drilling. An ergonomic designed tool and equipment can help to perform the tasks easier and more comfortably. The improper designed tools and equipment causes low productivity and reduces workers performance. It is also responsible for different body parts injuries reported by 41.10% of workers. Personal protective equipment (PPE) helps to reduce employee exposure to hazards and risks to acceptable levels. PPE is the first and most important equipment for construction workers. Lack of personal protective equipment workers may face different types of accident and injuries. About 35.60% of workers had musculoskeletal symptoms due to not wearing the personal protective equipment (PPE).

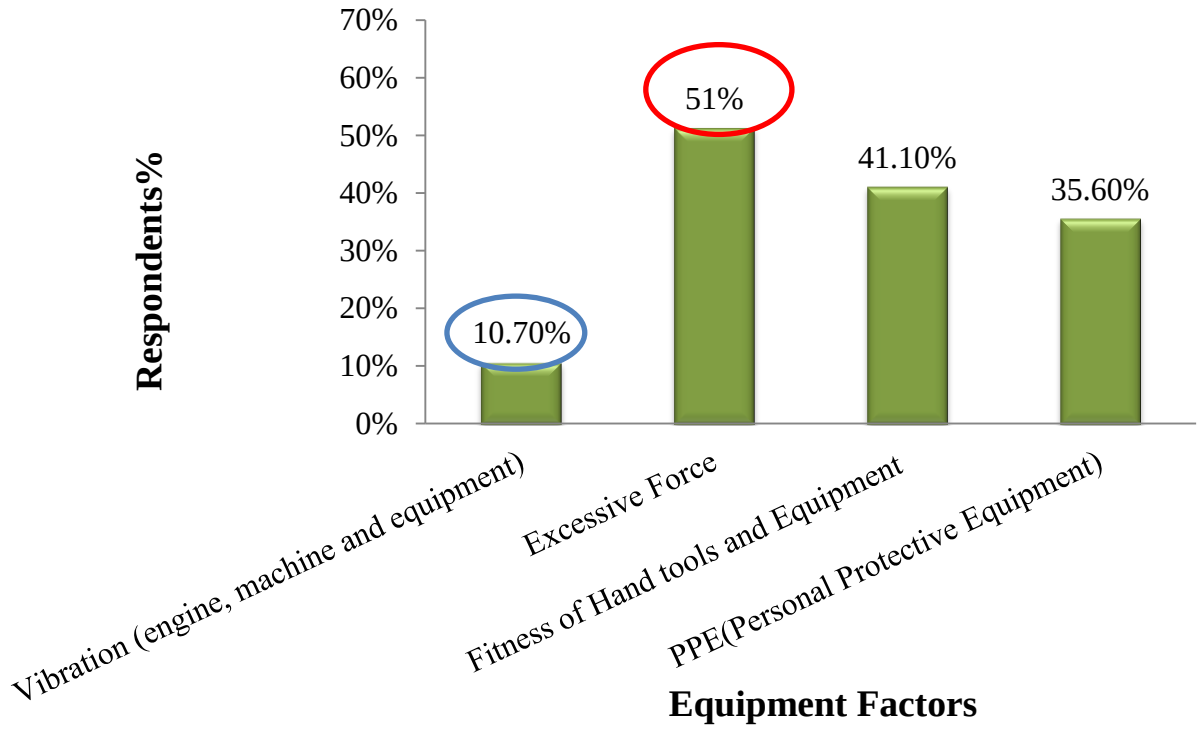

Figure 8: Equipment factors associated with participant's respond.

4.3 Ways to minimize the Work-related Musculoskeletal Disorders (WMSDs)

During data collection, a question was asked to the workers to know their opinion about the ways of minimizing the musculoskeletal pains. For this purpose, possible references were provided to the workers. Based on workers respond, figure 9 shows the ways to minimize the Work-related Musculoskeletal Disorders (WMSDs).

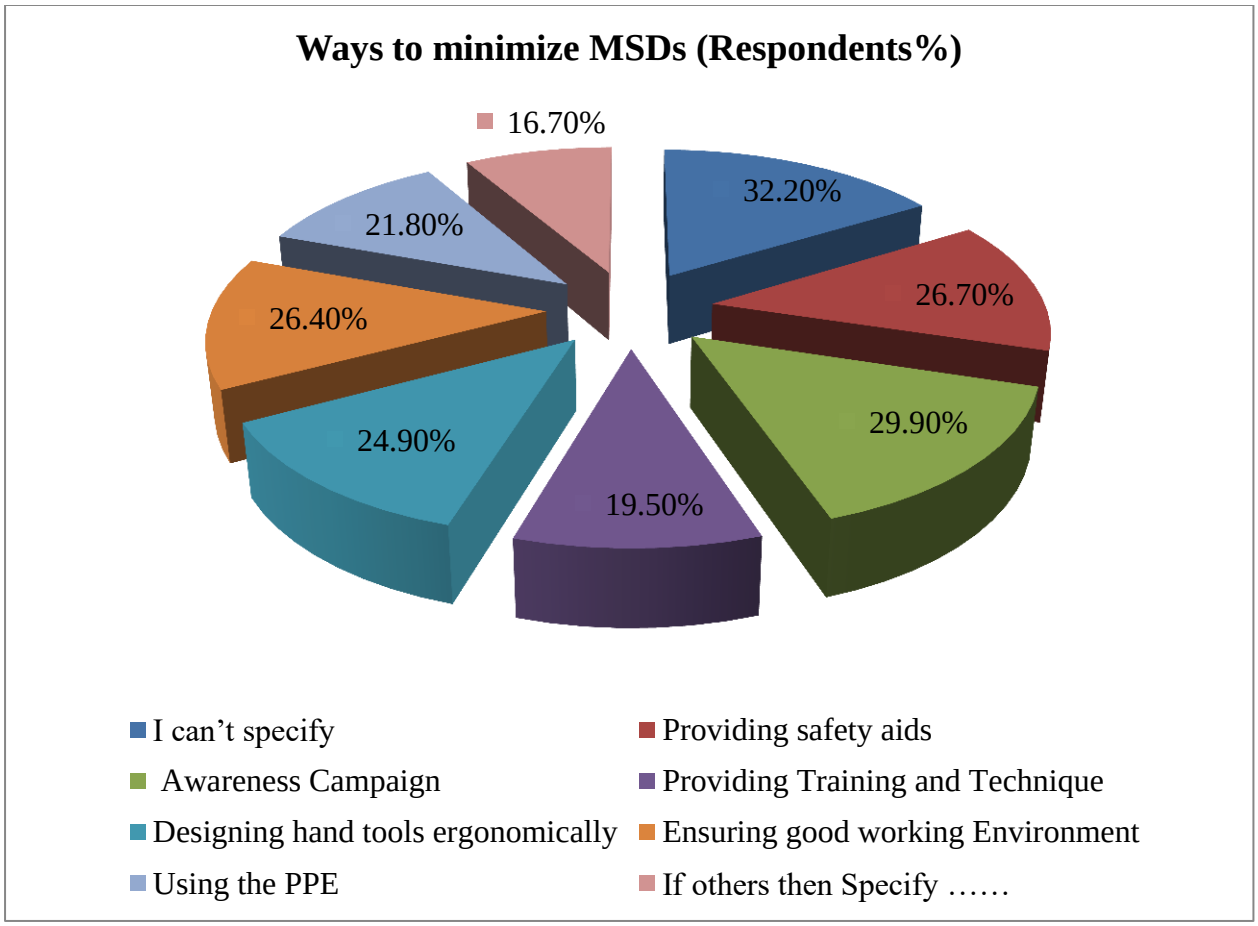

Figure 9: Ways to minimize the MSDs.

