



Review article

Musculoskeletal disorders in construction: A review and a novel system for activity tracking with body area network



Enrique Valero*, Aparajithan Sivanathan, Frédéric Bosché, Mohamed Abdel-Wahab

RAE Centre of Excellence in Sustainable Building Design, Heriot-Watt University, Edinburgh EH14 4AS, United Kingdom

ARTICLE INFO

Article history:

Received 13 March 2015

Received in revised form

26 November 2015

Accepted 30 November 2015

Available online xxx

Keywords:

WMSDs

Construction

Health

Well-being

Biomechanics

Inertial measurement unit

ABSTRACT

Human body motions have been analysed for decades with a view on enhancing occupational well-being and performance of workers. On-going progresses in miniaturised wearable sensors are set to revolutionise biomechanical analysis by providing accurate and real-time quantitative motion data. The construction industry has a poor record of occupational health, in particular with regard to work-related musculoskeletal disorders (WMSDs). In this article, we therefore focus on the study of human body motions that could cause WMSDs in construction-related activities. We first present an in-depth review of existing assessment frameworks used in practice for the evaluation of human body motion. Subsequently different methods for measuring working postures and motions are reviewed and compared, pointing out the technological developments, limitations and gaps; Inertial Measurement Units (IMUs) are particularly investigated. Finally, we introduce a new system to detect and characterise unsafe postures of construction workers based on the measurement of motion data from wearable wireless IMUs integrated in a body area network. The potential of this system is demonstrated through experiments conducted in a laboratory as well as in a college with actual construction trade trainees.

© 2015 Elsevier Ltd and The Ergonomics Society. All rights reserved.

Contents

1. Introduction	121
1.1. WMSDs in construction	121
1.2. Contribution and structure of the article	121
2. Current practice for evaluating postures and body movements in the workplace	121
2.1. Current WMSD risk assessment method	121
2.1.1. Assessment of repetitive task (ART) and Manual handling assessment (MAC)	122
2.1.2. Ovako working analysis system (OWAS)	122
2.1.3. Posture, activity, tools and handling (PATH)	122
2.1.4. Rapid upper limb assessment (RULA) and rapid entire body assessment (REBA)	122
2.1.5. Quick exposure check (QEC)	122
2.2. Application in construction	122
2.3. Summary	122
3. Biomechanical measurement devices	123
3.1. Overview	123
3.2. In construction	124
3.3. Summary	124
4. Real-time and automated assessment of construction work postures. A new system	125
4.1. System overview	125
4.2. Evaluation and preliminary results	126

* Corresponding author.

E-mail addresses: e.valero@hw.ac.uk (E. Valero), a.sivanathan@hw.ac.uk (A. Sivanathan), f.n.bosche@hw.ac.uk (F. Bosché), m.abdel-wahab@hw.ac.uk (M. Abdel-Wahab).

5. Conclusions	127
Acknowledgements	129
References	129

1. Introduction

Deterioration of workers' physical health and loss of workdays not only impact their well-being and quality of life, but also the country's economy. For example, in 2011 more than 400,000 people in the United Kingdom suffered from illness caused by their work, resulting in 7.5 million lost days (The Health and Safety Executive, 2014).

Musculoskeletal Disorders (MSDs) are injuries or pain affecting muscles, joints and tendons. MSDs result from daily awkward postures and handling tasks, such as: forceful exertions in lifting or carrying loads, bending and twisting the back or limbs, exposure to vibration or repetitive movements (including keyboard typing). If these activities are work-related, then the resulting injuries and disorders are referred to as Work-related Musculoskeletal Disorders (WMSDs).

1.1. WMSDs in construction

Construction workers are particularly at risk of WMSDs because they are frequently exposed to awkward postures and motions, such as lifting, bending or twisting, sometimes for long periods of time. Comparing the different industries in the UK, the Health and Safety Executive (HSE) shows that, despite some improvement over the last 10 years, the rate of self-reported work-related illness in the construction sector remains the second highest behind transport and storage (The Health and Safety Executive, 2014).

