Assessing the Level of Physical Activity in the Workplace: A Case Study With Wearable Technology

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ABSTRACT

Occupational hygiene requires evaluation of different risk sources in the workplace. The level of physical workload may create stress, fatigue and injuries. Therefore, activity monitoring provides valuable information for companies in assessing and solving possible hazards in the workplace. The article presents a system using wearable technology to monitor and evaluate physical workload with in situ measurements. The system uses a smartwatch and a mobile application for Android phones. During workload monitoring, the application displays physiologic variables such as heart rate, calories, body temperature, galvanic skin response and number of steps. Additionally, the system computes absolute and relative cardiac cost, and Frimat coefficients. Tests were performed on 10 individuals from a janitor staff (5 men and 5 women), monitoring every task during their most demanding hour. Results agree with the type of activity developed in different intervals, showing light and very light workload for different tasks in all workers.

KEYWORDS

Body Sensor Networks, Frimat, Janitor Workload, Occupational Hygiene, Wearable Technology

1. INTRODUCTION

According to the World Health Organization (WHO), work stress affects physical and psychological health, possibly reducing work effectiveness of people at their workplace (World Health Organization, 2003). Therefore, this kind of risk must be considered in the definition process of jobs and working areas. An intense physical workload can cause high levels of stress, fatigue, and even prevent people from continuing with their activities. Studies of effects of working stress use heart rate measurements to estimate physical workload, due to its close relation to energy use (Keytel et al., 2005). According to the National Institute of Security and Occupational Hygiene of Spain, the variables to evaluate the physical workload can be cardiac indicators such as the absolute cardiac cost, the relative cardiac cost,

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Frimat coefficients and Chamoux coefficients (INSHT, n.d.). Some variables for determine physical workload may be monitored with static equipment, since people are mostly seated in the same office or space during their work hours. However, wireless devices may be more adequate for monitoring physical workload in people who need to constantly move at their workplace.

One option for monitoring this information is to locate sensors on the body of working people and transmit data directly to a remote facility. However, this option may require radio propagation trough Non-Line-of-Sight (NLOS) conditions, which may affect communication protocol performance (Berdugo, Buchelly, Calle, & Velez, 2012).

A second option is to transmit information from the sensors located on the body to a main node placed close to the subject. This approach is implemented in Wireless Body Area Networks (WBAN) IEEE Standard 802.15.6. The standard allows for information transmission from sensors in body, on body and maximum 5 meters outside the body, to a Coordinator node, which in turn may send data to different networks. According to the standard, sensors inside the body should transmit at 402MHz, on body may use 900MHz or 2.4GHz (Movassaghi, Abolhasan, Lipman, Smith, & Jamalipour, 2014).

Other options include wireless standards for information transmission in short distances, such as IEEE802.15.4 and IEEE 802.15.1 (Bluetooth). Both technologies work in the 2.4 GHz frequency band. The former allows multi-hop communication and possibly hundreds of nodes. The latter allows the connection of 7 active slaves to a master in a star topology (Kabara & Calle, 2012). Different wearable sensors embedded in wristbands employ this communication standard and transmit the measured information to a cellular phone (Apple Inc., 2018; Garmin, 2018). The transmission may occur during the activity or after finishing the activity, by synchronizing the wristband to the phone. In the first case, communication may be affected when the location of the cellular phone does not allow direct line of sight to the wristband. Therefore, communication may be affected by a Grey Area, where there are high levels of packet losses (Aguirre et al., 2014). The second case may solve this situation, if the wristband is located close to the phone.

The literature shows different systems for physical activity monitoring in the workplace. One example estimates the physical workload of professional dancers based only on heart rate variation measurement with a commercial wearable monitor, such as the Polar S810 (Aranas, Veláquez & Carvajal, 2013). This device was previously validated by (Gamelin, Berthoin, & Bosquet, 2006) as a reliable heart rate monitor compared to clinical monitors. The paper from (Aranas, Veláquez & Carvajal, 2013) also classifies physical activity by gender and age, concluding that the energy demand for the considered sample of professional dancers was greater than their energy capacity.

Another example measured the heart rate and the number of steps of a group of nurses during a workday. The paper used a heart rate belt and a mobile phone using the ANT+ protocol to collect data (Jovanov, Frith, Anderson, Milosevic, & Shrove, 2011). The ANT+ protocol is a wireless standard specialized in sport-related wearable devices. To establish communication between the belt and the smartphone, authors used an ANT+ gateway as described in their real-time physiological monitoring work described on (Jovanov, 2011). However, the system does not provide information related to physical workload. Other studies track person activities with accelerometer data, but they do not relate activities with energy use (Intille et al., 2011; Jovanov et al., 2005; Meena, Ravishankar, & Gayathri, 2014). Also, it is worthy to remark that the communication standards used in these works were Bluetooth (Intille et al., 2011) and Zigbee (Jovanov et al., 2005; Meena et al., 2014).

Additional works developed wearable heart rate monitoring systems without presenting information about physical load at the workplace (Hendrikx et al., 2017; Khan, Akbar, Pervaiz, & Hassan, 2016; Popa, Marinescu, & Nedeleva, 2017). Also, all of these works presented an architecture composed by a smartwatch with an embedded heart rate sensor and a Bluetooth link. Another study presents an Android application to track the physical workload (Pereira, 2016). The application is developed for a smartwatch and displays the level of workload every 5 minutes, classifying workload as adequate or high. The system calculates the heart rate variability using a photoplethysmography
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