About 32.20% of workers did not specify the ways for reducing WMSDs. Among them 26.70% of workers reported, that safety aids should be provided that could reduce the work-related musculoskeletal symptoms. Most of the construction workers were illiterate. They are not conscious of their health and safety. Therefore, the awareness campaign (29.90% reported) about health and safety may help to minimize the accidents and injuries in construction sites. At the first beginning of the job, workers remain unskilled. They did not know the proper use of tools, equipment, and technique, as they did not get any brief before starting the work. As a result, they face many occurrences. Thus, 19.50% of participants suggested conducting proper training and technique to the workers before starting the job. That will help to reduce the number of accidents and injuries. An ergonomic design hand tool means fit for the hand. Unfit hand tools cause the

injuries on elbows, wrists, and fingers. It also reduces the worker's efficiency. Only ergonomic design hand tools (24.90% reported) could reduce hand's injuries and illness. The working environment plays an important role in workers safety and performances. Usually a hazardous environment in construction, industry leads to accidents and work-related injuries among the workers. Thus, 26.40% of the participant reported keeping the working environment as much suit for work. Personal protective equipment is the foremost equipment to protect the user from unexpected occurrences. Therefore, 21.80% of workers suggested that they should be supplied with personal protective equipment regularly to reduce injuries. Only 16.70% of the workers reported other ways such as medical facilities, job rotations, and exercise, mechanization the works, etc. could help to eliminate or to reduce the work-related musculoskeletal injuries.

4.4 Body postural risk factors

The result of postural risk analysis of selected tasks through the Rapid Entire Body Assessment (REBA) is shown in table-8. The REBA score of following tasks as mixing sand and cement, lifting, carrying, plastering, bricklaying, concretelaying, ironworking and tiles fitting tasks were 9, 10, 6, 10, 11, 11, 6, and 10 respectively. The average REBA score of the mentioned task was 9.13. It shows that MSDs seemed to be uppermost among the brick and concrete laying workers followed by lifting, plastering, tiles fitting and sand mixing workers. Carrying and ironworkers are the smallest affected among the eight tasks.

Table 8: Rapid Entire Body Assessment (REBA) scores

Task	REBA Score	Risk Level	Action
Mixing sand and cement	9	High	Necessary soon
Lifting	10	High	Necessary soon
Carrying	6	Medium	Necessary
Plastering	10	High	Necessary soon
Bricklaying	**11**	Very high	Necessary now
Concrete laying	**11**	Very High	Necessary now
Iron work	**6**	Medium	Necessary
Tiles fitting	10	High	Necessary soon
Average	**9.13**	high	Necessary soon

Among the selected tasks, the minimum REBA was 6 for carrying and ironworkers. This indicates the carrying and iron-related workers suffered in medium risk condition. Thus, the necessary action should be taken to improve the process or techniques. Figure-10(a) and figure-10(b)) show the working body posture and relative REBA scores for the sand and cement-mixing worker. Bending and twisting are the two awkward body postures of sand mixing tasks. The

arrows sign indicate the most affected body parts of the sand mixer, which are neck, shoulders, lower back, knee, elbows, and wrists. The angles of different postures have been used in rapid entire body assessment (REBA) analysis.

Figure 10 (a): Body posture of mixing the sand and cement task.

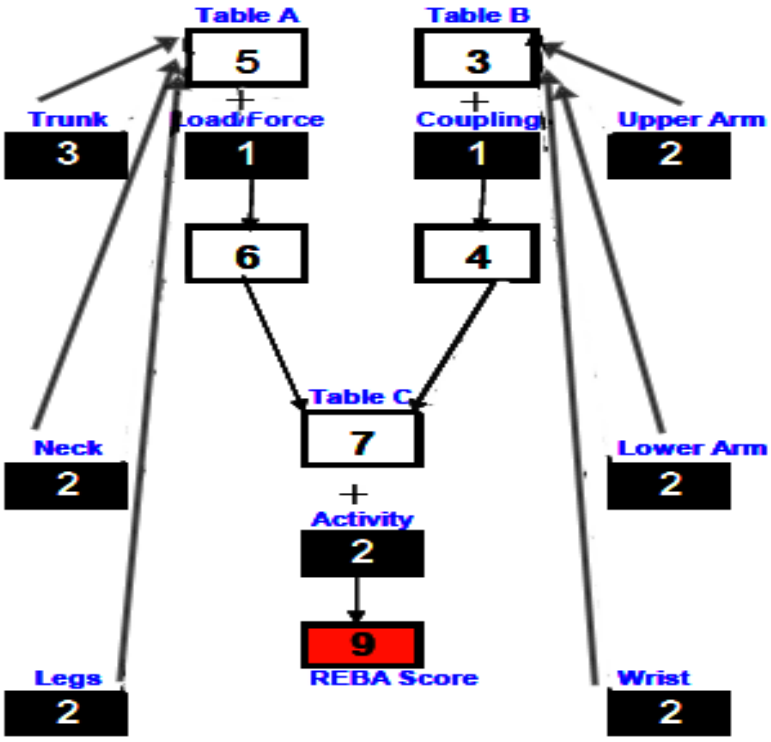

Figure 10 (b): REBA scores for the sand and cement mixing task worker.

A 3 score has been used for the trunk position due to the angle 34.10°. For the neck position (61.17°), a score 2 has been used for the neck. The knee position (23.84°) indicates the leg score is 2 for the table A. Here figure-10 (a) shows that the upper arm is locating at 34.39° from the original position. As a result, a score of 2 has been used for the upper arm. The scores 2 and 2 have been used for the lower arm and wrist positions as 47.63° and 48.22 degrees respectively.

Figure -11(a) represents the working postures of lifting materials. To lift the sand or other materials from ground or below the knee, workers need to kneeling the body. The repetitive lifting materials lead to pain on several body parts. Arrows sign indicate the affected body portions such as the knee, lower back, upper back, elbow, and shoulders during lifting the materials. Figure-11(b) represents the REBA score for the the workers while lifting the materials from the ground. For the trunk and leg positions 45.37° and 39.46°, the REBA scores have been used 5 and 2 respectively. On the other hand, the REBA score 2 has been used for both the upper and lower arms. In this case, the positions of the upper and lower arm are 40.31° and 90.69° from the normal position.

Figure 11 (a): Body posture of lifting task workers.

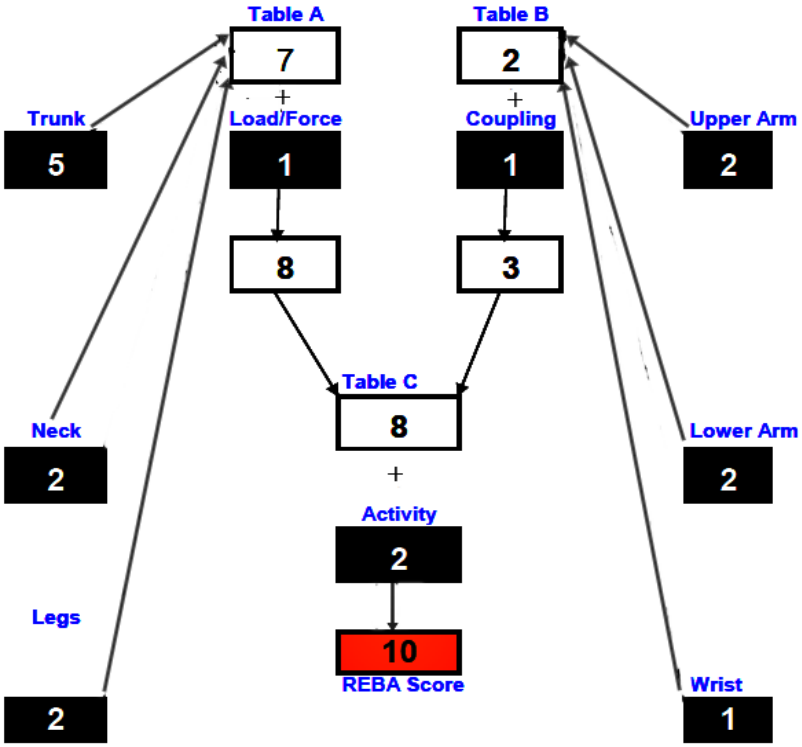

Figure 11 (b): REBA score for the lifting task workers.

