Work-Related Musculoskeletal Disorders Among Workers In Brick-Making Factory And Building Construction Sites: An Overview

Godwin, Harold C And Ndubueze, Daniel U

Department Of Industrial/Production Engineering

Nnamdi Azikiwe University, Awka, Nigeria

Corresponding Author: Godwin, Harold Chukwuemeka

1.0 CONCEPT OF MUSCULOSKELETAL DISORDERS

Musculoskeletal disorder (MSD) is an umbrella term that covers a number of injuries caused by awkward movements repeated frequently over time. MSDs occur to the muscles, nerves, joints, ligaments, tendons, arms, shoulders, and neck etc. Most work-related MSDs develop over time and are caused either by the work itself or by the employees' working environment. Other aggravating factors include poor postures, an improperly designed workstation, poor tool design, and work stress. MSDs are also referred to as occupational overuse disorders, cumulative trauma disorders, and repetitive stress injuries.

Musculoskeletal disorders can also occur in the patients' life outside work through some sports like - tennis (elbow); music - guitar playing. These external work events can be exacerbated by their daily profession. Typically, MSDs critically affect the back, neck, shoulders and upper limbs; however, they also affect the lower limbs.

Health problems range from discomfort, minor aches and pains, to more serious medical conditions.

1.1 Classification of Musculoskeletal Disorders

Various types of Musculoskeletal Disorders have been discovered, and are classified thus;

1.1.1Repetitive strain injury (RSI)

This is the general word that is used to describe the prolonged pain experienced in shoulders or hands or neck or arms. It is the common word used for referring the types of soft tissue injuries like the nerve spasms, trigger finger and carpal tunnel syndrome. Repetitive Strain Injury occurs when the movable parts of the limbs are injured. It is usually due to repetitive tasks, incorrect posture, stress and bad ergonomics. Generally it causes numbness, tingling, weakness, stiffing, and swelling and even nerve damage. The chief complaint is the constant pain in the upper limbs, neck, shoulder and back.

1.1.2Nerve and circulation disorders

When friction or inflammation causes swelling, both nerves and arteries can be compressed and so restrict the flow of blood to muscles. This can cause a disorder known as thoracic outlet syndrome. The symptoms of this disorder are pain in the entire arm, numbness, coldness, and weakness in the arm, hand, and fingers. If the blood vessels in the hands are restricted, Raynaud's disease can result. Symptoms include painful sensitivity, tingling, numbness, coldness, and paleness in the fingers. It can affect one or both hands. This disorder is also known as vibration syndrome because it is associated with vibrating tools.

1.1.3Muscle and tendon disorders

Tendons connect muscles to bones. They can accommodate very little in the way of stretching and are prone to injury when overused. Overworking a tendon can cause small tears in it. These tears can become inflamed and cause intense pain. This condition is known as tenditis, and it occurs in the muscles of a shoulder, forearm tenditis causes pain in fingers, wrist, and muscles in the top of the hand. Moreover, overexertion can cause myofacial muscle damage. The symptom of this disorder is soreness that persists even when resting. Muscles may burn and be sensitive to the touch. When the muscles become inflamed and swell, the symptoms are aggravated even further by nerve compression.

Tendons which curve around bones are encased in protective coverings called sheaths. Sheaths contain a lubricated substance known as synovial fluid. When tendons rub against the sheath too frequently, friction is produced. The body responds by producing additional synovial fluid. Excess build-up of this fluid can cause swelling which, in turn, causes pressure on the surrounding nerves.

1.1.4Cervical radiculopathy

This disorder is as a result of compression of the cervical discs in the neck making it painful to turn the head. Hence, Putting the body in an unnatural posture while sing the hands is always dangerous.

1.1.5Carpal tunnel syndromes

Tunnels are conduits for nerves that are formed by ligaments and other soft tissues. Damage to the soft tissues can cause swelling that compresses the nerves

that pass through the tunnel. These nerves are the medial, radial, and ulnar nerves that pass through the tunnel in the forearm and wrist. Carpal tunnel syndrome is the inflammatory disorder that is caused due to repetitive stress, physical injury or any other condition that causes the tissues around the median nerve to inflate. Pain experienced with carpal tunnel injuries can be intense, and people with this injury might experience numbness, tingling, and a loss of gripping power.

