Applied Ergonomics 51 (2015) 189–198

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Managing children's postural risk when using mobile technology at home: Challenges and strategies

Marina Ciccarelli [a,*], Janice D. Chen [b], Sharmila Vaz [a], Reinie Cordier [a], Torbjörn Falkmer [a,c]

[a] School of Occupational Therapy and Social Work, Faculty of Health Sciences, Curtin University, GPO Box U1987, Perth, 6845, Australia
[b] Rehabilitation Department, National University Hospital, 119074, Singapore
[c] Rehabilitation Medicine, Department of Medicine and Health Sciences (IMH), Faculty of Health Sciences, Linköping University & Pain and Rehabilitation Centre, UHL, County Council, Linköping, SE 581 85, Sweden

ARTICLE INFO

Article history:
Received 28 August 2014
Accepted 9 April 2015
Available online 4 June 2015

Keywords:
Minimising risk
Mobile technologies
Rapid Upper Limb Assessment (RULA)

ABSTRACT

Maintaining the musculoskeletal health of children using mobile information and communication technologies (ICT) at home presents a challenge. The physical environment influences postures during ICT use and can contribute to musculoskeletal complaints. Few studies have assessed postures of children using ICT in home environments. The present study investigated the Rapid Upper Limb Assessment (RULA) scores determined by 16 novice and 16 experienced raters. Each rater viewed 11 videotaped scenarios of a child using two types of mobile ICT at home. The Grand Scores and Action Levels determined by study participants were compared to those of an ergonomist experienced in postural assessment. All postures assessed were rated with an Action Level of 2 or above; representing a postural risk that required further investigation and/or intervention. The sensitivity of RULA to assess some of the unconventional postures adopted by children in the home is questioned.

1. Introduction

Information and communication technologies (ICTs) are an indispensable part of modern day society. School-aged children in Australia use a variety of ICT for educational, leisure and social purposes (Australian Bureau of Statistics (ABS), 2006, 2009a, 2009b). Several studies report associations between ICT use in children and adolescents and musculoskeletal discomfort (Bélanger et al., 2011; Hakala et al., 2006; Jacobs and Baker, 2002; Straker et al., 2008; Straker et al., 2011), which are similar to those observed among adult computer users in vocational settings (Gerr et al., 2004). Given that children are still developing physically, there is reasonable concern regarding the long term impact of such exposure on their musculoskeletal health (Bélanger et al., 2011; Jacobs and Baker, 2002; Straker et al., 2009).

Recent technological advances have inspired a genre of portable, compact and personalised ICT devices, such as laptop computers, touch screen tablets and smartphones. These mobile devices can be used in a wide range of physical environments while adopting a range of postures (Harris and Straker, 2000; Sommerich et al., 2007). In other words, nowadays, *anywhere* can be considered an ICT workstation.

Studies into the postures adopted by school-aged children while using an ICT workstation have predominantly been within school environments (Breen et al., 2007; Geldhof et al., 2007; Kelly et al., 2009; Murphy et al., 2004). Mismatches between the dimensions of school furniture and body anthropometrics are regarded as the most observed contributors of reported discomfort and musculoskeletal complaints in various parts of children's bodies (Barrero and Hedge, 2002; Ciccarelli, Straker, Mathiassen and Pollock, 2011b; Saarni et al., 2007). Limited research exists on the postural risks associated with children's ICT use in the home environment (Jacobs and Baker, 2002; Kimmerly and Odell, 2009).

When at home, children are likely to use their mobile ICT devices for unsupervised leisure and social pursuits (Rideout et al., 2010); have longer durations of use for completing educational tasks than when at school (Ciccarelli, Straker, Mathiassen and Pollock, 2011a; Kent and Facer, 2004; Kerawalla and Crook, 2002); and adopt a range of postures across different locations in the home (Harris and Straker, 2000; Sommerich et al., 2007). With

* Corresponding author. Tel.: +61 8 9266 3692; fax: +61 8 9266 3636.
E-mail address: M.Ciccarelli@curtin.edu.au (M. Ciccarelli).

http://dx.doi.org/10.1016/j.apergo.2015.04.003
0003-6870/

increasing numbers of children using mobile ICT devices at home, it is important to assess their impact on children's posture, so that appropriate guidelines for the healthy use of these mobile technologies can be developed (Young et al., 2012).

1.1. Measuring postural risk in children

School-aged children's use of mobile technologies in and out of classroom environments may be categorised as sedentary work (US Department of Labor, 1993), wherein postural exposures can vary widely based on factors including: (i) the design and layout of furniture in the school and home; (ii) whether tasks involving mobile technologies are individual or group tasks; and (iii) the natural postural preferences of children. When determining individuals' postures in field studies, the use of job titles and descriptions of workplace characteristics are the least valid and reliable; direct monitoring using electro-goniometers limits the body segments that can be simultaneously measured (Bao et al., 2007); and time-stamping postures to specific tasks requires high observer burden (Ciccarelli et al., 2011b). The use of videorecorded work tasks performed in natural environments can allow for the impact of environmental, task, and personal factors on postures to be considered in later analysis.