With the construction sector employing almost twice more people than the transport sector (2.3 million and 1.47 million respectively, according to the British Office for National Statistics), the number of self-reported work-related illness in the construction sector is likely the highest among all sectors. Note that these figures do not take account of the additional large number of unreported injuries.

The extent to which certain construction occupations are exposed to awkward positions is well summarized by the Center for Construction Research and Training (CPWR) in the United States which reported that carpet and tile installers are on their knees, crouching or stooping more than the 80% of the time, and bricklayers spend 93% of their time bending and twisting the body or doing repetitive motions (The Center for Construction Research and Training, 2013). Memarian and Mitropoulos (2012) conducted a detailed study of incidents and risk activities in a large masonry company and concluded that the tasks resulting in most incidents (and consequently an important number of days away from work and days with modified tasks) were: laying bricks (19%), scaffold erection (18%) and material handling (14%).

Focusing on the postures resulting in WMSDs, Zimmerman et al. (1997) identify the top five ergonomic problems in construction as: working in the same position for long periods, bending or twisting the back in an awkward way, working in awkward or cramped positions, working when injured or hurt, and handling heavy materials or equipment.

1.2. Contribution and structure of the article

Occupational health has been recognized as an important

problem since Gilbreth started his motion studies in the early 20th century (Gilbreth and Gilbreth, 1917). Yet, despite advancements in technology and the development of many tools and initiatives, WMSDs persist as statistics reflect. Better monitoring the body movements of workers, including during their training period, could help correct bad postures and raise awareness about good practice, and consequently improve their quality of life and save working days and money.

Focusing on the construction sector, this article first reviews tools currently employed by government and companies to assess the postures and motions of workers with regard to their long-term health, including the risk for WMSDs (Section 2). Next, Section 3 provides an in-depth review of measurement tools that have been proposed and used for human biomechanical analysis. The use of Inertial Measurement Units (IMUs) is particularly studied as this relates to the system proposed here. Section 3 concludes with the identification of the need for developing and assessing non-invasive wearable systems for continuous body motion monitoring to support assessors and workers in improving construction tasks and preventing WMSDs. Section 4 then presents our proposed Activity Tracking system based on IMUs integrated in a novel wireless Body Area Network (called AT-BAN) and reports experimental results on the recognition of body postures related to lifting, an activity well-known to be problematic. The experiments are conducted both in a laboratory and in a college with actual construction trade trainees. Section 5 concludes this article with an analysis of the contributions made and suggestions for further development and assessment of the proposed system.

2. Current practice for evaluating postures and body movements in the workplace

The postures and body movements of workers can impact their health and well-being and also affect productivity. F. B. Gilbreth was a pioneer of motion study in the field of industrial management (Gilbreth and Gilbreth, 1917, 1924), focusing mainly on better coordinating the body motion of workers to improve productivity. Ever since, practitioners, physiotherapists and ergonomists, from both public and private organisations, have taken a keen interest in the study and evaluation of tasks and workers, developing various assessment methods with focus on productivity and/or health. These methods consider different parameters to be measured, from motion amplitude and frequency to muscle activity.

Section 2.1 reviews the main risk assessment methods that have been developed and applied in various sectors. Section 2.2 then reviews how most of these methods have particularly been applied within the construction sector. Section 2.3 summarizes the strengths and limitations of these methods, with particular focus on the posture and motion measurement techniques they employ.

2.1. Current WMSD risk assessment method

Government agencies dedicated to health and safety issues across industries (such as the Health and Safety Executive (HSE) in the UK or the National Institute for Occupational Safety and Health (NIOSH) in the United States), universities as well as some companies have been developing techniques and proposing guidelines

Download English Version:

<https://daneshyari.com/en/article/6947913>

Download Persian Version:

<https://daneshyari.com/article/6947913>

[Daneshyari.com](https://daneshyari.com)