According to Rosemarie (2005), carpal tunnel is a small canal or tunnel that runs from the forearm through the wrist. Bones form three walls of the tunnel, which are bridged by strong, broad ligament. The median nerve passes through this tunnel, actually supplies feeling to the thumb, index, and ring fingers, the nine tendons that flex the fingers and also provides function for the muscles, at the base of the thumb. This ultimately results in pain, numbness, and tingling sensation in the wrist, hand, and fingers leaving the little finger, as it is not affected by the median nerve which is nothing but the Carpal Tunnel Syndrome. Many believe that constant repetitive use of the hand causes the Carpal Tunnel Syndrome. This is referred to as repetitive or accumulative trauma disorders. This results in wrist pain and numbness to the thumb and first two fingers.

2.0 MUSCLE

Muscle is a kind of soft tissue of animals. Muscles function to produce force and cause motion of individuals/animals. They are primarily responsible for maintenance of and changes in posture, as well as movement of internal organs, such as the contraction of the heart and movement of food through the digestive system via peristalsis. Muscle cells contain protein filaments that slide past one

another, producing a contraction that changes both the length and the shape of the cell.

2.1 Types of Muscle

2.1.1 ***Skeletal muscle*** or *"voluntary muscle"* is anchored by tendons to bone and is used to effect skeletal movement such as locomotion and in maintaining posture. Though this postural control is generally maintained as an unconscious reflex, the muscles responsible react to conscious control like non-postural muscles. An average adult male is made up of 42% of skeletal muscle and an average adult female is made up of 36% (as a percentage of body mass).

2.1.2 Smooth muscle or "*involuntary muscle*" is found within the walls of organs and structures such as the stomach, intestines, bronchi, blood vessels etc. Unlike skeletal muscle, smooth muscle is not under conscious control.

2.1.3 Cardiac muscle is also an "involuntary muscle" but is more akin in structure to skeletal muscle, and is found only in the heart.

2.2. Strength and Efficiency of Human Muscle

The efficiency of human muscle is defined as the ratio of *mechanical work* output to the *total metabolic cost*, as can be calculated from oxygen consumption. The efficiency of human muscle has been measured at 18% to 26%. This low efficiency is the result of about 40% efficiency of generating ATP from food energy, losses in converting energy from ATP into mechanical work inside the muscle, and mechanical losses inside the body.

A display of "***strength***" (e.g. lifting a weight) is a result of three factors that overlap:

Physiological strength (muscle size, cross sectional area, available cross-bridging, responses to training);

Neurological strength (how strong or weak is the signal that tells the muscle to contract); and

Mechanical strength (muscle's force angle on the lever, moment arm length, joint capabilities).

3.0 HUMAN TASKS ASSOCIATED WITH MUSCULOSKELETAL DISORDERS

There are numerous human tasks that can cause MSDs among workers in various fields. These tasks include, but are not necessarily limited to: lifting, carrying/transporting, reaching, gaining ingress and egress, conducting maintenance, repetitive motion, continuous work in stationary positions (seated or standing), climbing etc. These tasks are applicable across numerous work functions, including brickmaking and construction works.

3.1 Lifting The weight of an object may exceed the ability of the human(s) to safely lift and/or lower it, causing excessive force and strain to the musculoskeletal system and subsequent injury. This strain can be exacerbated by environmental factors such as vibration, repetitive task performance etc. Though mechanical lifting aids or equipment can reduce manpower requirements, in addition to lifting risk, manual lifting operations are often performed in bricks and construction industries.

3.2 Reaching Reaching for awkwardly placed equipment can also cause the human to assume a posture that places musculoskeletal strains and stresses on

the body, leading to injury. Awkward postures also reduce the effective force that can be applied to a given task and limit the stamina (available task performance duration) of people operating under suboptimal conditions thereby reducing human performance.

3.3 Carrying/Transporting Carrying heavy loads, particularly over long distances and extended periods of time, can cause skeletal system compression, muscular system stress, and injury. As more and more equipment is integrated into the warrior "system", this becomes a greater problem.

3.4 Push-pull Pushing or pulling a heavy object exacts heavy physical demands on the human musculoskeletal system leading to injury. Humans are typically in awkward postures when performing this type of task, which exacerbates the injury potential. This is often critical, especially when the push-pull task is on a vertical plane versus a horizontal plane.

3.5 Head supported weight Heavy and poorly balanced gear worn on the head can place a significant stress on the head and neck, particularly the cervical area, leading to injury. These effects may be amplified by motion (whole body vibration) and by sudden acceleration (such as shock or impact on a crash) or duration.

3.6 Continuous sitting or standing Continuous operations in a single seated or standing position creates musculoskeletal stress and injury.

