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New easy to use postural assessment method through visual management

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ABSTRACT

Earlier studies have demonstrated the strong relationships between manual assembly work with a high repetition level and the presence of repetitive strain injuries (RSI) or repetitive motion illnesses (RMI). Moreover, recent works have also correlated the high physical load level in assembly lines with an increased number of quality defects in finished products. Thus, the ergo-quality level of a manual workstation needs to be carefully monitored not only to respond to the legislation but first of all to ensure a high system productivity level in the medium-term perspective. The objective of this study was to develop and test a new easy-to-use postural assessment tool and its performance in a car component assembly system. The results show the promising potential of the methodology particularly when compared with the well-known OCRA method.

1. Introduction and problem definition

This research was motivated by the observation of manual operations in a real automotive assembly system characterized by simple manufacturing cycles and fast tasks and aims to define a general ergonomic methodology which could be applied to similar industrial realities. After an analysis of manual assembly tasks in car component manufacturing, results showed several significant correlations between ergonomics and operation complexity, recovery time and assembly task failures.

In order to increase the assembly system efficiency and quality, a high ergo-quality level is required in all workstations since high physical load levels and high complexity levels are not acceptable. Benefits provided by ergonomics application in assembly systems design are first of all linked to the reduction in occupational injury risks, and to the improvement of physical and psychosocial conditions of the workforce, with a drastic reduction in all costs linked to absence, medical insurance and rehabilitation (Carey and Gallwey, 2002).

Despite the many different approaches offered in literature for analyzing the ergo-level of a working task, managers need new easy-to-use postural analysis protocol able to support posture analysis by means of visual intuitive maps and speed up the process evaluation (Battini et al., 2011 and Battini et al., 2014). In addition, several activities performed in assembly systems, in particular those associated with repetitive movements and with considerable level of stress or with extended assumption of uncomfortable postures, might be correlated to the insurgence of Work Related Musculoskeletal Disorders – WMSD (Cecchini et al., 2010). For this reason, it is becoming of paramount importance to create a research that develops and validate an integrated approach in assembly system design, and takes into account technological variables (related to assembly times and methods) and environmental/ergonomics variables (i.e. human diversity). However, in several cases, ergonomics evaluations happen too late in the design process, hence, only minor 'ergonomic' adaptations and corrections can be made and ergonomics is perceived as a time-consuming and costly activity (Dul and Neumann, 2009). Proactive risk identification in early product development stages is still unusual although today much scientific evidence is available to confirm both the human and economic benefits of a proper ergonomic fit. Corrective assembly ergonomics measures are often made late, and reactively, only when problems have already occurred (Falck and Rosenqvist, 2014). The consideration and implementation of ergonomic practices can generally be regarded as a means to preserve and enhance a company's workforce and therewith its competitiveness above all

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for automotive manufacturers, where workers are required to fulfill physical and strenuous tasks on the shop floor (Thun et al., 2011).

Considering this assumption, this research focuses on developing and testing a new easy-to-use postural analysis tool for a full body ergonomic assessment which is capable of:

- considering additional factors related to action repetitiveness, steps walked and loads handled, which are sometimes excluded by other ergonomic methods.
- evaluating the full body rather than only body portions
- applying a visual management approach offered by a new set of visual ergonomic assessment maps, in order to speed up the analysis and reduce the analyst training time.

The approach presented is achieved by condensing the most recognized method for full body (Rapid Entire Body Assessment – REBA, Ovako working posture analysis system – OWAS) and upper limb (Rapid Upper Limb Assessment – RULA and OCRA checklist) ergonomic assessment and by adding peculiarities related to overload and repetitiveness as in the OCRA checklist and OWAS. The main goal of such methodology is to offer a wider vision of overall exposure to ergonomic risk and to provide clear suggestions for corrective actions to reduce ergonomic risk.

The basic research goals addressed by the present work may be outlined as follows: (i) To design a methodology for a full body ergonomic assessment taking into account both postures and physical efforts by considering (1) repetitiveness of operations and (2) load handled during the working shift; (ii) To provide a fast analysis method for the identification of possible risks to posture requiring a further deepened analysis and corrective actions. The second goal is here achieved by developing a document tool (made up of a set of visual ergonomic assessment maps) easily accessible according to the visual management approach paradigms.

2. Literature review

The problem of unfavorable working conditions, or poor workplace ergonomics, is a hot topic today. Ergonomic risks at the workplace cause a lot of damage to the health and quality of life of workers, and are financially damaging for employers and the economy as a whole (Otto and Scholl, 2011).

