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Shoulder muscle loading and task performance for overhead work on ladders versus Mobile Elevated Work Platforms

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ABSTRACT

A high incidence of Musculoskeletal Disorders (MSDs) has been reported in the construction sector. The use of ladders in the workplace has long been identified as a significant risk that can lead to workplace accidents. However, it is unclear if platform types have an effect on the physical risk factors for MSDs in overhead work. The aim of this study is to perform a pilot study on the effects of hand activity on both shoulder muscle loading and task performance while working on ladders versus Mobile Elevated Working Platforms (MEWPs). It is hypothesised that work on ladders would result in greater muscle loading demands, increased levels of discomfort, and reduced performance due to the restrictions on postures that could be adopted. A field study ($n = 19$) of experienced electricians on a construction site found that workers spent approximately 28% of their working time on ladders versus 6% on MEWPs. However, the durations of individual tasks were higher on MEWPs (153 s) than on ladders (73 s). Additionally, maximum levels of perceived discomfort (on a VAS 0–100) were reported for the shoulders (27), neck (23), and lower regions of the body (22). A simulated study ($n = 12$) found that task performance and discomfort were not significantly different between platform types (ladder vs. MEWP) when completing either of three tasks: cabling, assembly and drilling. However, platform and task had significant effects ($p < 0.05$) on median electromyographic (EMG) activity of the anterior deltoid and upper trapezius. EMG amplitudes were higher for the deltoid than the upper trapezius. For the deltoid, the peak amplitudes were, on average, higher for ladder work over MEWP work for the hand intensive cabling (32 vs. 27% Maximal Voluntary Exertion (MVE)) and the assembly task (19 vs. 6% MVE). Conversely, for drilling, the peak EMG amplitudes were marginally lower for ladder compared to the MEWP (3.9 vs. 5.1% MVE). The general implication was that working on the MEWP involved lower shoulder muscle loading for cabling and assembly task. A difference due to platform type was not present for drilling work.

1. Introduction

Musculoskeletal Disorders (MSDs) describe a wide range of inflammatory and degenerative diseases and disorders which can result in pain and functional impairment of the neck, shoulders, elbows, forearms, wrists and hands (Buckle and Devereux, 2002). The European Foundation for Living and Working Conditions report that MSDs are the most common occupational disease suffered by European workers (EU-FOUND, 2007). A recent report from the European Survey on Working Conditions highlighted that 24.7% of European workers complain of backache as a result of performing work, with a further 22% complaining of muscular pains (Eurostat, 2010). An EU study on risk factors associated with MSDs concluded that construction workers were more likely to be exposed to a number of risk factors including work at high speeds, repetitive hand movement, carrying heavy loads, standing or walking, painful or tiring positions, or vibration, when compared to other sector workers (Eurostat, 2010).

Brenner and Ahearn (2010) report data on numbers of construction trade workers that retired due to ill health over a period from 1981 to 1996 in Ireland. Sheet metal workers, floor layers and electricians represented the more frequent occupations of retirees under fifty years of age. During this period, it was estimated that 24,428 years of working lives were lost due to premature

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retirement from the industry. However, the report only considers employees who are members of the regulated environment of the Irish Construction Industry Federation pension scheme.

Anderson (1988) details trade worker activities that may be associated with MSDs. Many of these activities include typical construction activities such as sanding, grinding, hammering, carpentry, overhead work, turning screws, soldering, welding, use of hand tools, wiring, use of pliers, polishing, sawing, operating finger triggers, jack hammering, use of vibrating tools, and working in a cold environment. It is not surprising that the incidence of MSDs in this industry is particularly high (Schneider, 1997). Albers et al. (2004), in a study of ergonomic interventions to reduce musculoskeletal loading in building installation tasks, identified a number of high risk tasks associated with the electrical and mechanical trades. These included pulling cables/wires, attaching raceway to ceilings, positioning fixtures, and connecting wires. However, no reference is made to the variety and effects of the many access platforms used in the industry.

