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Head, trunk and arm posture amplitude and variation, muscle activity, sedentariness and physical activity of 3 to 5 year-old children during tablet computer use compared to television watching and toy play

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ABSTRACT

Young children (ages 3 to 5) are using mobile touchscreen technology, including tablet computers, yet little is known on the potential musculoskeletal and physical activity implications of its use. This within-subject laboratory study ($n = 10$) examined head, trunk and arm postures, upper trapezius muscle activity, and total body and upper limb physical activity during playing with tablets compared to during TV watching and playing with non-screen toys. Overall, this study found that during tablet play children had greater mean head, trunk and upper arm angles compared to both TV watching and toy play. Conversely, compared to toy play, children playing with tablets had lesser trunk, upper arm and elbow postural variation, lesser trapezius activity, more time sitting and lesser physical activity. Thus, to minimize potential musculoskeletal and sedentary risks, non-screen toy play should be encouraged and education and guidelines provided for parents and caretakers to support wise use of tablets.

1. Introduction

Research on the potentially negative physical and mental health effects of interacting with electronic screens has traditionally focused on television (TV) watching and desktop or laptop computer use (Straker et al., 2015). However, use of new mobile touch screen devices such as smart phones and tablet computers can now be observed in various age groups including very young children. The new user interface for these devices may be particularly suitable for young children who can intuitively interact with the graphical touchscreens (Neumann and Neumann, 2014), find them engaging (Couse and Chen, 2010), and can be independent in playing games and watching videos as early as two years of age (Geist, 2012). In a study of young children (0–4 years of age) from low-income, urban areas in the US, 97 percent had used a mobile device and two-thirds of 4-year olds owned their own tablet computer (Kabali et al., 2015). A study of children in Singapore found that over 60 percent of children from 18 to 24 months used mobile technology daily (Goh et al., 2016). Tablet use among young children is thus becoming widespread and is expected to increase.

The growing use of tablet computers by young children has many potential benefits and risks for children's mental and physical health. For example, research suggests that tablets can be used to accelerate the development of pre-academic skills (Plowman et al., 2012) such as emergent literacy (Neumann and Neumann, 2014). Unfortunately, despite widespread use, little is known on the physical implications of tablet use in children. Previous research on the musculoskeletal effects of screen use in children and adolescents reported that increased time spent TV watching (Balague et al., 1999), using desktop/laptop computer (Hakala et al., 2006; Shan et al., 2013; Straker et al., 2009), and electronic gaming (Straker et al., 2014) were related to pain and discomfort suggesting tablet computer use may also increase health risks. Laboratory studies in adults have found extreme neck and wrist angles during mobile touch screen device use (Pereira et al., 2013; Young et al., 2012, 2013), along with higher cervical gravitational demand (Vasavada et al., 2015) and deeper neck flexion (Ning et al., 2015), which are likely to be dependent on task and location of use. Similarly, upper trapezius activity during tablet use has been reported to be affected by contextual factors such as screen size (Kietrys et al., 2015). Limited research has been conducted in younger populations. Epidemiological surveys in adolescents have shown an increased risk of neck pain with greater tablet use (Shan

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et al., 2013) and tablet related discomfort in the neck, lower back and eyes (Sommerich et al., 2007). Only one previous study, to our knowledge, has examined tablet use in younger children. During tablet use, 5 to 6 year-old children had less neutral spinal postures and higher activity in upper trapezius and cervical erector spine muscles but greater posture variation as compared to desktop computer or pencil and paper use (Straker et al., 2008). However, this study did not utilize the current generation of touchscreen tablets, which are structurally and functionally different.

In addition to musculoskeletal health, tablet use may also influence children's physical activity and sedentary behaviour. Screen use across a number of devices has been shown to typically be a sedentary activity (Straker et al., 2015) and higher screen time has been associated with decreased physical activity in children (Melkevik et al., 2010; Sandercock et al., 2012). Similar to most screens, tablet use may displace more active time such as playing outdoors (Straker et al., 2015) leading to increased sedentary time, however, its mobility could be used to increase movement compared to TV watching. How sedentary or physically active young children are during tablet use is not yet reported.

It is important to understand the physical implications of tablet use in young children, as young children may experience negative effects of tablet use during childhood, and may also experience longer term effects in adulthood. For example, experience of musculoskeletal disorders early in life has an impact on learning and activity participation and quality of life at the time (O'Sullivan et al., 2012), as well as predicting musculoskeletal problems later into adulthood (Hestbaek et al., 2006). Similarly children are establishing habits and practices for lifelong technology use, which may track into adulthood as sedentary behaviours and physical activity track into adulthood (Jones et al., 2013).