The Rapid Upper Limb Assessment (RULA) is an observation-based postural screening tool originally developed for use in ergonomic investigations of workplaces, to assess individual worker's exposure to load factors due to posture, muscle function and related forces (McAtamney and Corlett, 1993). RULA was designed to be carried out quickly, with minimal equipment or change to the working environment and with minimal disruption to the person under observation. It is reportedly easy to learn, and requires no previous skills in observation techniques (McAtamney and Corlett, 1993).

RULA can be used to observe and rate postures in situ, or from video recordings. RULA uses a series of illustrations of different body segments, and allocates a numerical score to each body segment based on the degree of deviation from a neutral position. Additional ratings are assigned to factors that place strain on the musculoskeletal system, including repetitive actions, static loading, and force. RULA provides ratings for individual body segments and converts these ratings to a Grand Score. The Grand Score is used to assign the observed posture into an Action Level that indicates the level of intervention required to reduce the musculoskeletal risks of injury on the individual (see Table 1). For example, an Action Level of 3 or 4 signifies that further investigation and changes in how the task is performed are required, so as to reduce postural risk (McAtamney and Corlett, 1993).

Originally developed through evaluation of workers in a range of manufacturing industries, including the garment manufacturing industry, and among computer operators (McAtamney and Corlett, 1993), researchers have since used RULA to assess postural risks among adults in a wide range of occupational groups including light and medium manufacturing workers (Bao et al., 2007; Chiasson et al., 2012; Kee and Karwowski, 2007), automotive assembly operators (Drinkaus et al., 2003; Kee and Karwowski, 2007); healthcare workers (Bao et al., 2007; Kee and Karwowski, 2007); office workers (Cook et al., 2000; Cook and Kothiyal, 1998; Sen and Richardson, 2007); simulated surgical tasks (Lee et al., 2005); saw mill filers (Jones & Kumar, 2007); food processing workers (Chiasson et al., 2012); truck drivers (Massaccesi et al., 2003); and tree nursery workers (Chiasson et al., 2012). The RULA rating scale is reported to have good reliability when used by physiotherapists, and industrial and safety engineers to assess adults; although the exact values of the reliability calculation are not documented (McAtamney and Corlett, 1993).

Several researchers have use RULA to assess postures among children in school environments (Breen et al., 2007; Dockrell et al., 2010; Kelly et al., 2009; Laeser et al., 1998; Oates et al., 1998); with a few alluding to its reliability when used to rate children's postural risk (Breen et al., 2007; Laeser et al., 1998; Oates et al., 1998). A recent study compared the inter-rater and intra-rater reliability of the RULA to assess postures adopted by 12 year old students ($n = 24$) as they used computers in school during school hours (Dockrell et al., 2012). Using Intra Class Correlation Coefficient as an index of reliability, the study found moderate agreement between trained physiotherapists ($n = 3$) and undergraduate physiotherapy students' ($n = 3$) Grand Score and Action Level ratings; with scores in all cases found to be more reliable on retest. Inter-rater reliability varied depending on the summary score used; with the RULA Grand Score of the “trunk and legs” subscale (RULA − D score) found better than that of the “arms” subscale (RULA − C score). The authors did not present each rater's raw scores. Thus, one cannot rule out the influence of dispersion in raters' scores as a potential cause for the lower inter-rater ICC values (Bland and Altman, 2003).

An earlier study by Chen et al. (2014), investigated if experience in postural risk assessment contributed to differences in outcome scores obtained by experienced and novice occupational therapists while using RULA to rate video recordings of self-selected postures adopted by a 12-year old child using mobile ICT in the home environment. The study found no significant group differences in the Grand Score and the Action Level ratings for each video. Furthermore, the authors did not discuss the raw scores ratings of each video, or the postures that presented the greatest risk to the child's musculoskeletal system while using ICT at home. Thus, further research is needed to not only substantiate inter-rater agreement of the RULA in assessing postural risk in children at home, but to also identify the nature of high risk postures that children may adopt while using mobile ICT devices at home. The current study intended to bridge these gaps.

Table 1
RULA Grand scores, action levels and implications.

Grand Score	Action Level	Implications
1 or 2	1	Posture is acceptable if not maintained or repeated for long periods.
3 or 4	2	Further investigation needed, changes may be required.
5 or 6	3	Investigation and changes are required soon.
7	4	Investigation and changes are required immediately.

2. Study purpose

The purpose of this study was to:

a) test the agreement between an expert rater and experienced and novice raters' scores (Grand scores and Action Levels) on the RULA, whilst undertaking a postural risk assessments of a child using mobile ICT devices in the home environment;
b) identify the postures of a child using mobile ICT in the home environment that are rated as requiring further investigation and/or change; and
c) provide suggestions on how to translate ergonomics principles for healthy ICT among children into practical solutions for families to manage postural risks.