The use of ladders in the workplace has long been identified as a significant risk factor leading to workplace accidents. The safety concerns relating to ladders have been well documented and include the absence of fall protection for the user and the difficulty in securing fall restraints in the event of a fall. In the US, it was reported that 133 fatal ladder related falls occurred in 2004, with ladders accounting for 16% of workplace fall related fatalities (Lombard et al., 2011). Previous ergonomic studies on ladders have focused on climbing/handling of ladders (Bloswick and Chaffin, 1990; Imbeau et al., 1998; Hoozemans et al., 2005). Ladder handling was identified as a significant risk hazard for MSDs within the telecommunication sector (Imbeau et al., 1998). This included loading/unloading of ladders from vehicles and the positioning of ladders onto the shoulder. Overexertion was considered a risk factor in the handling of ladders (24–31 kgs). However, no reference is made to ergonomic risks of work on ladders. Bloswick and Chaffin (1990) examined the ergonomic implications of ladder climbing activities using EMG of the erector spinae muscle group with biomechanical modelling of compressive and shear forces at L5/S1. They concluded that fast climbing resulted in 35% greater EMG activity than slow climbing for the torso muscles, and that erector spinae EMG activity almost reached the maximum during a fast climb, but no data were presented on shoulder muscle activity. Hoozemans et al. (2005) examined the effect of differing rung separation on perceived exertion, discomfort, safety and mechanical loading of the lower joints during ladder ascending and descending, but the study did not include the effects of performing tasks using the ladder as a platform.

The stepladder is a very common feature on the majority of construction sites in Ireland, used by craftspersons when performing work at height. The popularity of the stepladder is likely to be influenced by its versatility and low relative economic cost. The use of Mobile Elevated Work Platforms (MEWPs) on construction sites is also very common. MEWPs are self propelled machines that are capable of raising a working platform to the desired working height. Irish health and safety legislation (HSA, 2007a) recognises that work at height can be performed safely using a wide range of work equipment, but guidance favours the use of MEWPs over ladders (HSA, 2007b). On MEWPs, the risk of an operator falling is minimised as the operator is contained within a double handrail. Additionally, in the event of a fall, the operator is secured if a body harness is worn. It is clear that MEWPs are a preferred method for accessing work at height compared to ladders due to their safety features in preventing falls from height. However, it is unclear if MEWPs are also preferable in preventing MSDs during overhead work. A review of the literature indicated no previous studies comparing the use of MEWPs to ladders on risks of MSDs for overhead work. The MEWP provides a working platform, typically about 1.0 × 2.0 m, thus allowing the user a stable base to move while performing construction tasks. Additionally, the height of the platform can be adjusted with ease as per the user's preference.

The purpose of this study was to compare work on a ladder versus a MEWP for three different tasks on shoulder muscle loading and discomfort, and also task performance. Part I reports on platform type usage on a commercial construction site at a point in time. Part II was a simulated study of commercial electrical work to compare the effect of working on ladders versus MEWPs on shoulder EMG, discomfort, and task performance. The hypothesis of this study was that work on ladders would lead to greater muscle loading demands, increased discomfort and lower levels of performance than on a MEWP, due to both the posture and balance constraints required for ladder work and the stable platform and reduced balance requirements on MEWPs.

2. Method

The research methods were approved by the University of Limerick Research Ethics Committee.

2.1. Part I: field study of discomfort

The survey was performed at a construction site of a large pharmaceutical plant in Ireland. Site management approved the study. Labour levels peaked at approximately 400 personnel with up to 60 electricians at any one time. The electricians on site (all male) were presented with details of the survey during their morning meetings and invited to participate. Twenty electricians agreed to participate in the one day study from a workforce of 30 on the day of sampling. One had to leave the site during the day giving a sample size of 19.

The survey comprised a simple checklist of broad work activities and location by time segment (15 min) which the participants completed as the day progressed. The work activities on the checklist were as follows:

- Working on ladder
- Working on a MEWP
- Working on other access platform
- Electrical work from ground
- Completing safety documentation/retrieving materials
- Other (please state)

A modified version of the Corlett and Bishop (1976) body part discomfort rating method was used to record perceived discomfort at the end of the working day in the neck, shoulders, upper arms, lower arms, lower trunk and upper trunk. The main difference was the use of a 100 mm visual analogue scale with anchors of "no discomfort" on the left and "extreme discomfort" on the right, as per Carey and Gallwey (2002, 2005).

2.2. Part II EMG study of overhead work

2.2.1. Treatment details and experimental design

Twelve qualified electricians (all male) with a minimum of four years work experience in the company volunteered to participate in the experiment, none of which participated in Part I of this study. The mean age was 43 yrs (SD 6.11), mean body mass 88.8 kg (SD 5.80) and stature 1.81 m (SD 0.05). There were no female electricians available in the company at the time of the study to participate in the experiment.

The experimental design was full factorial. The independent variables were Platform (2 levels: MEWP and ladder) and Task (3

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