In the past, ergonomics was always aimed at designing tools and working environments which were comfortable and suitable for human use. Nowadays the objectives of ergonomics can be identified as the usability and safety of systems where the operator is considered as a user and an integral part (Vignais et al., 2013). Ergonomics can therefore be configured as the study and design of complex systems whose effectiveness is determined by the functioning of the system and its sustainability in terms of technological, economic and social features. Attention is paid to the interaction between human and machine within the production cycle. The task is performed by involving all production phases in order to improve health, safety, welfare and operator satisfaction, and, at the same time, reduce rising costs of ergonomic nature. In particular, Guimarães et al. (2012) studied correlations between ergonomic improvement, increased sales and expense reduction by performing a cost-benefit analysis on a test line of a manufacturing plant. Similarly, investigations and discussions on the interconnections between ergonomics and productivity and management can be found in several authors (Kihlberg et al., 2002; Dul et al., 2004; Dul and Neumann, 2009; Battini et al., 2011).

Referring to productivity in most industries, work-related musculoskeletal disorders or WMSDs have been recognized as a health issue leading to considerable loss of productivity among workers with highly physical jobs. Meanwhile, posture, repetition and duration have been identified as the main risk factors of WMSDs in highly repetitive tasks instances (including assembly tasks) (Cheshmehgaz et al., 2012). WMSDs imply additional high costs related to absent workforce, medical insurance and rehabilitation, which cause significant expenditures not only to the company but also to the public in those countries with a public health system. In this context, synergies between the design of assembly systems and ergonomic features must be adopted to guarantee a reduction in global costs owed to injuries. Kee et al. (2011) studied laws governing WMSD prevention in Korea and introduced corrective actions designed to ensure ergonomic improvement in a big automotive context by evaluating impacts and positive reflections regarding production processes. In particular, they paid attention to the analysis of repetitive movements and uncomfortable postures during assembly phases. Extensive reviews or researches on the issue, including assembly or automotive lines can be found in literature (Ouellet and Vezina, 2014; Ferguson et al., 2011) with reference to shoulder disorders (van Rijn et al., 2010), carpal tunnel syndrome (van Rijn et al., 2009), dynamic spinal stability (Graham et al., 2012), low-back disorder in parts distribution (Lavender et al., 2006) but also to age management aspects (Landau et al., 2008).

2.1. Research on ergonomic exposure in manufacturing and assembly lines

There is substantial epidemiologic evidence of associations between physical ergonomics exposure at the workplace, such as lifting, constrained postures, repetitive movements, fast work pace, heavy material handling, forceful exertions and vibration, and the occurrence of upper extremity musculoskeletal disorders (d'Errico et al., 2007), associated with the fact that assembly workers are involved in jobs characterized by prolonged standing, which decrease the blood flow to the muscles, accelerate the onset of fatigue, and cause pain in the leg, back and neck muscles. Excessive standing may also cause the joints in the spine, hips, knees and feet to become stiff or locked (Balasubramanian et al., 2009). Bao et al. (1996) followed optimization and rationalization processes of a big production firm dealing with ergonomics of production processes. Their aim was to evaluate the ergonomic impact of workloads before the planned improvements and to compare them with the future state of the line. Similarly, Gooyers and Stevenson (2011) showed the existing link between working cycle time and ergonomic load of an operator during manufacturing operations; twelve operators participated in the simulation of a working session to test a new semi-automatic tool. Mirka et al. (2001) presented a research project for the development and evaluation of technical control to reduce low back injury risks in workers in the furniture manufacturing industry; an analysis of injury/illness records and survey data identified upholsterers and workers in the machine room as at elevated risk of low back injury. Neumann and Medbo (2010) presented a design stage comparison of an existing “big box” material supply strategy common in Swedish manufacturing with a proposed “narrow bin” (NB) approach common in Japanese production systems which is used to make logistics activities more efficient. Biomechanical loading on the spine and shoulder for a given workstation were analyzed with reference to these two opposite approaches. They demonstrated that the NB approach is preferable in terms of both productivity and ergonomics since it improves loads on the vertebral column.

Automotive production systems (e.g. assembly or disassembly) are oftentimes characterized by a large number of various processes in highly automated environments, which can have severe consequences for the number and nature of tasks performed by employees. In this context are simple, monotonous, and highly