3.7 Repetitive motion Repetitive motions associated with some tasks such as using hand tools or power tools, and assembly line actions etc, can cause temporary and permanent damage to the body's soft tissues such as muscles, nerves, tendons and ligaments. Damage can occur to hands, wrists, elbows, shoulders etc.

4.0 CONCEPT OF BRICKS AND CONSTRUCTION

Brick is a standard-sized weight-bearing building unit, often made from clay, lime-and-sand, concrete, or shaped stone. Also a brick is referred to as a block or a single unit of a ceramic material used in building construction. Bricks are typically produced in common or standard sizes in bulk quantities. They have been regarded as one of the longest lasting and strongest building materials used throughout history.

Construction as applied to the fields of architecture and engineering is a process that consists of the building or assembling of infrastructure. Far from being a single activity, large scale construction involves numerous human multitasking activities.

Building construction, one of the types of construction, is the process of adding structure to real property. However, all building construction projects include some elements in common – design, financial, estimating and legal considerations.

4.1 Overview of Existing Statistics

In the United State it has been estimated that there are approximately 1.8 million disabling work-related injuries per year, 60000 of which result in permanent

impairment (Frymoyer, 1997). It's not surprising, given that cumulative trauma disorders are a huge problem. In 1994, they accounted for about 64 percent of America's half million annual workplace illnesses. This excludes disorders due to over-exertion, such as lifting. All told, this is America's fastest-growing workplace hazard.

European Agency for Safety and Health at Work, (EASH, 2004) Stated that, Musculoskeletal disorders are some of the most common forms of ill health in construction. About 25% of European workers consider that their work affects their health in the form of back pain, which tops the list of all reported work-related disorders.

Musculoskeletal disorders are particularly prevalent across a range of construction industry with estimates suggesting that as many as 30% of the workforce may be affected. Recent research has indicated that musculoskeletal disorders are particularly prevalent in certain construction trades or occupational groups such as bricklayers, plasterers and joiners. Among the Work-related health problems reported annually, Musculoskeletal Disorders constitute about 52%, being the highest (European Social Statistics 2002:108). Below is a figure, showing the work-related health problems existing among workers and the percentage of each problem.

