Designing Safe Lifting Tasks for Occupational Workers

A Synopsis
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Low back pain is a disorder that commonly affects the occupational workers, resulting in disability, and a socioeconomic burden. Occupational repetitive and/or heavy lifting is a known risk factor for the development of low back pain (Wai et al., 2010). Statistics from around the world shows that nearly one-quarter of the working population falls victim to manual handling injuries especially low back injuries (Kothiyal and Kayis, 2000; Graham et al., 2009). Manual lifting is the highest classified cause (19.6%) of mishap incidence and also the highest classified cause (31.1%) of injury on the job as per the Kansas department of human resources (2000). It is cited that the second greatest reason for lost workdays is injuries due to overexertion when performing lifting tasks (Snook, 1988). It is estimated that 2% of the U. S. workplace suffers compensable back injuries for a total of over 500,000 injuries annually, and that low back cases constitute about 16% of all workers compensation cases and are responsible for 33% of the total cost (Andersson, 1998; Bernard, 1997). Researchers from diverse fields have focused manual material-handling (MMH) tasks to reduce manual handling injuries which led to the development of guidelines such as National Institute for Occupational Safety and Health (NIOSH) work practices guide and lifting equations (NIOSH, 1981; Waters et al., 1993), National Occupational Health and Safety Commission (NOHSC) manual handling Standard (NOHSC, 1990), design database (Tables of recommended weight of lifting) for lifting (Mital et al., 1993), etc. The primary motivation for these research efforts has been to model human capabilities so that the demands of MMH tasks can be designed at or below
the worker capacity to perform the task. Various criteria for defining acceptable task demands have been developed from the principles of biomechanics, physiology, and psychophysics (Ayoub and Mital, 1989; Dempsey, 1998). Based upon these criteria and researches, NIOSH equation has assisted ergonomists and occupational safety and health practitioners in analyzing the lifting demands on the low back. Since NIOSH equation could only be applied to symmetrical lifting tasks that do not involve torso twisting, the equation was revised and expanded in 1991 for application to a greater variety of lifting tasks (Waters et al., 1993). MMH, in general, involves lifting, pushing, pulling, lowering, holding and carrying of loads, however, we primarily focus on lifting activities in the proposed research work.

It is commonly agreed that the cause of lower back pain and injury is frequently related to the posture of lifting, the load, muscle fatigue etc. Many investigations (Norman et al., 1998) have demonstrated that there is a clear relationship between low back injuries and biomechanical factors such as posture at the initiation of the lift (trunk inclination and knee angles), moment, shear, and compression forces at muscle/joint complexes, trunk sagittal angle (flexion), peak trunk velocity, bending frequency, and average force on the hands.

Lifting involves the various human joints in a complex manner. The external force applied by the load to be lifted is shared primarily by the low back, hip and knee joints. The relative proportions of their sharing is also influenced by human factors (age, sex, body dimensions, strength of various involved muscles etc.), task factors (load, posture...
awkwardness, location of load, lift frequency, speed of lifting, size of container, coupling etc.), and environmental factors (temperature, humidity, ventilation, noise etc). Kumar (1984) suggested that posture during lifting is a crucial factor. It is perhaps due to this reason, that training on manual handling tasks in industry emphasizes the role of 'correct' postures which should be adopted by workers during lifting the objects (NIOSH, 1981). Studies have been carried out to determine, using physiological and psychophysical methods, safe and perhaps optimal lifting techniques / postures. Parnianpour et al. (1987) have pointed out the fallacy of a single correct lifting technique. They recommend different lifting techniques for individuals with different joint problems. Kumar (1984) has examined three different lifting postures (stoop lifting, squat lifting and 'free style' lifting with no postural constraints) to determine which of these is/are optimal. From the subjective point of view, squat lifting was found to be more tiring than straight leg posture. In terms of physiological cost, the stoop method (bent back, straight legs) of lifting was found to be least and the squat method (flexed knee, straight back) most demanding. Subjectively free style lifting was considered the best.

Lifting postures are as much a function of individual characteristics as of external constraints. To clarify the role of various factors such as magnitude of load, individual anthropometric characteristics, shape, size and location of loads etc. in determining the optimal working postures, a model approach can be reasonable, economic and less time consuming. NIOSH believes that the revised equation is more likely to protect most workers than the 1981 equation, though differences in the physique of varying racial populations limiting the applicability of this equation have not been considered.
Most MMH-related studies have been based in Europe and North America and the data were obtained from the Caucasian population (Maiti, 2008). On the contrary the manual material-handling problem is more severe in developing and underdeveloped countries and research on the populations of these countries is needed (Wu, 2003). In Indian context, the laborers are continuously over-exhausted without the protection of any constraint law. These workers are employed temporarily by the labor contractors on daily wage basis, not as the direct payee of the organization. No records are maintained on their health or industrial accidents. The Factory Act, 1948, does not indicate the safe load limit for Indian population. According to Joshi et al. (2001), the existing Indian Factory rule inadvertently created the occupational health hazard conditions in industries. In the proposed research work, we intend to develop a system to investigate and clarify the role of various factors involved in the load lifting for occupational workers in and around Agra. A model with multi-segment link may be devised for determining the joint moments and reactive forces during load lifting. The model can then be used to search for optimal values of factors for reducing work related disorders. We can also determine postural angles based on reducing the reaction force/moment at the low back subject to all other muscle-joint complexes not being overstressed.

