Gait & Posture 53 (2017) 121–126

Contents lists available at ScienceDirect

Gait & Posture

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

Full length article

Effects of singular and dual task constraints on motor skill variability in childhood

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ARTICLE INFO

Article history:
Received 25 February 2016
Received in revised form 6 December 2016
Accepted 23 January 2017

Keywords:
Variability
Motor planning
Coordination
Children

ABSTRACT

We examined the effects of singular versus dual task constraints involving upper and lower extremities in typically developing children in young (4–6 years old), middle (7–9 years old), and old (10–13 years old) age groups. The purposes of this study were: 1) to investigate the effects of singular upper and lower extremity and dual upper and lower extremity conditions on motor variability and 2) to examine if variability in children's motor actions would differ according to age (i.e., young, middle, or old). Twenty-four children (M age = 8.7; SD = 3.7) completed three tasks: finger rotation (upper extremity singular task constraint), obstacle crossing (lower extremity singular task constraint), and box carrying while walking (upper and lower extremity dual task constraint). Compared to the old age group, the young age group displayed more variable rotation strategies during clockwise ($\chi^2(8, N = 24) = 12.4$, $p = 0.046$) and counterclockwise finger rotation ($\chi^2(8, N = 24) = 12.8$, $p = 0.047$). During box carrying, children in the young age group had the most motor variability in their stride length, velocity, the vertical positioning of the box, and minimum and maximum joint excursion (all $ps < 0.05$). Crossing leg frontal plane hip angles were more variable on low versus high obstacles (all $ps < 0.05$). Our results suggest that four- to six-year-old children may still be developing the ability to produce consistent motor actions, especially under dual-task constraints. Examining children in the context of completing tasks with a variety of constraints may be useful in assessing the development of children's motor variability.

1. Introduction

Many everyday tasks require children to execute smooth and coordinated motor actions. For example, manipulating small objects with their fingers [1] or stepping over obstacles in their path [2,3] all necessitate intact motor skills. Most daily tasks are not done in isolation; they require children to simultaneously complete multiple tasks (i.e., dual task). For instance, traversing a room while carrying an object steadily means controlling upper and lower extremity actions at the same time.

Dual tasking can be challenging for children who are still fine-tuning their motor skills. Between 4 and 6 years old, children have refined their gait so that it resembles adult-like walking [4,5], which coincides with improved upper extremity control [6]. The development of upper extremity control (i.e., bimanual coordination) improves at 5 years old [6] with continued improvements until 15 years old [7,8]. A hallmark of refined motor skill involves variability in motor actions. For example, around 12 months when toddlers first learn how to walk, their gait is variable (e.g., stride length fluctuates from step to step) [9,10]. As their skill improves, toddlers' gait is less variable (e.g., stride length becomes consistent from step to step) [9,11]. How children perform skills is reflective of their development; 4–6 year olds modify their gait when simultaneously performing a cognitive task [12,13]. Effects appear to be stronger in younger versus older children; postural control affects 5–6 year olds, but not 7–16 year olds under dual task constraints [14]. Therefore, investigating the influence of singular task constraints on motor variability (i.e., consistency of motor performance) and the effects of dual tasking on motor variability may provide a chance to understand motor development in childhood.

Despite the influence of children's upper and lower extremity development on completing functional activities, few studies have examined singular and dual task constraints across tasks involving upper extremities, lower extremities, and both in young children.

