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Photograph-based ergonomic evaluations using the Rapid Office Strain Assessment (ROSA)

J. Liebregts, M. Sonne*, J.R. Potvin

Department of Kinesiology, McMaster University, 1280 Main St. W, Hamilton, Ontario L8S 4L8, Canada

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ABSTRACT

The Rapid Office Strain Assessment (ROSA) was developed to assess musculoskeletal disorder (MSD) risk factors for computer workstations. This study examined the validity and reliability of remotely conducted, photo-based assessments using ROSA. Twenty-three office workstations were assessed on-site by an ergonomist, and 5 photos were obtained. Photo-based assessments were conducted by three ergonomists. The sensitivity and specificity of the photo-based assessors' ability to correctly classify workstations was 79% and 55%, respectively. The moderate specificity associated with false positive errors committed by the assessors could lead to unnecessary costs to the employer. Error between on-site and photo-based final scores was a considerable ~2 points on the 10-point ROSA scale (RMSE = 2.3), with a moderate relationship ($\rho = 0.33$). Interrater reliability ranged from fairly good to excellent (ICC = 0.667 −0.856) and was comparable to previous results. Sources of error include the parallax effect, poor estimations of small joint (e.g. hand/wrist) angles, and boundary errors in postural binning. While this method demonstrated potential validity, further improvements should be made with respect to photo-collection and other protocols for remotely-based ROSA assessments.

1. Introduction

Recent developments in information technology have resulted in dramatic increases in occupational computer use (Blatter and Bongers, 2002). In 2000, approximately 60% of Canadian workers reported computer usage as part of their job duties, while 82% of those workers reported daily occupational computer use (Lin and Popovic, 2003; Marshall, 2001). In the United States, 2003 census data showed that over 50% and 60% of all employed men and women, respectively, used a computer as part of their job (Day et al., 2005). This trend of increasing workplace computer use has been associated with an increase in work-related musculoskeletal disorders (WMSDs) and symptoms among workers (Mani and Gerr, 2000). Meta-analyses (Gerr et al., 2006; IJmker et al., 2007) found an overall positive association between computer usage and WMSDs.

Computer use has been identified as a risk for the development of WMSDs. Risk factors of computer use include prolonged non-neutral postures of the: 1) hands and wrists (Jensen et al., 2002; Keir et al., 1999; Marcus et al., 2002), 2) head and neck (Gerr et al., 2002; Marcus et al., 2002) and 3) shoulder, elbow and lower back (Burdorf et al., 1993; Juul-Kristensen et al., 2004).

The commonly used Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993) was created to identify postures that can lead to WMSDs. While some computer workstation risk factors may be assessed using RULA, it does not necessarily assess risk factors specific to those associated with the set-up of office equipment, such as office chairs, monitors, phone, etc. (Sonne et al., 2012). Computer workstation-specific evaluation tools, such as the modified Rapid Upper Limb Strain Assessment for computer workstations (Lueder,1996; Lueder and Corlett, 1996) and the University of California Computer Checklist (Janowitz et al., 2002), are rapid ergonomics assessment tools for the office workstation. However, both were found to be inadequately associated with symptoms of WMSDs and were inconsistent in their prediction of these symptoms (Menendez et al., 2009). The Strain Index (Moore and Garg, 1995) has also been applied to the office workstation setting, however, it does not appropriately take into account all risk factors in the office, including the equipment and work habits of the user (e.g. telephone location and telephone user strategy). Finally, many generic computer workstation checklists involve dichotomous questions and answers (e.g. 'yes' or 'no' responses) to identify risk factors that do not account for the magnitude of the

* Corresponding author. Department of Kinesiology, McMaster University, 1280 Main St. W, Hamilton, Ontario L8S 4K1, Canada.
E-mail address: sonnemw@mcmaster.ca (M. Sonne).

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risk factors, and are not validated against WMSD symptoms (eg. OHSA Office ergonomics checklist, Ontario MOL Office ergonomics checklist).

The Rapid Office Strain Assessment (ROSA) (Sonne et al., 2012) allows ergonomists to quickly quantify risk factors specific to the computer workstation through workplace posture and equipment assessment. Risk factors are weighted based on increasing WMSD risk, and provide users with risk scores for subsets of the workstation (i.e. chair, monitor/telephone, mouse/keyboard) as well as an aggregate ROSA final score from 1 to 10. Original validity testing of the tool (Sonne et al., 2012) found a significant correlation of ROSA final scores with reported discomfort, with a proposed action level score of 5 indicating an increased risk of discomfort for workstations with final scores equal or above that score. In addition, original on-site interrater reliability testing was shown to be high (ICC = 0.88, 0.91, respectively) (Sonne et al., 2012), further demonstrating the effectiveness of the tool.

Conventionally, field office ergonomic assessments have been limited to an in-person, one-on-one assessment format. While this is considered to be a reliable and proven methodology, it may become costly and inefficient for an ergonomist faced with assessing a large number of workstations. As a potential alternative, Sonne and Andrews (2012) investigated the validity of worker self-assessment using ROSA via an online interface; however there was a noted issue with the untrained workers' ability to properly assess their own mouse and keyboard risk factors.