Carrying the materials on the head or shoulders are one of the common tasks in construction tasks. During carrying the materials on head the hand used to support the loads. This is an awkward working posture.

Figure 12 (a): Body posture of carrying task.

Repeatedly and long term raising a hand above shoulders height causes musculoskeletal problems on shoulders, elbow, and neck on the workers. The carrying task is shown in figure 12(a). During the carrying task workers are suffered pain in shoulders and elbows which indicate by arrows. The REBA score for the carrying materials task is shown in figure- 12 (b). The upper arm angle 135.22 degree has used for the upper arm score 4 and the lower arm angle 59.56 degree has used for the lower arm score 2. Other scores have been used as normal body postures.

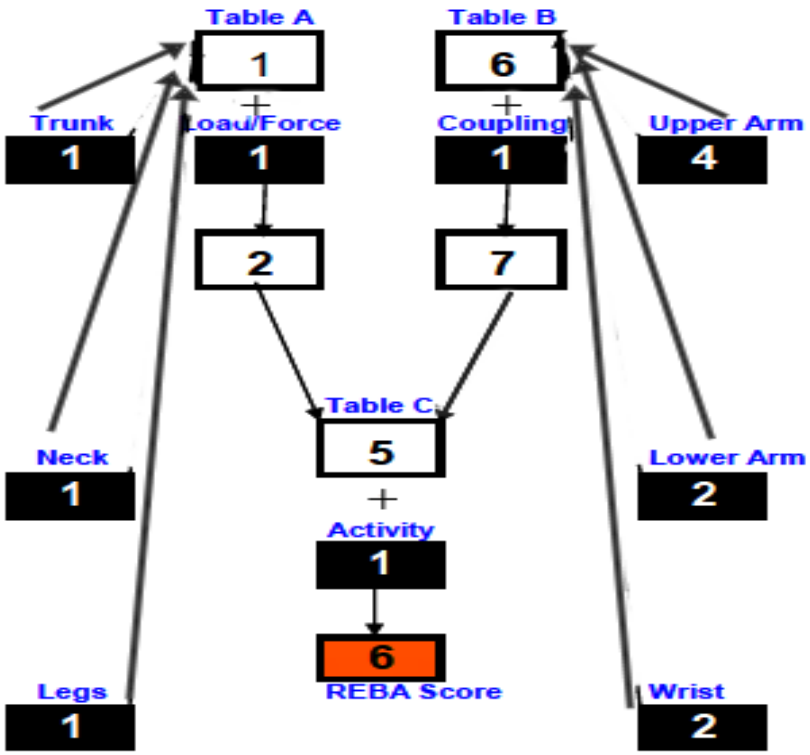

Figure 12(b): REBA score for the carrying task worker.

The body posture of bricklaying to make the wall is shown in figure-13(a). Workers bend down the body to lift the cement mixer and bricks, straighten up and turn the body to lay the cement and bricks into the job locations. The repetitive movement of body for long periods led to physical discomfort. The bricklaying workers frequently suffer from the knee, lower back, shoulders, and elbows pains that are indicated by arrow sign.

Figure 13 (a): Body posture of bricklaying worker.

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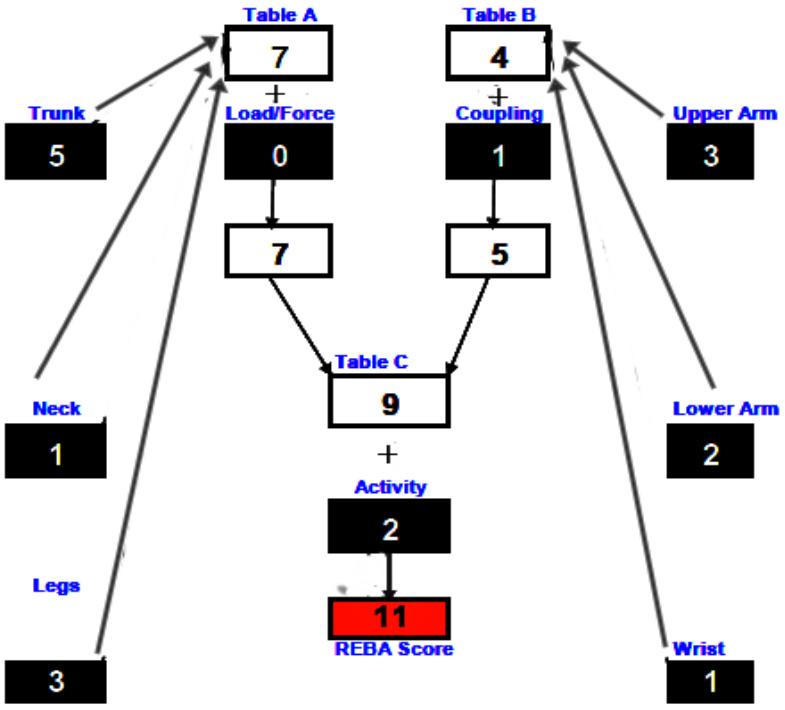

Figure 13 (b): REBA postural score of bricklaying worker.

The figure-13(b) indicates the REBA postural score for the brick-laying worker. Score 5 is used for the trunk position 70.33 degrees from the normal position. The scores 3 and 2 are used for the upper and lower arm due to the angles 112.45° and 29.46 degrees. Other scores are used for the normal body positions. The body condition of wall plastering shown in figure-14(a). To perform this task worker continuously ben down, up and twist the body. As a result, arrows indicate the

most affected body region of plastering workers. The figure-14(b) shows the REBA score of the plastering worker.

Figure 14 (a): Body posture of plastering worker.

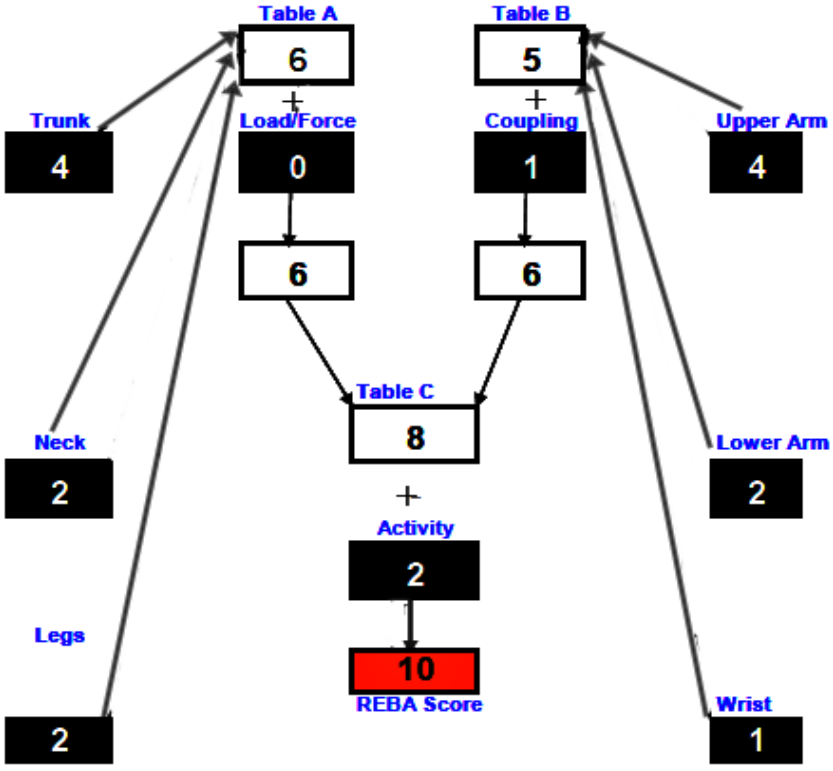

Figure 14 (b) REBA score of the plastering worker.