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http://dx.doi.org/10.1016/j.gaitpost.2017.01.021
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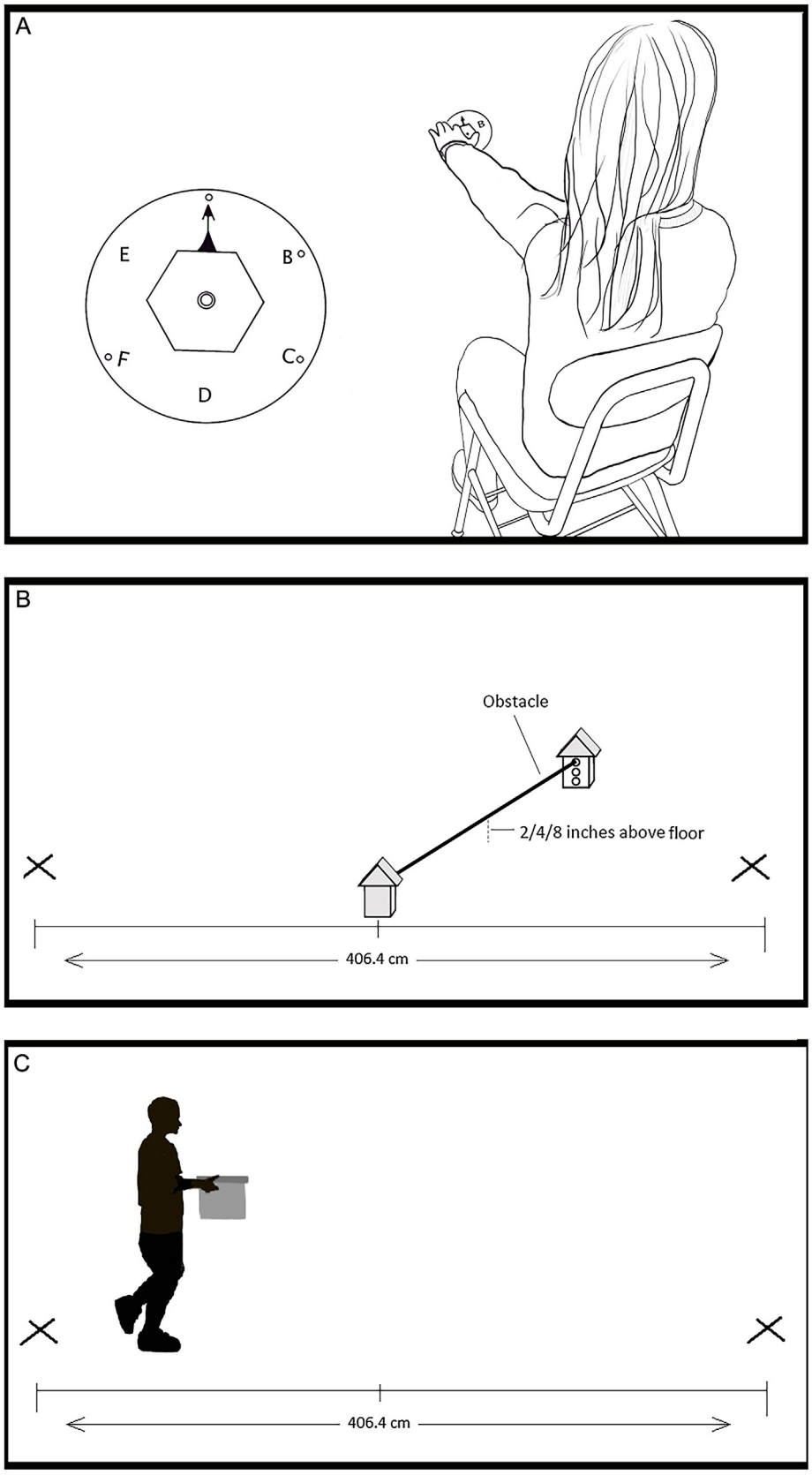

Fig. 1. A–C Finger rotation setup (A). The hexagons mounted onto the circles were mounted onto the wall at children's seated eye level. Children reached forward with their dominant hand to rotate the hexagons. Each hexagon was positioned in the center of the circle. Letters were placed around the perimeter of the circle to cue children to turn the hexagon in clockwise or counterclockwise directions to 60 at B or E, 120 at C or F, or 180 at D degrees. Obstacle crossing experimental setup (B). Participants began obstacle trials at the far end of the carpet facing the wooden dowel. They crossed three obstacle heights created by fitting the dowel into corresponding holes in each tower. Box carrying task (C). For the box carrying task, participants walked under two conditions: carrying an empty plastic box and carrying nothing. During the carrying condition, they were instructed to walk while holding the box steady and level without allowing the box to touch their body with their elbows flexed at right angles.