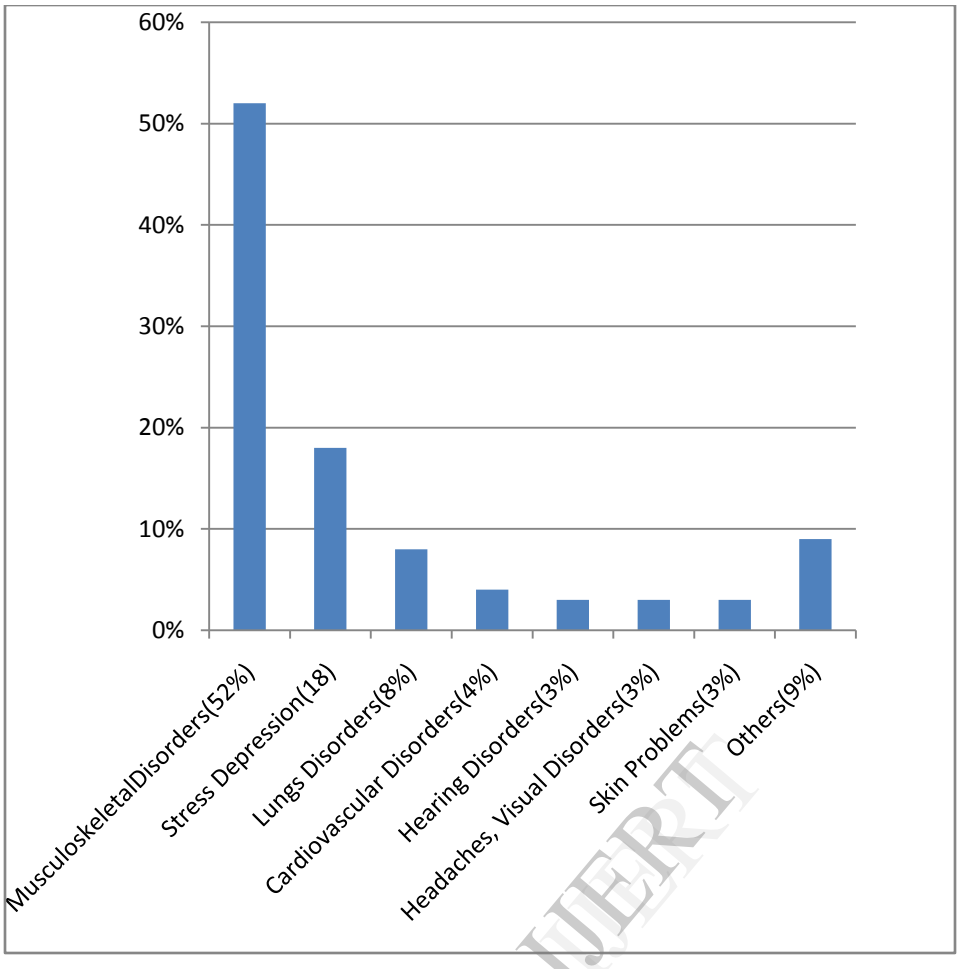

Figure 1 Work-related health problems by diagnosis group; serious health problems only (European Social Statistics 2002: 108))

Back disorders are one of the leading causes of disability for people in their working years and afflict over 600,000 employees each year with a cost of about $50 billion annually in 1991 according to NIOSH. The frequency and economic impact of back injuries and disorders on the work force tends to increase further. The Bureau of Labour Statistics (http.bls.gov.oshhome.htm) trend data for 1992-1995 indicate a general decline in injuries and illnesses requiring days away from work. For example, the incidence rate of overexertion (Lifting) declines between 1992 and 1995. According to NIOSH, there may be several reasons for these

declines, including general trends in reporting injury, socio-economic trends and improvements due to effective prevention and intervention programs (NIOSH, 1997).

Generally, statistical information regarding the studies of MSDs among workers in various fields, and particularly in constructions and block-making factory in ***Anambra State***, and generally that of Nigeria is still very scanty. Hence this research work is very imperative.

4.2 Musculoskeletal Disorders in Brickmaking Factory and Building Construction Sites

In both Brick making factories and building construction sites, various manual tasks, involving human efforts and muscles, are carried out on daily basis. These tasks which include; lifting, pulling/pushing, carrying/transporting among others, often cause musculoskeletal disorders among the workers. This MSDs arises as a result of frequent bending, twisting, and other awkward postures necessitated by poorly designed workstations and/or method of operations adopted.

Trevelyen and Haslam (2001) investigated musculoskeletal disorders in a handmade brick factory, concentrating on the 'moulding' department, where clay is shaped into bricks. Result identified both upper limb and back problems. Posture and force analysis found poor standing posture and undesirable wrist positions, accompanied by significant force loadings.

4.2.1 The low back pain

Low back pain is one of the most common ailments of today. About 90 percent of the population is likely to have at least one severe episode at some time during their lives and about 7 percent of these will be off work for 3 months or more. Apart from the direct drain on medical resources, the economic costs of low back pain are high. It has been estimated that as much as 14 billion dollars is spent on treatment of low back pain and compensation claims in a year in the United States of America and this does not include the economic costs of days lost from work (Nachemson and Andersson, 1982 and White et al., 1982)

4.2.2 Potential risk factors

To prevent musculoskeletal disorders effectively, the risk factors in the workplace must be identified and then practical measures taken to prevent or reduce the risks. In order to achieve this, there is need for ergonomic examination of the work systems, which involves looking at the effect of the whole workplace/workstation, equipment, work methods, and work organisation etc.

A risk factor is a variable associated with an increased risk of disease or infection. Risk factors are correlational and not necessarily causal, because correlation does not imply causation. These risk factors are classified thus;

4.2.3 Workplace risk factors

The physical conditions to which workers are exposed while they work can contribute to musculoskeletal disorders (MSDs). Work performed under cold/sunny conditions and involving exposure to vibration have both been shown to contribute to MSDs. Under cold conditions, the circulation of blood to the arms and legs may be restricted, reducing the rate at which muscles can recover from work. (http:/employment.alberta.ca)

4.2.4 Job-related risk factor

According to Ayoub et.al, there are job-related risk factors associated with manual handling of loads.

Horizontal and vertical location of the load relative to the worker: with an increase in horizontal distance the external joint loads will increase and workers will use a large proportion of their strength capacity.

Distance of travel: increased travel distance results in reduced strength and higher energy expenditures.

Frequency and duration of the task: as the frequency of lifting increases, metabolic demands are higher and the onset of physical fatigue is more rapid.

Weight and size of the load: the weight of the load can affect the required strength, postural stress and metabolic demands.