The workers use excessive force to straighten, bend or cut the rod. Figure-15(a) shows the working posture of ironworker in construction trades. Ironworkers frequently feel pain from knee, lower back, elbows, and shoulders sickness. These body parts are indicating through arrows sign in figure 15(a).

Figure 15 (a): Body posture of ironworker.

The REBA postural score for the ironworker as shown in figure 15(b).

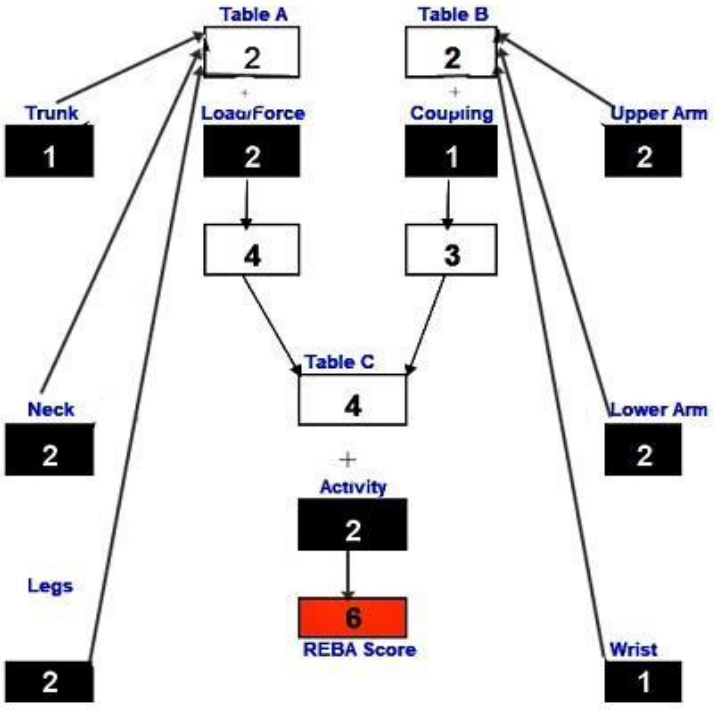

Figure 15 (b): REBA score of ironworker.

In this case, the neck and legs score is two for the postural angles 45.62° and 40.83°. On the other hand, for the postural angles 42.46° and 69.93° the score of both upper arm and lower arms is two. The trunk and wrist score is one for normal body posture.

Figure 16 (a): Body posture of concrete laying task.

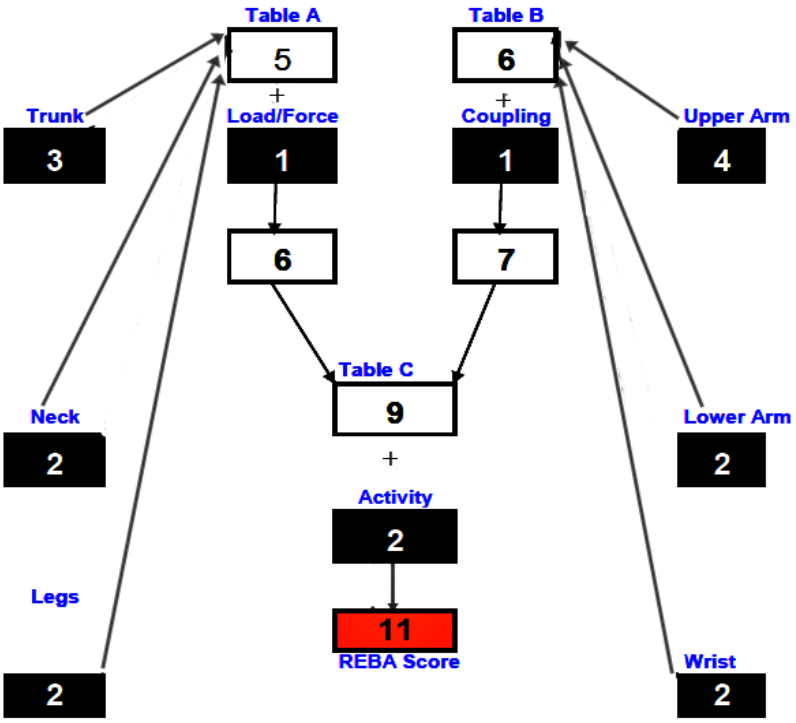

Figure 16 (b): REBA score of concrete laying worker.

Figure-16(a) shows the concrete laying activity. Kneeling is a common problem among manual concrete laying workers. This kneeling causes serious musculoskeletal problems among the workers. Knee, lower back, upper back, wrist, elbow, and the neck are the main affected body parts of the concrete laying workers that are indicating by arrows sign.

The REBA scores for the concrete laying worker as shown in figure 16(b). Here the scores 3 and 4 have been assigned for the trunk and upper arm with respect to the postural angles 57.37° and 103.63° respectively (figure- 16 (b)). Tiles fitting in the floor are one of the common tasks in construction trades. Generally, the workers perform this task by sitting position as shown in figure 17(a). Working in a sitting position for long period causes a different physical sickness. The tiles fitting workers frequently suffer from the elbow, lower back, upper back, and shoulders pans that indicates by arrows.

Figure 17 (a): Body posture of tiles fitting work.

The Reba score for the tiles fitting worker is shown in figure 17(b). Here the scores 3, 4 and 3 have been assigned for the body postures trunk legs and upper arm. Figure 17(a) shows the relative postural angles such as 40.01°, 49.41° and 77.46° respectively.

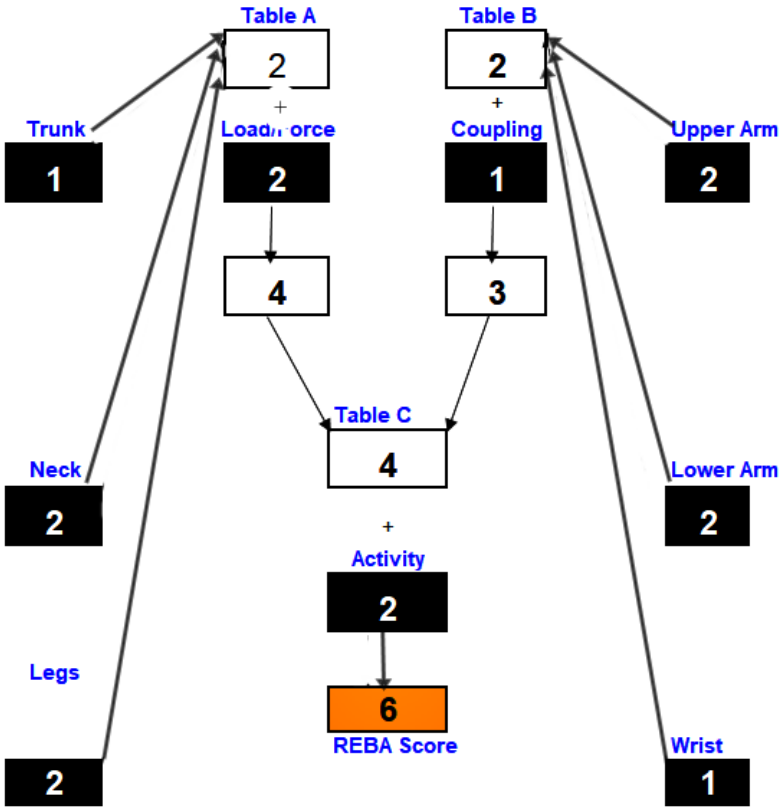

Figure 17 (b): REBA score of the tiles fitting worker.