In addition to checklist entries concerning the presence/absence of workstation characteristics (e.g. documents holder, screen glare), a variety of ROSA's checklist entries require the estimation and classification of posture angles into interval bins, including; knee flexion, trunk flexion/extension, neck flexion angles etc. The practicality of office assessments, based on static photos and/or video observations, has seldom been investigated in past literature. However, image observation has been widely investigated in occupational biomechanics experimental settings to analyze the validity and phenomena surrounding joint angle estimation (Li and Buckle, 1999; Abu-Rajab et al., 2010; Baluyut et al., 1995; Bao et al., 2007; Genaidy et al., 1993; Lau and Armstrong, 2011; Liu et al., 1997; Paul and Douwes, 1993). Researchers found satisfactory accuracy of joint angle estimates, with errors ranging from ~2 to 10% (Baluyut et al., 1995; Covalla, 2003; Genaidy et al., 1993; Paul and Douwes, 1993). Also, joint angle bin widths (in degrees) were positively correlated with posture rating reliability (Bao et al., 2009) and accuracy (Van Wyk et al., 2009), with the optimal angle interval widths being found to be 30°.

Bao et al. (2007) compared two static image analysis methods used for postural estimations ("worst-case" posture assessment vs. frame-by-frame posture sampling assessment) using RULA (McAtamney and Corlett, 1993). However, they only compared and contrasted the results between the two image selection approaches, and did not analyze the accuracy of the methods for estimating actual postures. Covalla (2003) compared static and dynamic image observation to evaluate the validity of using of RULA and the Strain Index (Moore and Garg, 1995). It still remains, however, that no studies have investigated the use of static images while using risk analysis tools for office workstations.

On-site office ergonomics assessments are currently the preferred method with ergonomic practitioners. We have proposed that the use of static image observation may be a valid method to improve the efficiency of these assessments. To investigate this proposal, we need to compare remotely performed photo-based assessment scores against on-site assessment scores using the Rapid Office Strain Assessment tool. The purpose of this study is to determine the validity and reliability of remotely performed photo-based ROSA assessments.

2. Methods

2.1. Participants

One ergonomist performed the on-site assessments (Section 2.2), while three ergonomists were recruited to participate in the remote photo-based assessment portion of this study (Section 2.4). In addition, computer workstation users (n = 23; 11 males, 12 females) were recruited to participate in this study as the subjects of the assessments. Each workstation user was required to read a letter of information and sign a consent form before participation in the study. All procedures in this study approved in advance by the university's research ethics board.

2.2. On-site assessment

On-site assessments of workstations were performed by an expert ergonomist trained in using the Rapid Office Strain Assessment (ROSA) tool (Sonne et al., 2012). This ergonomist, henceforth called the 'on-site assessor', had experience working as a consultant in the public sector conducting office ergonomic evaluations of government worker offices. Since the interrater reliability of on-site assessments using ROSA has already been established in previous studies (Sonne et al., 2012; Sonne and Andrews, 2011), just one assessor was chosen to do the on-site assessments.

The on-site assessor was given a 60-min tutorial on using the ROSA tool, and afterwards performed 20 ROSA assessments of office mock-ups using vacant office spaces at the university. This practice allowed the on-site assessor to gain a consistent comfort level and understanding of the tool for a wide variety of workstations. The 23 desktop workstations were evaluated while being operated by the workstation user, and three ROSA sub-scores: 1) chair, 2) monitor/telephone and 3) mouse/keyboard, and a ROSA final score were obtained for each workstation. Estimated work duration was reported by the workstation user. This value was used as the assumed duration of use for all components of the workstation. The on-site assessment scores were considered most accurate, and were used as the reference against which the photo-based assessment errors were calculated.

2.3. Photographs

Five photos were taken of each of the 23 workstations during completion of the on-site assessment, by the on-site assessor. The perspectives were chosen to capture as much workstation information as possible within the fewest number of photos. It was determined that five photos would provide a minimum of two viewing angles for all, or most, body postures during a ROSA office assessment, while including visual information of all workstation features.

The first photo (Fig. 1a) was taken from the sagittal perspective while the workstation user operated the keyboard. The photo captured a fully inclusive view of the workstation user and workstation components (i.e. chair, monitor, keyboard, etc.) and was to be used for the estimation of all chair-related characteristics (e.g. seat pan depth/height, back rest angle, arm rest height, space under desk, etc.), monitor-related factors and postures, keyboard factors (with the exception of wrist deviation), and the presence of an overhead cabinet. The second photo (Fig. 1b) was taken from the same sagittal perspective as the first photo; however the workstation user demonstrated a reach to the telephone. The third photo (Fig. 1c) was taken from the coronal perspective with the workstation user performing a typing task and included the workstation user's head, shoulders, and arms, as well as all workstation components found on the desk surface. This angle was chosen for the