4.2.5 Awkward postures

Awkward posture means a considerable deviation from the neutral position of one or combination of joints (Pinzke and Kopp. 2001). These postures typically include reaching behind, twisting, wrist bending, kneeling, stooping, forward and backward bending, and squatting. Such postures are related to injuries that are incurred during tasks that are static in nature and relatively long lasting. It also occur during tasks that demand exertion of force (Westgaard and Aaras, 1984)

Such strenuous working postures combined with heavy physical workload, result in a high frequency of WMSDs (Pinke and Kopp. 2001). However, awkward postures cause pain and injuries in the musculoskeletal system (Grandjean and Hunting, 1977). In most cases, the cause of musculoskeletal disorders can be traced to body movements and the demands of the job. Given the physical nature of construction and bricks making jobs, it is not surprising that many complain of back, shoulder, or knee problems. Many of these conditions could be prevented if we reduce the amount of awkward, heavy, repetitive activities required by the job (OSHA's 1999).

Luopajarvi (1990) indicated the most common and well-known risk factors in different parts of the body as follows:

- In the neck the most work-related disorders and pains seem to be associated with sustained positions with a bend or twist of over 20 degrees
- In the shoulders, the disorders are related to repeated elevation of the arms to more than 30degrees from the body.

- In the elbows and hands, the reported causes of disorders were unaccustomed movements, repetitive movements exerted with high speed, extreme positions of wrist and fingers.

4.2.6 Personal factors

These factors include level of physical fitness, weight, diet, habits, previous medical record and lifestyle; also affect the development of musculoskeletal disorders (Waters and Putz-Anderson, 1997). Some important personal risk factors and possible reasons for their association with injury risk:

- ***Age****:* muscle strength appears to be greatest in the late 20's and early 30's and declines thereafter.
- ***Gender***: women on average are weaker than men. Gender differences are explained by differences in muscle size, as estimated by either the person's fat-free weight or cross sectional area dimensions
- ***Anthropometry***: body weight and height have been correlated with muscle static strength.

4.2.7 Psychosocial factors

The psychosocial work environment constitutes an important part of an ergonomics evaluation of a workplace. Here, "Psychosocial" is used as the general term to describe a very large number of factors that fall within these separate domains:

- Factors associated with the job and work environment,

- Factors associated with the extra-work environment, and
- Characteristics of individual worker.

It has been indicated that physical work risk factors acting with psychosocial work risk factors increases the risk of self-reported back disorders (Devereux, 1998; Linton, 1990).

5.0 WEIGHT LIFTING

Lifting is defined as a forceful movement requiring energy and muscle effort. Lifting stresses muscles, tendons and ligaments and increases forces on spine. Moreover, bending from the waist and lifting at the same time exerts more force on the spine. Using one arm to lift an object or carrying an object on one shoulder or one hip also places extra and uneven stress on the spine (OSHA's 1999).

The lower back is often the most vulnerable to injury due to its distance from the load handled by the hands. Both the load and the weight of the upper torso (trunk) create significant stress on the body structures at the low back.

The figure below demonstrates the areas around the body within which loads may be lifted without risk for 95% of the male population and for 95% of the female population (Manual Handling Operations Regulations; 1992).