Figure 18(a) shows the prevalence of musculoskeletal pain in the different body region of the participants. The results indicate the overall prevalence of work-related musculoskeletal disorders (WMSDs) among construction workers in Bangladesh was 70.20%.

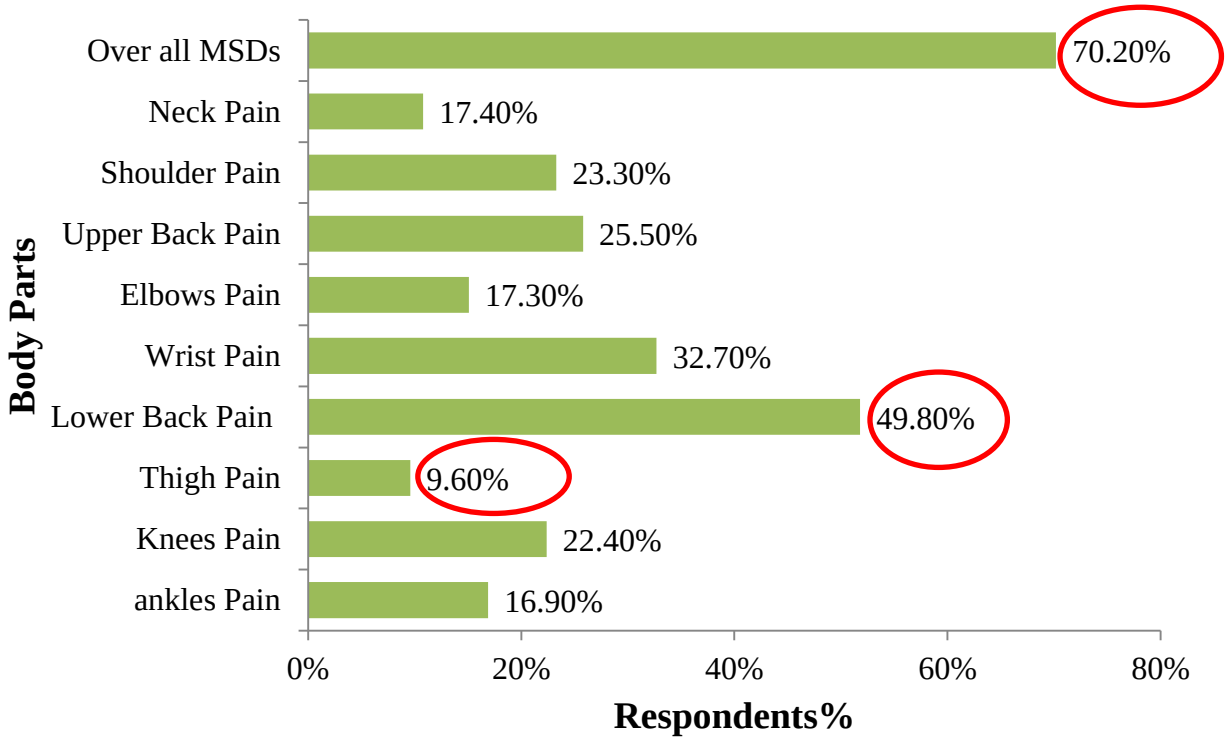

Figure 18 (a): Musculoskeletal pain on different body parts.

Figure 18(b) shows the percentages of MSDs pain occurred in different body parts of interviewed construction workers at different construction sites.

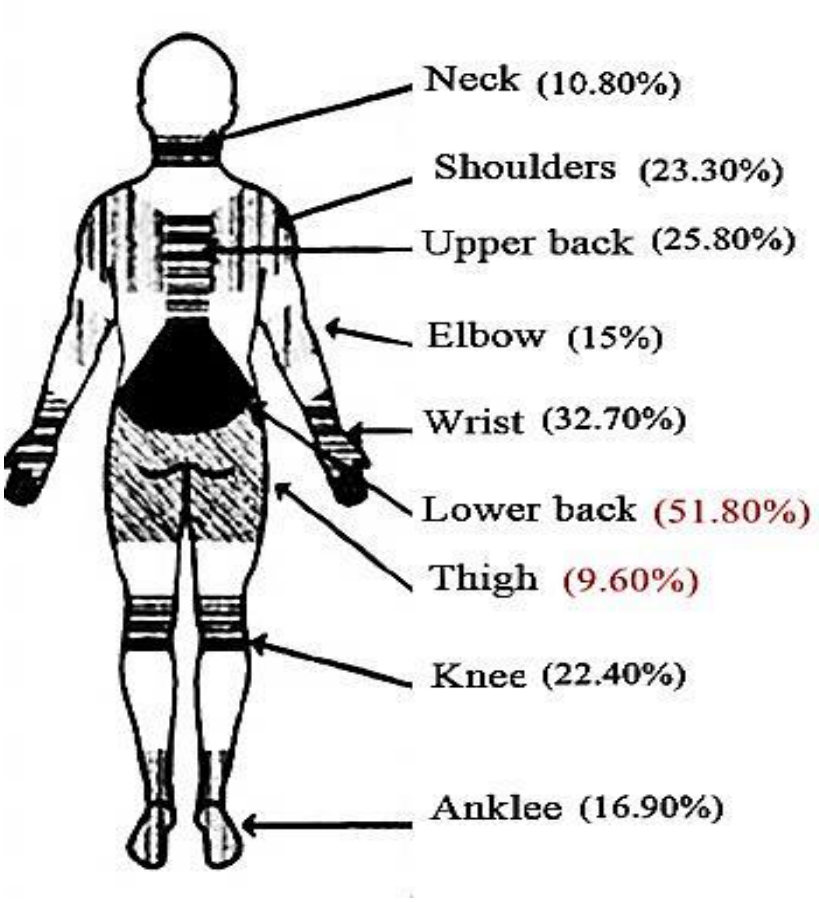

Figure 18 (b): Percentages of MSDs pain occurred in construction workers.

4.5 Accident related information

An accident is a common occurrence in the construction workers in Bangladesh. Workplace accidents are unpredictable. In this study, it observed that most of the workers (60.70%) faced accidents during their job experiences. Only 39.30% of workers did not face any accidents (Figure-19). The workers who faced accidents, they have also met different types of physical problems.