Therefore the purpose of this study was to describe the amplitude and variation in head, trunk and arm postures, muscle activity, sedentariness and physical activity of young children while using a tablet computer and to compare these to TV watching and non-screen toy play.

2. Materials and methods

2.1. Study design

This study was a within subject laboratory trial, with additional physical activity data collected for the week following attendance at the laboratory. Participants completed three conditions in a balanced, randomized order. Randomization to the order of conditions occurred using a random draw of sealed envelopes and was stratified between males and females. The trial was registered with the Australian New Zealand Clinical Trials Registry (#ACTRN12615000090516) and approved by Curtin University Human Research Ethics Committee prior to commencing study activities. Written informed consent was obtained from all parents and assent was obtained from children after an age-appropriate verbal explanation of the study protocol. Parents and children were free to stop the trial at any time. Parents or guardians were present for all data collection procedures.

2.2. Participants

Children were recruited from the Perth metropolitan area through advertisements placed in local media and flyers posted in community centres/universities. Participants were included in the study if they were aged between 3 and 5 years and were willing to complete the study protocol as outlined in the parent information sheet. Participants were excluded if they had a diagnosed disorder likely to impact their study participation or illness around the time of data collection.

2.3. Procedures

Participants and parents attended the Curtin University motion analysis laboratory between January to March 2015. Height and body mass were measured using a stadiometer and calibrated scales, respectively, using standard protocols (McKenna et al., 2013). Participants then underwent a 20 min period of data collection preparation. This included the placement of retro-reflective markers, electrodes, and accelerometers (described in detail below), and further explanation of trial procedures. Prior to data collection participants completed a calibration trial for the Vicon system and a submaximal trial during which muscle activity was recorded and later utilised for normalisation procedures as described below.

Each child participated in three 15 min play conditions in a constant physical environment which was a large play mat (1.2 m × 1.2 m located in a motion analysis laboratory) as seen in Fig. 1a. The only variation between the three conditions was the provided toy(s). The three conditions included; (1) a Tablet condition where children played with an iPad2 (Apple, Cupertino, USA) with age-appropriate apps (Peppa's Paintbox, Entertainment One, UK; Fish School HD, Duck Duck Moose, USA; ABC Playschool Playtime, ABC, Australia), (2) a TV watching condition where children watched an age-appropriate program (Frozen, Walt Disney Pictures, USA; Peppa Pig, Entertainment One, UK; Octonauts, Vampire Squid Productions, UK) and, (3) a Toy play condition where children played with traditional age-appropriate toys (e.g books, toy cars, drawing/craft materials). The toy play condition was chosen as the non-screen based activity most commonly offered to young children by parents and early child carers. The toys/tablet were placed in the middle of the mat, and the TV (30″ screen on a 0.25 m high bench, with screen centre 0.5 m high) was placed 2.5 m in front of the play zone. Prior to each condition, the research staff introduced each toy and allowed the child to ask any questions. Children were instructed that they may move about the mat freely, but must stay on the mat. The research staff supervised play for safety, but engagement with the child during play was minimised, with the exception of assistance when requested.

2.4. Measures

2.4.1. Amplitude and variation of head, trunk and arm postures

A Vicon (Oxford Metrics, Oxford, UK) three-dimensional motion analysis system, operated with 18 cameras at 250 Hz, was utilised to collect participants' head, trunk and arm postures throughout each play condition. Retro-reflective markers were fixed to the head (immediately lateral of the canthus of the left and right eyes, and over the tragus of their left and right ears), trunk (interclavicular notch and the spinous processes of the 7th cervical and 10th thoracic vertebrae), shoulder (cluster of three markers placed over the acromion plateau), upper arm (cluster of three markers placed below deltoid on the lateral aspect of the upper arm), lower arm (cluster of three markers placed on the forearm 5 cm above the wrist) and hand (radial and ulnar styloid process and 3rd metacarpal), as previously described (Campbell et al., 2009b; Wu et al., 2005) with posterior markers seen in Fig. 1b. A single calibration trial was performed for the recording of anatomical landmark locations (Cappozzo et al., 1995). This required each child to stand still for 3 s, with their shoulders and elbows flexed 90° so that their arms were held in front of their trunk.

The kinematic data was processed using Vicon Nexus software (Vicon Industries, Hauppauge, USA). Standard biomechanics procedures, including cubic spline interpolation, were used to impute