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Impact of experience when using the Rapid Upper Limb Assessment to assess postural risk in children using information and communication technologies

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ABSTRACT

The Rapid Upper Limb Assessment (RULA) is an observation-based screening tool that has been used to assess postural risks of children in school settings. Studies using eye-tracking technology suggest that visual search strategies are influenced by experience in the task performed. This study investigated if experience in postural risk assessments contributed to differences in outcome scores on the RULA and the visual search strategies utilized. While wearing an eye-tracker, 16 student occupational therapists and 16 experienced occupational therapists used the RULA to assess 11 video scenarios of a child using different mobile information and communication technologies (ICT) in the home environment. No significant differences in RULA outcome scores, and no conclusive differences in visual search strategies between groups were found. RULA can be used as a screening tool for postural risks following a short training session regardless of the assessor's experience in postural risk assessments.

1. Introduction

The use of information and communication technologies (ICT) by children has been associated with musculoskeletal discomfort (Burke and Peper, 2002; Harris and Straker, 2000; Jacobs and Baker, 2002; Ramos et al., 2005; Straker et al., 2009). This is concerning as children are still physically developing, and there might be negative long-term consequences on their physical health (Straker et al., 2009).

There are no risk assessment tools specifically developed to assess postural risks in children. However, researchers have previously used the Ovako Working Posture Analysing System (OWAS) (Karhu et al., 1977) and the Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993), both originally developed to assess adult workers, to assess postural risks among children in school settings. The use of RULA to assess children's posture has been reported more extensively in the scientific literature (Breen et al., 2007; Dockrell et al., 2010, 2012; Kelly et al., 2009; Laeser et al., 1998; Oates et al., 1998) than the OWAS (Saarni et al., 2007a, 2007b).

1.1. Rapid Upper Limb Assessment

The RULA is an observation-based screening tool used to quickly assess an individual's exposure to load factors due to posture, muscle function and forces they exert. Administration of the tool is simple to learn and does not require the use of special equipment or pre-existing skills in observation techniques (McAtamney and Corlett, 1993). The RULA involves assigning: 1) a numerical rating to the posture of the upper limbs, neck, trunk and legs, and 2) another numerical rating for additional factors that strain the musculoskeletal system, such as repetitive action, static loading and force exertion. These ratings are scored according to an algorithm to obtain a Grand Score ranging from 1 to 7, and an Action Level ranging from 1 to 4 that has associated implications for remedial action (Table 1). The RULA allows the left and right upper

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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.

limbs to be assessed separately, yielding a Grand Score and Action Level for each side of the body.

Prior ergonomics studies have used the RULA to assess the postures of children when performing academic tasks at computer workstations in school environments; in these studies the children's postures were influenced by the classroom furniture (Breen et al., 2007; Dockrell et al., 2010, 2012; Kelly et al., 2009; Laeser et al., 1998; Oates et al., 1998). No prior studies have used the RULA to perform postural risk assessments in home environments wherein children have high exposure to mobile ICT for leisure (Rideout et al., 2010), and use ICT for longer durations than when at school (Ciccarelli et al., 2011; Kent and Facer, 2004; Kerawalla and Crook, 2002).

1.2. Visual search

Due to the observational nature of risk assessments, visual search is an essential skill utilized by the assessor. Visual search depends primarily on eye behaviours of saccades and fixations (Falkmer et al., 2008; Liversedge and Findlay, 2000; Yang et al., 2002). Saccades are the voluntary rapid eye movements that direct the eye to points of interest in the environment; no visual information is projected on the fovea during this movement (Fuchs, 1971). Fixations are periods of gaze stability that occur between saccades (Duchowski, 2007). During fixations, the eye is directed such that information from the environment is projected onto the fovea, registered and processed (Fuchs, 1971).

It is recognized that visual attention can be influenced by characteristics of the visual environment (bottom–up) and cognitive processes (top–down) (Henderson, 2003; Wolfe et al., 1989). Bottom–up factors that can affect visual attention include salient characteristics of the visual scene such as movement, contrast, and colour. On the other hand, top–down cognitive processes are related to short-term visual memory of the present scene, long-term memory about similar scenes and knowledge related to the visual search task (Henderson, 2003). During skilled, purposeful and active search, top–down cognitive processes tend to influence visual attention more than bottom–up processes (Henderson, 2003; Yang et al., 2002). The fixation point is assumed to reflect the focus of attention in a top–down approach (Henderson, 2003), and therefore is commonly used to provide an insight into the cognitive processes involved during visual search tasks (Falkmer et al., 2008).

1.2.1. Differences in visual search strategies due to experience

Previous studies have demonstrated that experience influences an individual's visual search strategy. In radiology, experts have significantly fewer numbers of fixations while making a greater number of correct judgements, and have a tendency to use a more global perception strategy (Kundel et al., 2007; Manning et al., 2006). In driving studies, experienced drivers have more flexible search strategies, indicated by larger spread of visual search on horizontal and vertical planes, shorter fixation durations and shorter hazard processing times (Hosking et al., 2010; Underwood, 2007; Underwood et al., 2002). Experienced gymnastics coaches displayed fewer numbers of fixations, but longer fixation durations, during evaluation of gymnastics routines (Moreno et al., 2002). Training in a systematic visual search strategy for a visual inspection task resulted in improved task performance (Wang et al., 1997). These studies showed that experience and training could make a difference in visual search strategies and the interpretation of information obtained from visual search (Yang et al., 2002). However, it is not known if this is the case in postural risk assessment scenarios.

1.3. Aims of the study

The aims of this study were to determine differences between experienced and novice assessors in their RULA scores (Grand Scores and Action Levels) and their visual search strategies during a postural risk assessment of a child using mobile ICT in the home environment.

2. Methods

2.1. Study design

This was an experimental study conducted under controlled, standardized conditions within a laboratory setting. Between-group comparisons of the RULA Grand Scores and Action Levels, and visual search strategies measured in terms of durations and locations of the participants' initial fixations, were performed.

2.2. Sample size

The desired difference between the groups was 0.51, which is just above half a scale step on the RULA Action Level. With an estimated standard deviation of 0.5 derived from pilot data of 19 participants, the desired effect size was Cohen's d of 1 or larger. A power calculation based on a critical α-value of 0.05 and a $1 - \beta$ of 0.2, i.e., a power of 80%, indicated that a minimum of 16 participants in each group was required to detect this effect size.

2.3. Participants

2.3.1. Student occupational therapists

A convenience sample of students enrolled in the third year of the undergraduate Bachelor of Science (Occupational Therapy) program at Curtin University in Perth, Western Australia; who had successfully completed the introductory ergonomics course entitled 'Ergonomics & Safety Science I' during the second year of the program were invited to participate. Students with prior work experience in vocational rehabilitation and ergonomics were excluded from the study. Fourteen female and two male occupational therapy students (mean age 24.7 years, standard deviation (SD) 8.1) participated in the study. None of the students had prior knowledge about the RULA as a postural risk assessment tool.

2.3.2. Experienced occupational therapists

Occupational therapists who possessed a minimum qualification of a Bachelor of Science in Occupational Therapy recognized by the World Federation of Occupational Therapists and had more than four years of experience in the field of ergonomics and/or vocational rehabilitation were invited to participate via telephone and email recruitment. Eleven female and five male occupational therapists (mean age of 40.7 years, SD 9.9), with relevant work experience ranging from four to 35 years (mean length of experience 15.3 years, SD 9.0) participated in the study. All participants