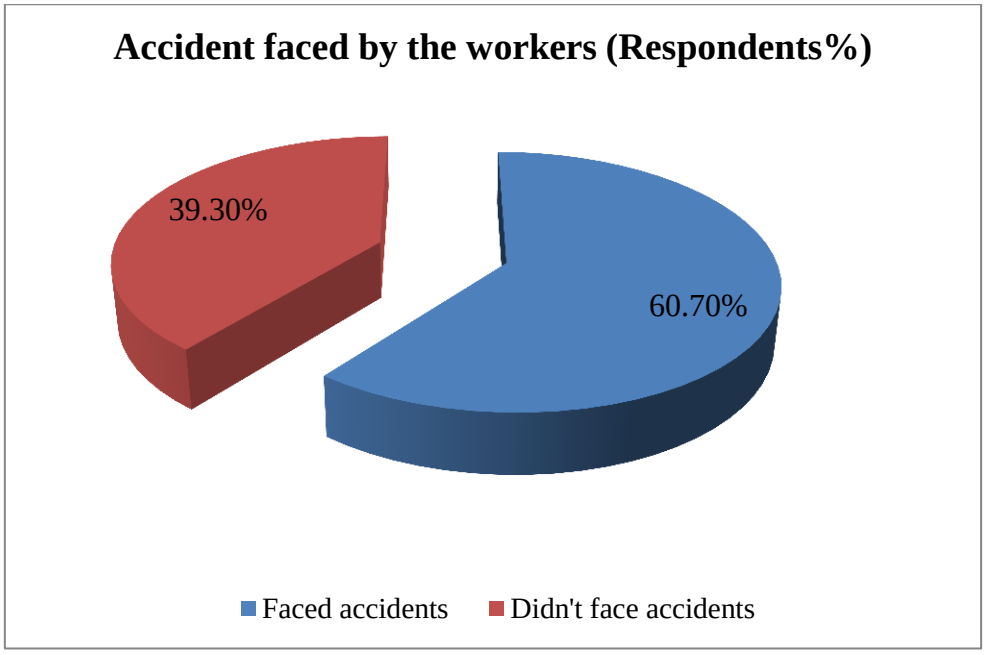

Figure 19: Accident related information.

Figure 20 shows the different accidental effects on the worker's body. Workers (29.80%) reported that they suffered different types of musculoskeletal injuries due to workplace accidents. Due to this type of injuries, they felt pain on different body organs. About 24.70% of the workers were partially disabled through accidents in construction sectors. Due to partial disability, the workers lose the full physical capacity to perform the work. The most common partial disability in construction workers are back injuries, amputation, carpal tunnel disorder.

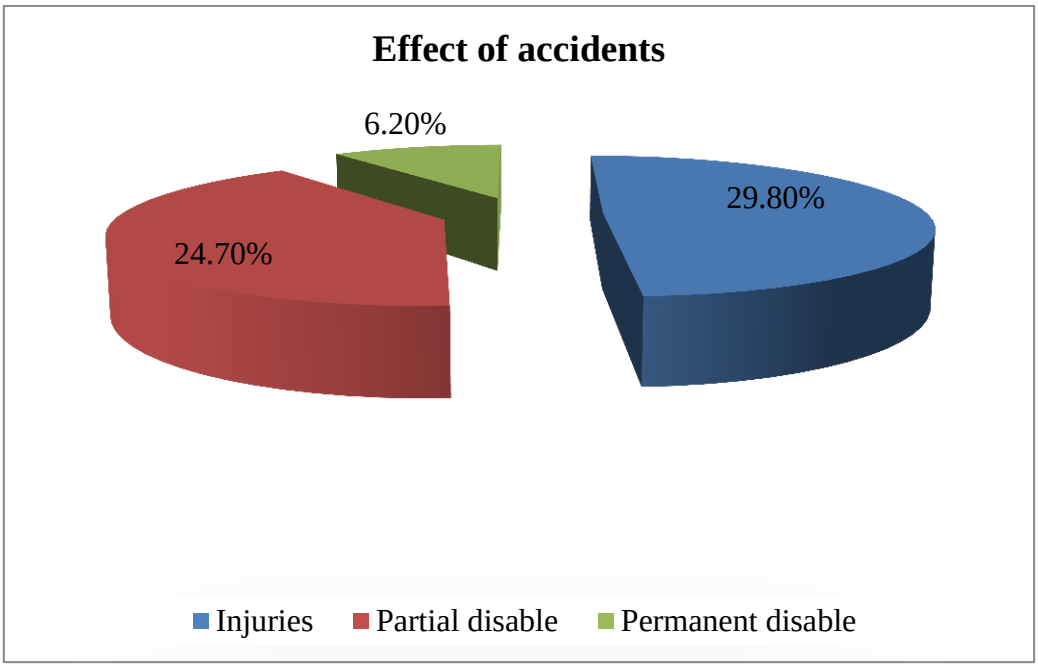

Figure 20: Problems occurred due to accidents.

Another hand 6.20% of the workers reported they were permanent disabled for the worksite accidents. The permanent disable refers to the long-lasting disability or injuries in permanent than temporary conditions.

There may be various agents for accidents in the construction sites. In this study, author considered only the four main agents (Figure-21). Among the 19.10% of the total workers faced accidents by falling objects on the worker's body. Due to lack of proper safety facilities in construction site, various objects fall on workers. Accidents were caused by the worker fall from a height (25.30% reported). Workers may fall from height due to slip, unawareness, lack of experiences, improper working conditions. Electrocution is one of the crucial agents for construction accidents. In this study, a few workers (3.30%) reported that they faced accidents by electrocution. In building construction, workers use the electricity to drive the motorized machine. Only 12.90% of workers were faced accidents by other agents as inserting the rod, cut by tools, etc. (figure-21).

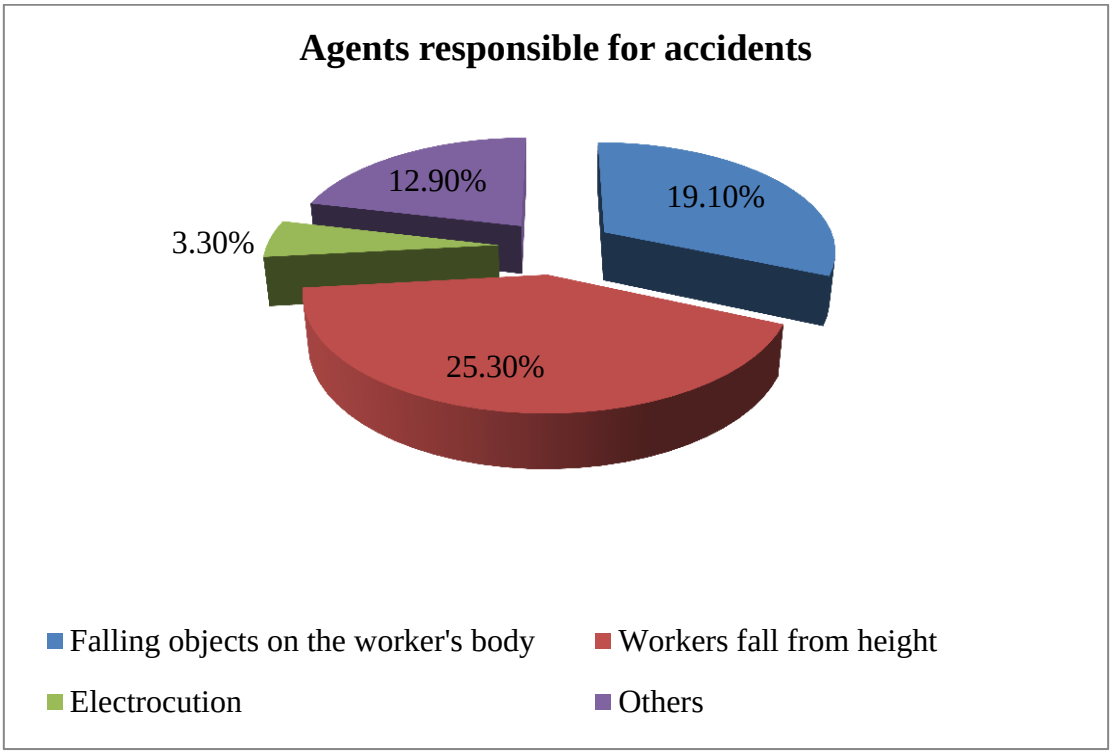

Figure 21: Agents responsible for accidents.

