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Review

Effects of active pause pattern of surface electromyographic activity among subjects performing monotonous tasks: A systematic review

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ABSTRACT

Active pauses have shown potentially beneficial effects to increase the variability of the electrical activation pattern of muscles. However, there is a lack of consensus as to how to design and implement those pauses and the processing methods of surface electromyography (EMG) data when evaluating low-level monotonous tasks. The aim of this systematic review was to synthesize the evidences regarding the way which active pauses have been applied, and the methods used to investigate the related EMG changes. PubMed-MEDLINE, Embase, Web of Science, Lilacs, Ebsco, and Scopus databases were searched. Two authors independently extracted data from the primary studies. The methodological quality was assessed using a list from van der Windt et al. (2000), and the level of evidence was synthesized through GRADE. The ISEK guideline for reporting EMG data was also applied as a checklist. Fifteen studies were included - 14 with high methodological quality. In general, active pauses were able to change the level of EMG activity in monotonous tasks. The level of evidence through GRADE was very low for all EMG processing methods, except RMS which was low. A vast heterogeneity concerning the methods applied to analyze EMG data contributed to decrease the quality of evidence synthesis, and the findings need to be carefully considered. The GRADE approach and the ISEK guideline contributed to identify important flaws in the literature. Future studies investigating active pauses in longitudinal studies and following the standard for recording and reporting EMG data care are warranted.

Contents

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1. Introduction

Work related musculoskeletal disorders (WRMDs) are highly prevalent in industrialized countries and are responsible for absenteeism, early retirement, and disabilities (Bergström et al., 2007; David et al., 2008; Bevan et al., 2009; Schneider and Irastorza, 2010). Particularly, the neck-shoulder region suffers from prolonged exposure during low-level monotonous tasks, such as computer work and industrial repetitive tasks (Côté et al., 2008; Schneider and Irastorza, 2010; Waersted et al., 2010), which may lead to an overload of that region. This overload could be explained by the Cinderella hypothesis (Hägg, 1991). This hypothesis is based on the principle of size-ordered motor-units (MU) recruitment where low muscular rest leads to continuous and sustained activation of small MU, which contributes to the development of fatigue, discomfort, and pain often reported among workers performing sustained static and repetitive tasks (Søgaard, 1995; Hägg, 2000; Sjøgaard et al., 2006; Thorn et al., 2007; Côté, 2012). Increasing motor control variability during stereotyped low-level monotonous tasks could reduce the symptoms of muscle pain and thereby control the development of WRMDs (Mathiassen, 2006; Madeleine et al., 2008a, 2008b; Richter et al., 2009; Srinivasan and Mathiassen, 2012). Motor variability can be addressed as variability in the firing pattern of the MU, evaluated by EMG measurements, for example (Srinivasan and Mathiassen, 2012). It can be achieved through strategies such as job rotation, reduction of the working period, implementation of exercises or regular working pauses (Galinsky et al., 2000, 2007; Mclean et al., 2001; Rissén et al., 2002; Mathiassen, 2006). In general, pauses can be accomplished through informal or programmed breaks. During tasks with flexible rhythm, the subject can perform informal pauses as often as wanted. Programmed pauses should be considered as a specific time for rest or perform workplace exercises.

Although the current literature has a substantial number of studies investigating pauses in relation to occupational exposures (e.g. Henning et al., 1989, 1997; Christensen et al., 2000; Galinsky et al., 2000; Mclean et al., 2001; Balci and Aghazadeh, 2003; van den Heuvel et al., 2003; Larsen et al., 2009; Samani et al., 2009a), only a few studies have evaluated the immediate effects of pauses in terms of the pattern of muscle surface electromyographic activity (EMG). In general, most of the available studies only evaluated the effectiveness of resting periods during low-level monotonous tasks (Henning et al., 1997; Galinsky et al., 2000; Mclean et al., 2001; Balci and Aghazadeh, 2003; van den Heuvel et al., 2003). A systematic review by Brewer et al. (2006) showed that this type of pause, also known as passive pause or rest break, has no benefits on musculoskeletal outcomes when compared with other types of intervention among computer users.

As opposed to passive pauses, active pauses can be described as a muscle contraction performed for a relatively short period of time that is able to redistribute muscle load through changes in the spatial distribution of EMG amplitude and reduce the development of fatigue during prolonged and sustained muscle activities (Falla and Farina, 2007). Active pauses enable active recovery after strenuous physical activity among athletes (Weltman et al., 1977; Ahmaidi et al., 1996). This new approach has also shown potential benefits on muscle oxygenation (Crenshaw et al., 2006) as well as on promoting variability in muscle activation patterns (Crenshaw et al., 2006; Larsen et al., 2009; Samani et al., 2009a, 2009b, 2009c, 2010a, 2010b). On the other hand, to date no agreement is found as to applying active pauses to effectively modify the sustained muscle activation pattern (Samani et al., 2009c).

Considering that the exposure to sustained static and repetitive tasks directly affects the muscle load, the EMG recordings play a central role and enable to assess the effect of active pauses. The EMG provides important information about muscle behavior and adaptations to changes in the sensory afferent volleys, especially in the neck-shoulder region (for reviews see Mathiassen et al., 1995; Visser and Van Dieën, 2006). Different processing methods and analysis have been developed over time to track down the changes in EMG signal. A wide range of methods has been used to analyze data in both time and frequency domain, such as root mean square (RMS), moving average, filter integration, mean or median power frequency, amplitude probability distribution function (APDF), EMG gap analysis, relative rest time (RRT), exposure variation analysis (EVA; Mathiassen and Winkel, 1991), job variability ratio (JVR; Barbieri et al., 2015) and recently non-linear methods have been applied (Samani et al., 2012; Rathleff et al., 2013).

Despite the prevalence of musculoskeletal disorders in the neck-shoulder region and the potential beneficial effects of active pauses, up to the present date no systematic reviews exist on that topic. Such a review can address the beneficial effects of pause regime and synthesize the methods used for implementing and processing of active pauses. Thus, the aim of this systematic review is to synthesize the evidences as to how active pauses have been applied, and the procedures used to investigate the EMG changes following active pauses.

2. Methods

2.1. Search strategy and selection process

The electronic search was performed on PubMed-MEDLINE, Embase, Web of Science, Lilacs, Ebsco and Scopus. The search terms were combined and resulted in the following string: "(work OR occupation) AND (pause OR break) AND (electromyography OR electromyographic OR EMG OR sEMG)".

Two independent reviewers selected the studies retrieved through the electronic search based on pertinent titles. After that, all abstracts considered relevant had their full-text retrieved for reading and were evaluated. The reference lists of all included studies were also checked to identify possible studies not retrieved by the electronic search. Systematic reviews were analyzed separately, and the primary studies were included through the snowballing method if considered pertinent.

The primary studies were considered pertinent for this review and were included if they were: (1) cross-sectional studies assessing the effects of active pauses on EMG during occupational