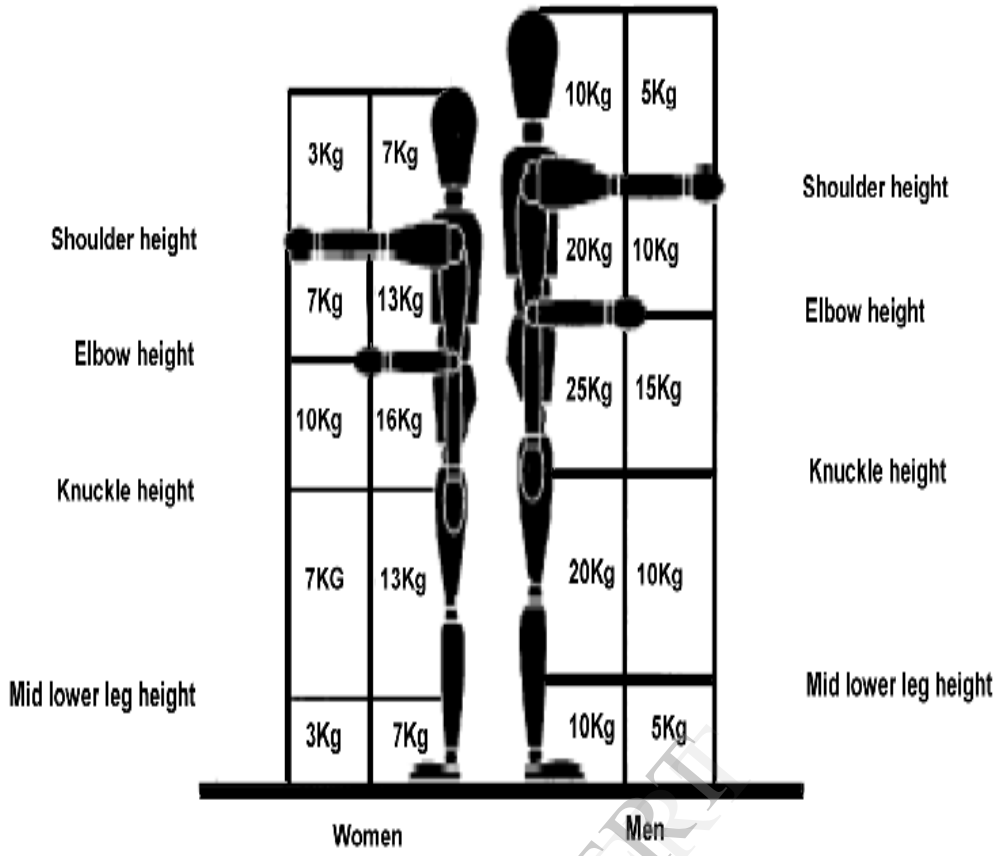

Figure 2 Demonstrating areas around the body within which loads may be lifted (HOR, 1992)

5.1 NIOSH Equation: Injury-Free Lifting Capabilities

The national Institute of occupational and safety health (**NIOSH**) having recognized the growing problem of work-related back injuries published the Work Practices Guide for Manual Lifting in 1981 (NIOSH 1981), which has undergone series of review to be applicable to a wide range of lifting jobs. The lifting equation provided an empirical method for computing a weight limit for manual lifting. This limit proved useful for identifying certain lifting jobs that posed a risk to the musculoskeletal system for developing lifting related low back pain. Using

the equation involves calculating values for the six factors in the equation for a particular lifting and lowering task, thereby generating a Recommended Weight Limit (RWL) for the task.

NIOSH lifting equation provides a method for determining two weight limits associated with two levels of back injury risk. The first limit is called an action limit (AL), which represents a weight limit above which a small portion of the workers involved in a given task may experience increased risk of injury if they are not trained to perform the lifting task. The second limit, called the maximum permissible limit (MPL) is calculated as three times the action limit. This weight limit represents a lifting condition at which most of the workers would experience a high risk of back injury.

The recommended weight limit (RWL) is the load value for a specific lifting task that nearly all healthy workers could perform for a substantial period of time without an increased risk of developing lifting-related low-back pain and is calculated as follows.

RWL = LC × HM × VM × DM × AM × FM × CM

Where;

LC – Load constant, Defines the maximum recommended weight for lifting under optimal conditions, such as symmetrical lifting position with no torso twisting, occasional lifting, good coupling, < 25 cm vertical distance of lifting.

HM – Horizontal multiplier, Reflects the fact that disc compression force increases as the horizontal distance between the load and the spine increases. As a result,

the maximum acceptable weight limit should be decreased from LC as the horizontal distance increases.

VM – Vertical multiplier, The NIOSH lifting equation assumes that the best originating height of the load is 75cm (or 30 inches) above the floor. Lifting from near the floor (too low) or high above the floor (too high) is more stressful that lifting from 75cm above the floor.

DM – Distance multiplier, based on the suggestion that as the vertical distance of lifting increases, physical stress increases.

AM – Asymmetric multiplier, torso (trunk) twisting is more harmful to the spine than symmetric lifting. Therefore, the allowable weight of lift should be reduced when lifting tasks involve asymmetric body twists. CM – Coupling multiplier, whose value depends on whether the load has good or bad coupling. If the loads have appropriate handles or couplings to help grab and lift the loads, it is regarded as good coupling. If the loads do not have easy-to-grab handles or couplings, but are not hard to grab and lift, it is fair coupling. Poor coupling is where the loads are hard to grab and lift.

FM – Frequency multiplier, is used to reflect the effects of lifting frequency on acceptable lift weights.

H – Horizontal distance between the hands lifting the load and the midpoint between the ankles.

V – Vertical distance of the hands from the floor.

D – Vertical travel distance between the origin and the destination of the lift.

A – Angle of symmetry (measured in degrees), which is the angle of torso twisting involved in lifting a load that is not directly in front of the person.

F – Lifting frequency i.e the average number of lift per minute (lifts/min) over 15 min periods.