A question was provided to the workers for identifying the main causes of accidents. Figure-22 shows the report of the workers. Among all causes behind the accidents, workers (29.80%) responded as due to personal negligence. As a hazardous condition, the construction workers should alert all-time in their work. Small negligence may cause a vital issue.

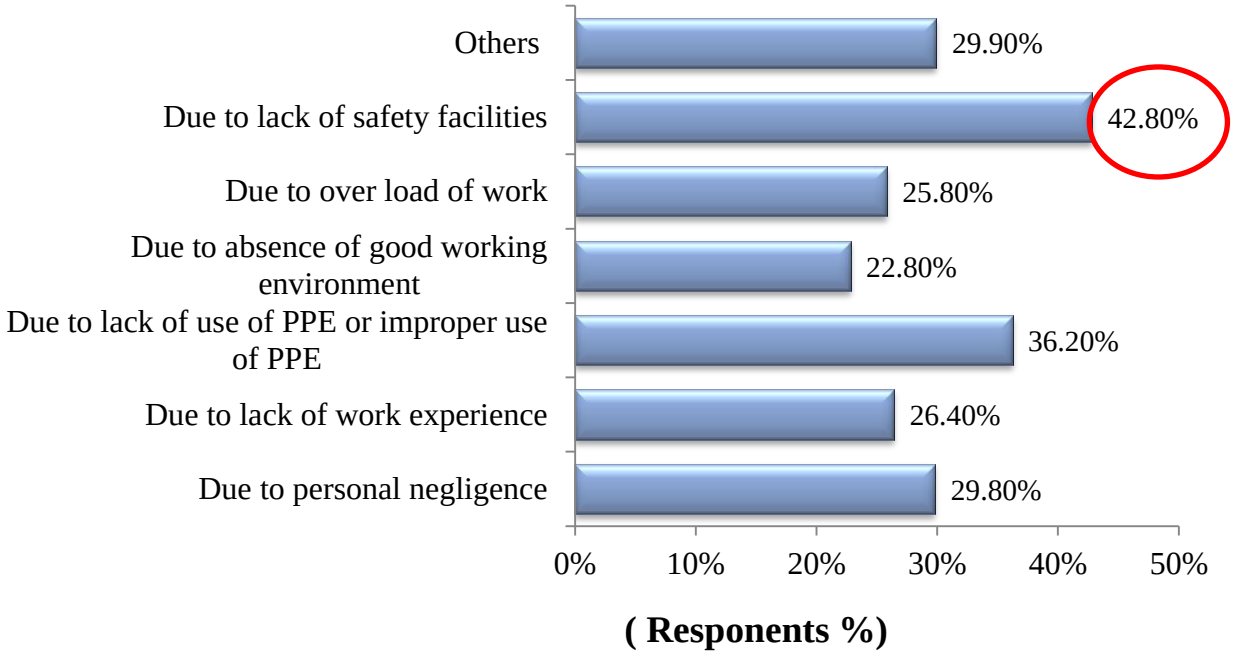

Figure 22: Causes behind the accidents.

New and unskilled workers face more accidents than skilled workers do. As a result, 26.40% of respondents reported unskilled workers frequently face accidents in construction site. Regular use of personal protective equipment may reduce most of the accidents in the workplace. Construction workers (36.20%) blamed that they faced accidents due to insufficient supply of personal protective equipment. Good working conditions can help to reduce different types of accidents and injuries. In this study, 22.80% of workers faced accidents for a bad working environment. High working stress also leads to accidents in construction workers. Most of the workers (42.80%) reported that they faced accidents in the construction site due to insufficient supply of safety facilities. Only 29.90% of workers specified the others causes as unsafe equipment, hazardous materials, mental depression, lack of authority consent, etc.

CHAPTER –V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study was conducted on 450 construction workers from the southern parts of Bangladesh such as Jashore, Khulna, and Satkhira. From this study following conclusions can be drawn:

- Maximum interviewed workers (70.20%) suffered from work-related musculoskeletal disorders.
- The result also showed that the most affected body parts were the neck, shoulders, upper back, lower back, elbows, wrists, and knees.
- Finding shows that maximum MSDs occured in the lower back (49.8%) and minimum in the thighs (9.6%).
- Various risk factors were identified that associated with work-related musculoskeletal disorders (WMSDs).
- The socio-demographic factors such as age, work experiences, working time and types of works were associated with musculoskeletal disorders (MSDs).
- The research finding shows that awkward working posture (50.20%), air temperature (54.700%) and excessive forces (51%) were highly responsible for the MSDs.
- The result shows the average REBA score of the selected tasks was 9.13.
- Research finding also shows 60.70% of interviewed workers faced an accident during work at the construction site. Whereas 39.70% of interviewed workers did not face an accident.
- The finding shows that maximum workers (25.30%) were injured by falling from the height.
- Moreover, the lack of safety facilities has been identified as a vital factor for workplace injuries.

These results indicated construction workers in Bangladesh worked in a risky zone, and they suffered from various types of work-related musculoskeletal disorders (WMSDs). Only by designing new or redesigning the existing process, tools and equipment can help to reduce or eliminate these problems.

5.2 Recommendations

The following recommendations will help to mitigate or reduce the work-related musculoskeletal disorders (WMSDs) and accidental injuries among the construction workers in future.

5.2.1 For the management:

The management and administration of the construction project should perform the following activities to reduce or to eliminate the work-related and accidental injuries from construction workers in Bangladesh.

- Redesign the processes, workplace, working layout by considering the strengths, weaknesses, and needs of the workers.
- Implementation of job replacement methods where employees will be replaced between jobs to minimize the period of frequent exertion, repetitive motions, and awkward postures.
- The management should provide ergonomically designed workplaces and tools to facilitate neutral postures.
- Provide adequate training and education to the workers, supervisors, and inspectors to others participate in the work-related musculoskeletal disorders control program.
- Utilize the administrative controls to reduce the number of working hours in one position, limit overtime, or to include more breaks time during shifting work.
- Provide safety aides facilities for all.
- First aid facilities should be provided for all injured workers at the construction site.
- Provide mechanical aids to eliminate the manual handling activity as much as possible.
- Provide proper personal protective equipment (PPE) for every worker at the construction site.

5.2.2 For the workers:

Besides the management, the workers also should perform the following activities to reduce or eliminate the work-related and accidental injuries.

- Perform the tasks in natural posture.
- Workers must wear personal protective equipment (PPE) regularly in order to prevent worksite injuries.
- Avoid twisting and implement proper manual handling technique.
- The workers should avoid static work posture for a long time. A periodic rest is needed to relax the body.
- Lifting and carrying the heavy load by the workres should be divided into a small one. Two or more person can handle heavy loads if required.
- To keep the body muscles, joint and spine sound, strong and flexible workers should do some exercise daily.

