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Ergonomic analysis of construction jobs in India: A biomechanical modelling approach

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Abstract

This paper discusses the details of a study undertaken for biomechanical evaluation of a number of Manual Material Handling (MMH) tasks being carried out at a construction site in India. A comprehensive methodology involving a two dimensional dynamic biomechanical evaluation approach is developed for such construction MMH tasks involving carrying and lifting of materials like normal and Reinforcement Concrete Cement (RCC) bricks and heavy jack pipes with prevailing occupational risk factors. Data were collected through direct observations with videography at the construction site. The methodology consists of static and dynamic biomechanical modelling, assessment of different risk factors and identification of preventive and remedial measures to minimize or eliminate their effects. A motion analysis system called Ariel Performance Analysis System (APAS) was used for the workcycles of each task to determine linear and angular acceleration for body joints and segments considered along all the three coordinates using a large number frames for each workcycle. The biomechanical evaluation shows that the compressive forces at L5/S1 disc are beyond the threshold value of 3.4 KN for the construction workers carrying out such tasks. Results also indicate that there is a need for ergonomic performance improvement for such MMH tasks by the identified preventive and corrective measures

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1. Introduction

MMH activities, such as lifting and carrying of normal, RCC bricks and heavy jack pipes are very common in any building construction site. These activities as they are being carried out, may be associated with poor and awkward body postures, repetition, heavy weight of the tool/equipment and extreme environmental conditions that may result in fatigue and high level of physical stress among the workers causing pain in upper extremity and lower back. Therefore, while designing a worksystem for manual MMH tasks, consideration of these fatigue and work stress-induced is of paramount importance in order to identify and minimize both short-term and long-term risks. Moreover, a biomechanical model helps in evaluating the work postures in order to identifying the critical and stressed body joints for evaluating the methods of work in a worksystem. In this context, biomechanical analysis of work postures with the consideration of functional and Newtonian anthropometry of the workers in actual working conditions is a critical research need for ergonomic design and productivity improvement of construction-related MMH tasks that are found to be occupationally risky [1,2,3].

In a typical construction site in India, a number of workers (both skilled and unskilled) with different occupations carry out various phases of the construction work. Skilled workers include carpenters, rod binders, masons, welders, grinders, gas cutters, fitters, riggers, and 'sarang' (crane operator). The unskilled workers mainly help the skilled workers to work at ground level and at heights.

Although over the years, a number of such tasks have been mechanized or automated as the technology has advanced, majority of these tasks are still performed manually in different industries of developing countries like India mainly because of the prevailing socio-economic conditions, availability of labour at a very low cost, expensive setup cost for fully automated machineries, etc [4, 5]. The method of carrying out such activities may have severe adverse effect on both physical and mental health of the workers involved. It is found that 37% of the low back pain worldwide is due to MMH jobs [6]. Manual lifting has been identified as a physical activity likely to be associated with low back injury [6,7].Although several attempts have been made by researchers for analyzing and designing of material handling tasks in moderate to heavy work categories under varied work environments, there exist opportunities for improvement in the design of jobs (for less incidence of musculoskeletal disorders and other adverse consequences) so that they may be carried out in the new form of 'man-machine- technology' interactions in the worksystem. These activities as they are being carried out, may be associated with poor and awkward body postures, repetitions, heavy weight of the tools/equipments used and extreme environmental conditions that may result in musculoskeletal disorders (MSDs), anthropometric mismatch, fatigue and high level of physical stress among the workers causing pain in upper extremity and lower back [8,9,10,11]. Therefore, while designing a worksystem for manual MMH tasks in construction, consideration of these fatigue and work stress-induced conditions is of paramount importance in order to identify and minimize both short-term and long-term risks.

In this paper, the details of the study methodology pertaining to biomechanical modelling of selected MMH tasks are discussed in a sequential manner, such as selection of tasks, data collection and data analysis resulting in results and discussion. A comprehensive framework is proposed for biomechanical evaluation of a number of MMH tasks or jobs under diverse work environments that are found to be of considerable risk. The basic objective of the study is to carry out a biomechanical evaluation of certain occupationally risky MMH tasks with respect to a typical construction worksystem in India. Such an evaluation would help in redesigning construction jobs with improved ergonomic performance of the workers and reduced occurrence of occupational risks like MSDs, fatigue, workstress etc.

2. Study methodology

In order to study and analyze occupational risk factors for different kinds of construction-related activities, a systematic methodology consisting of a number of steps in sequence, viz. (i) selection of tasks, (ii) biomechanical modelling, (iii) data collection for biomechanical evaluation, (iv) data analysis These steps are discussed below in brief.