Another important dimension of research in lifting tasks is determining maximum acceptable weight limit (MAWL) by the workers (Maiti and Ray, 2004). MAWL is the highest acceptable workload, which can be lifted comfortably based on their perceived exhaustion level (Gamberale, 1985). Use of psychophysical method in determining
MAWL in repetitive lifting jobs is well established (Snook, 1978; Legg and Myles, 1981). Many authors (Legg and Myles, 1981; Mital and Manivasagan, 1983; Aghazadeh and Ayoub, 1985; Karwowski and Yates, 1986; Ciriello et al., 1990; Fernandez et al., 1991) suggested that the psychophysical approach is a reliable method in assessing the perceived exertion during MMH task in low and moderate frequencies ($\leq 4$ lifts min$^{-1}$). However, it is also reported that this method overestimates the workers’ capacity for high lifting frequency (>6 lifts min$^{-1}$) conditions (Ciriello and Snook, 1983; Asfour et al., 1985; Karwowski and Yates, 1986). Regarding the selection of the duration of simulated experiment which should reflect the 8 hour job criteria in industry, Ciriello et al. (1990) suggested that 40 min work is sufficient to select the acceptable load. Ayoub and Mital (1989) categorically mentioned that 40–45 min work period is sufficient to determine the weight, which the subject can lift for 12 hour duration even if it includes 4 hour overtime about which they have no prior warning. In psychophysical experiment, the task is generally initialized with a random load weight and the subject is asked to adjust the load based on their choice such that the load will be acceptable for 8 h for repetitive handling operation. Snook (1978) provided a 40 min adjustment period to allow the participants to monitor their own feelings and adjust the load weight. A significant difference of this adjustment period is found in earlier studies. Some authors (Garg and Saxena, 1982; Garg and Beller, 1994) used a longer adjustment period (i.e. 45, 50, or 60 min). Again, in other studies (Mital, 1984 and Mital and Manivasagan, 1983; Karwowski and Yates, 1986; Mital and Aghazadeh, 1987; Zhu and Zhang, 1990; Chen et al., 1992), it is mentioned that participants could determine the MAWL load weight within shorter adjustment period. In these studies, the authors identified many factors affecting this perceived
subjective response such as, workers and load characteristics, type of task, work environment etc. and also the load weight factor. As part of this research work it is proposed to investigate the estimation of maximum acceptable load limit for manual lifting for occupational workers near Agra such as footwear production, brick manufacturing etc. The possible investigations can be (1) to estimate the MAWL level for brick/shoe/other workers following physiological / psychophysical criteria, (2) to study the psychophysical rating responses in different occupations against lifted load, (3) to find the effect of task factors on physiological parameters.

Most of the research efforts in manual lifting include only symmetric lifting; asymmetric lifting activities have been studied rarely. It is generally believed that asymmetric lifting involving torso twisting is more harmful to the back and spine than symmetric lifting. Although practically all manual handling training programmers recommend that asymmetric lifting should be avoided whenever possible (Rodgers, 1985), workers twisting their torsos while lifting is still inevitable in some work situations, especially during loading and unloading in restricted workplaces or for irregular material handling. A few studies on asymmetric lifting have been conducted (Mital and Manivasagan, 1983; Mital and Fard, 1986; Garg and Badger, 1986; Garg and Banaag, 1988; Rodrigues et al., 1989; Chen et al., 1992; Mital, 1992; Wu, 2000; Maiti 2008). More recently a study compared range of motion of trunk and pelvis during an asymmetric lifting task of a box between a group with a history of low back pain and a group with no history of low back pain (Seay et al., 2013). It also detailed out the implications for studying lifting paradigms at sub-maximal effort over longer periods of time. Most of these studies have
occurred in Europe and North America and the data were obtained from Caucasian populations. Therefore we intend to develop a system to facilitate the investigations of (1) the effects of angle of asymmetry on the low back pain, and (2) the resulting physiological costs and rating of perceived exertion for asymmetric lifting tasks by occupational workers near Agra.

It is important to educate the workers about the effects of various lifting parameters on the trunk and the upper extremity muscle recruitment to control the mechanical load on the muscles and spine. We propose to assess the effects on the upper extremity muscle recruitment when controlling the different lifting parameters such as horizontal distance of load, vertical distance of load, lifting frequency, lifting weight etc using electromyography signals of trunk and upper extremity muscles. The effects of heavier and repetitive lifting on change in the muscle recruitment throughout the lifting period can be investigated.
REFERENCES