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APPENDIX -I

SURVEY QUESTIONNAIRE FORM

Dear Respondent

Assalamualaikum, I am a student of M.Sc.Eng (Mechanical) is having Roll 1505553, at Khulna University of Engineering and Technology, Khulna – 9203, Bangladesh. I am going to conduct a research work about the "**A Cross-sectional study of Work-Related Musculoskeletal Disorders among Construction Workers in Bangladesh**". For the purpose of the study, I wish to ask you some questions. I will appreciate your cordial support answering the following questions. All information provided by you will be kept confidential and will be used only for the purpose of academic research.

Part-A: Socio-demographic information

Participant Name:					
Specify your gender		1. Male		2. Female	
What is your age (in years)?					
Working Experience(in years)					
Working time (in hours)					
Rest time (in hours)					
Smoking Habit		1. Smoker		2. Non-smoker	
Education Level		1.Illiterate	2. Up to primary	3. Up to Secondary	4. Above
BMI(Kg/m^2)	Weight				
	Height				
Marital Status		1. Married		2. Unmarried	
Type of work		1). Mixing Sand and Cement		2). Iron work	
		3). Lifting and Carrying mortar		4). Bricklaying	
		5). Plastering		6). Concrete laying	
		7). Tiles fitting		8). Others	

Part-B: Musculoskeletal disorder related information.

No	Questions	Response	
1.	Have you had experience of work-related musculoskeletal disorders on last 12 months in any part of your body?	1= Yes	0 = No
2.	If yes, Please, specify the affected body portion where the symptoms arise.	1	Neck
		2	Shoulders
		3	Upper Back
		4	Elbows
		5	Wrists
		6	Lower Back
		7	Thighs
		8	Knees
		9	Ankles

Part- C: Risk factors related information (self-reported):

Below are a number of factors that may/may not contribute to work-related musculoskeletal disorders of construction workers. Please tick the appropriate cell.

The physical factors that causes to MSDs
1. Awkward working posture
2. Static posture
3. Repeated Work
4. Heavy load
5. High work stress
The environmental factors that causes to MSDs
1. High/Low air temperature
2. Noise from the engine, machine and equipment
3. First aids facilities
4. Bad working layout
5. Safety facilities
The equipment factors that causes to MSDs
1. Vibration (from the engine, machine and equipment)
2. Excessive force
3. Fitness of hand tools and equipment
4. PPE(Personal Protective Equipment)

Part- D: Economical factors due to MSDs:

1	How many days you work in a month?		
2	What is your daily income?		
3	How many days did you absent in the job due to MSDs?		
4	Did you go to doctors?	1. Yes	2. No
5	How much money spent due to medical purpose?		

Part- E: The Ways to prevent/minimize MSDs:

Please, mention the ways those help to minimize or prevent the MSDs.

Ways	Tick the appropriate cell
I can't specify	**1**
Providing safety aids	**2**
Awareness campaign	**3**
Providing training and technique	**4**
Designing hand tools ergonomically	**5**
Ensuring good working environment	**6**
Using the PPE	**7**
If others then specify ……	**8**

Part-F: Accident related information:

Did you experience with accidents?	1. Yes(Self / others)	2. No	
Mention the effect of accidents	1. Injuries	2. Partial disable	3.Permanent disable 4. Death
Which agent was responsible for maximum accident?	1). Falling objects on worker's body. 2). Worker falls from the height. 3). Electrocution. 4). Others (Please specify)..		
What do you think about the main cause of accident?	**1.** Due to personal negligence		
	2. Due to lack of work experience		
	3. Due to lack of use of PPE or improper use of PPE		
	4. Due to absence of good working environment		
	5. Due to over load of work		
	6. Due to lack of safety facilities		
	7. Others (Please Specify)-		

Appendix – II

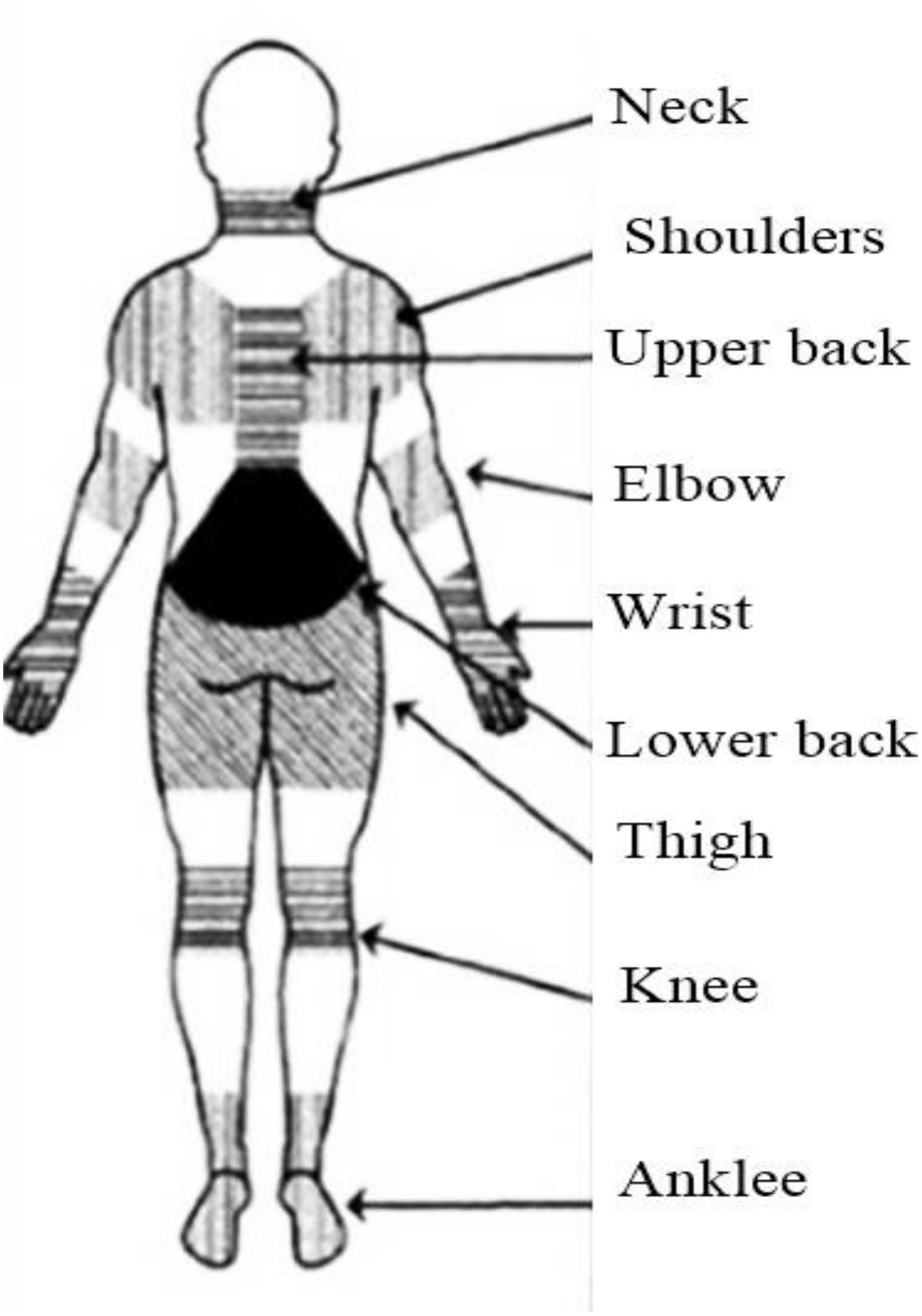

Photo of the human body

Source: https://www.google.com/search?q=nordic+musculoskeletal+questionnaire+form+pdf

Appendix III

Pictures of data collection

Rapid Entire Body Assessment Worksheet (REBA)