5.2 The Lifting index (LI)

To quantify the degree to which a lifting task approaches or exceeds the recommended weight limit (RWL), a lifting index (LI) was proposed.

The lifting index (LI) is a term that provides a relative estimate of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is the ratio of the load lifted (L) to the Recommended Weight Limit (RWL). In other words, LI is used to estimate the risk of specific lifting tasks in developing low-back disorders and to compare the lifting demands associate with different lifting tasks for the purpose of evaluating and redesigning them.

$$\text{Hence, } LI = \frac{\text{Load Weight (L)}}{\text{Recommended Weight Limit (RWL)}}.$$

Hence, Lifting tasks with:

LI > 1 – likely to pose an increased risk for some workers

LI > 3 – many or most workers are at high risk of developing low-back pain and injury.

5.3 Weight Lifting Procedures

NIOSHA, (1993) identified two types of manual lifting;

- Single-task manual lifting and
- Multi-task manual lifting.

Single-task manual lifting job is a type of which the task variables do not significantly vary from task to task, or only one task is of interest.

On the other hand, multi-task manual lifting jobs are those with significant differences in task variables between tasks. They are more difficult to analyse because each task must be analyzed separately. Therefore, a specialized procedure is used to analyse multi-task manual lifting jobs

European Agency for Safety and Health at Work (EASHW) gives the procedures involve in lifting loads. Before lifting of load, the lifter should make sure that the destination is known; the area around the load is clear of obstacles; there is nothing on the floor that could slip someone; there is a good grip on the load; and that hands, the load and any handles are not slippery. These also apply when lifting with someone.

However, when lifting load; feet should be around the load and body over it, muscles of legs be used, back should be kept straight, the load is pulled as close as possible to the body and the load be Lifted and carried with straight arms (http://osha.europa.eu).

Building blocks, according to Construction Industry Advisory Committee (1993), should be stacked close to where they are used, handled using mechanical lifting

and handling aids as much as possible for blocks weighing more than 20 kilograms, avoid over reaching or twisting, ensure good grip and secure support placement in the work area.

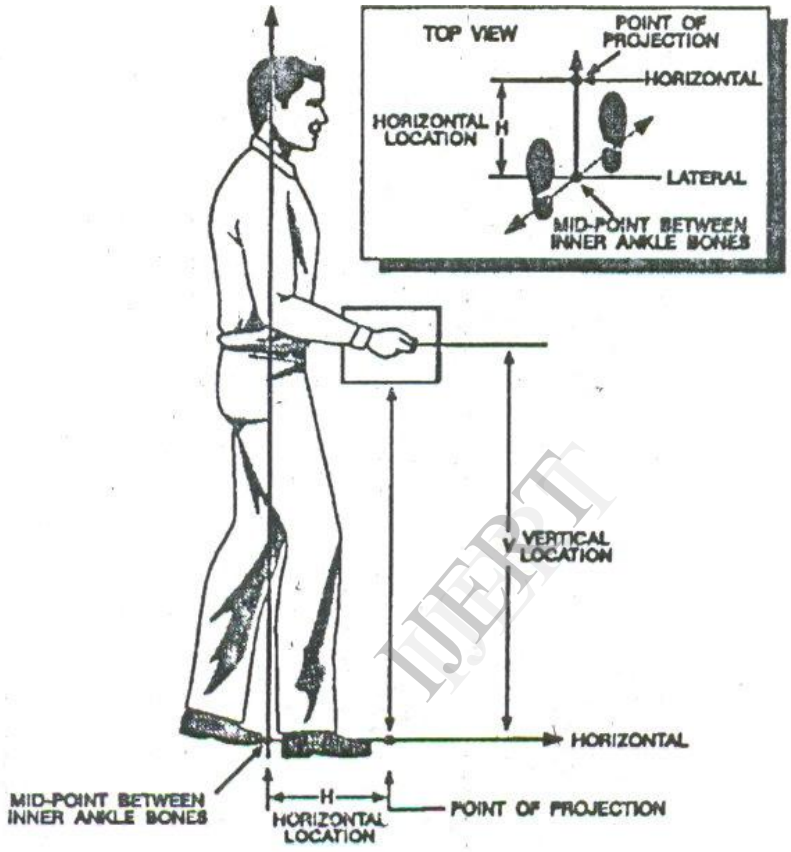

Figure 3*Graphic representation of hand Location (NIOSH WPG, 1981)*

6.0 BODY POSTURE

The amount of fatigue experienced during work depends largely on the posture of the performer. The goal of ergonomics in the workplace is to prevent injuries and illnesses (work-related musculoskeletal disorders) by reducing or eliminating worker's exposure to occupational hazards. These hazards include awkward postures, repetition, force, mechanical compression, duration, vibration, and temperature extremes (http://inventors.about. com).

