INTRODUCTION

Motor redundancy in manipulative tasks has been extensively investigated in adults (Zatsiorsky, et al. 2002; Shim, et al. 2004). However, far less attention has been drawn to children, especially, children with motor difficulties such as those with Developmental Coordination Disorder (DCD). Children with DCD have particular impairments in manipulation tasks which affect everyday and school activities such as eating, drinking, writing, drawing, etc.

It has been known that typically developing children increase their finger strength and capability to control finger forces as they grow up (Smits-Engelsman, et al. 2003; Potter, et al. 2006). Previous studies have also shown that children with DCD experience higher variability in controlling isometric finger force (Lundy-Ekman, et al. 1991; Pereira, et al. 2001). However, we know little about how typically developing children and children with DCD regulate force when multiple fingers are involved in a motor task (i.e., motor redundancy).

This study systematically investigates the age-related changes of finger strength and finger force or torque control in typically developing children and children with DCD using motor tasks with different kinetic redundancies.

METHODS

Forty-eight typically developing children aged 7 (7.6±0.5 yrs), 9 (9.6±0.3 yrs), and 11 (11.4±0.6 yrs) participated in this study: 15 children for each age. Sixteen nine-year-old children with DCD (9.6±0.2 yrs) also participated in the experiments. All of the subjects were right-handed. All children with DCD had Movement Assessment Battery for Children (MABC) (Henderson and Sugden 1992) scores below the 5th percentile – a standard cut-off point for this disorder. All typically developing children had MABC scores above the 35th percentile.

Three different experimental settings were used for three isometric force/torque production tasks with different numbers of kinetic redundancy (KR): constant index finger pressing force (KR=0) production, constant thumb-index finger pinching force production (KR=1), and constant thumb-index finger torque production (KR=5). Subjects were asked to perform two main tasks: maximum voluntary force/torque production (MVC) and constant isometric force/torque production at 40% of their MVC for 20 s (CONST).

A fixed horizontal line was displayed on the oscilloscope screen indicating the target force/torque. Another moving horizontal line indicating the force/torque produced by a subject was shown on the same screen as online feedback. Each trial started with a “get ready” signal, and the subjects were instructed to match the line showing the force or torque produced to the target force or torque. For MVC tasks, the instant peak
force/torque was selected as the maximum force/torque. From CONST tasks, coefficient of variation (CV = standard deviation/mean) was computed over the last 15s as an index of force or torque variability.

RESULTS

In typically developing children, both MVC force and torque all increased with age in typically developing children while CV during constant force and torque production decreased with age.

There was no significant difference between the 9-year old DCD group and their age-matched control group in MVC force or torque. In general, 9-year-old children with DCD, as compared to 9-year-old typically developing children, showed larger variability during constant force and torque production tasks (Figure 1). The difference in variability between these two groups was the largest during the torque production task while no significant differences were found for the press and pinch tasks. We also calculated the developmental delays in children with DCD as compared to their typically developing cohorts. The constant torque task showed the largest developmental delay (1.7 yrs) while pressing and pinching force tasks showed relatively small delays (1.0 and 1.1 yrs, respectively).

DISCUSSION AND CONCLUSION

The results from MVC tasks compliment the previous studies that showed increases in the maximum force production capability and variability of isometric force with children’s age. The unique finding of this study is the large difference in torque variability between typically developing children and children with DCD. This finding may suggest that children with DCD have deficits in controlling movements with a large number of degrees of freedom.

We intentionally used similar tasks with different numbers of kinetic degrees of freedom. However, we should also recognize that the tasks employed were functionally different (i.e., pressing and rotating). Another experiment with a same task involving different numbers of effectors (e.g., same pressing task with different numbers of fingers involved) may strengthen our claim.

REFERENCES


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