Body postures determine which joints and muscles are used in an activity and the amount of force or stresses generated or tolerated (Putz-Anderson, 1998), because the skeleton is essentially a lever system, there is certain postures in which it can absorb force more easily than in others. In other words, there are certain postures in which the body is more susceptible to injury.

In conclusion, it has been revealed that musculoskeletal disorders (MSDs) account for over 50% of work-related health problems among workers. MSDs occur across all types of jobs and work sectors. However, some types of employment groups seem to be particularly at higher risk. Workers in brick-making and construction industry, among others, are vulnerable groups due to the numerous manual tasks.

To prevent musculoskeletal disorders effectively, the risk factors in the workplace must be identified and then practical measures taken to prevent or reduce the risks effectively. Hence, attention needs to be paid to: risk assessment; health surveillance; prevention of fatigue; training; employee information and consultation. Moreover, greater attention needs to be paid to *ergonomic work*

systems with the aim of examining the effect of the whole workplace, equipment, work methods, work organization etc, and to identify problems and solutions.

Hence, a participative approach that includes the workers in the process of change may have a positive effect on the success of such intervention.

7.0 REFERENCES

Rosemarie A. 2005. Carpal Tunnel Syndrome: Another Source for Self Care. Safe Computing Tips.com

Frymoyer, J. 1997. Cost and control of industrial Musculoskeletal Disorders of the workplace: principles and practice. St. Louis. Missouri: Mosby-Year Book. 62-71.

European Agency for Safety and Health at Work (EASHW) 2004. "Building in Safety" – Bilbao Declaration following the "European Construction Safety Summit" of 22 November. Bilbao, Spain.

Nachemson A.L. and Andersson G.B.J. 1982. Classification of low back pain. *Journal of Work Environ. Health.* 8: 134-136

Linton, S.J. 1990. Risk factors for neck and back pains in working population in Sweden. *Work and Stress*. 4: 41-49.

Grandjean, E. and Hunting, W. 1977. Ergonomics of postures review of various problems of standing and sitting postures. *Applied Ergonomics* 8 (3): 135–140.

NIOSH. 1981. Work Practices Guide for Manual Lifting (WPG), NIOSH Technical Report. *U.S. Department of Health and Human Services, National Institute for Occupation*. 81-122.

NIOSH. 1997. "Musculoskeletal Disorders in the Workplace" *Occupational Health Report Publication* No. 97-141. Dept. of Health and Human Services, Cincinnati.

OSHA. 1999. Draft ergonomics requirements, Feature Articles - ISHN Article tools

Pinzke, S. and Kopp, L. 2001. Marker-less systems for tracking working postures- results from two experiments. *Applied Ergonomics.* 32: 461-471.

Putz-Anderson, V. 1998. "Cumulative Trauma Disorders - A Manual for Musculoskeletal Diseases of the Upper Limbs" Taylor and Francis, Bristol PA, London.

Waters, T.R. and Putz-Anderson, V. 1997. Manual material handling. In: Bhattacharya, A. and McGlothin, I. (Eds), *Occupational Ergonomics: Theory and Practice*. New York: Marcel Dekker. 329-350.

Bazroy J., Roy G., Sahai A. and Soudarssanane M.B. 2003. "Magnitude and Risk Factors of Injuries in a Glass Bottle Manufacturing Plant" *Journal of Occupational Health.* Vol. 45, pp. 53-59

Bellis, M. 2007. Lillian Gilbreth and Frank Gilbreth - The Birth of Ergonomics. *http://inventors.about. com/library/inventors/blGilbreth.htm*.

BurQeau of Labor Statistics 1997. "Annual Statistics Report" U.S Department of Labor, Washington DC European Agency for Safety and Health at Work.

Construction Industry Advisory Committee CONIAC, 1993. Published by *Health and Safety Commission*. Construction sheet No. 37 NIS/06/37 C40

European Agency for Safety and Health at Work (EASHW) 2004. "Building in Safety" – Bilbao Declaration following the "European Construction Safety Summit" of 22 November. Bilbao, Spain.

Gerr. F., Letz, R. and Landrigan, P.J. 1991. Upper extremity musculoskeletal disorders occupational origin. Ann. Rev. *Public Health* 12: 543-566.