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Differential effect of Taekwondo training on knee muscle strength and reactive and static balance control in children with developmental coordination disorder: A randomized controlled trial

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ABSTRACT

This randomized controlled trial aimed to investigate the effect of short-term intensive TKD training on the isokinetic knee muscle strength and reactive and static balance control of children with developmental coordination disorder (DCD). Among the 44 children with DCD (mean age: 7.6 ± 1.3 years) recruited, 21 were randomly assigned to undergo daily TKD training for 1 h over three consecutive months, with the remaining 23 children being assigned to the DCD control group. Eighteen typically developing children (mean age: 7.2 ± 1.0 years) received no training as normal controls. Knee extensor and flexor muscle strength and reactive and static balance control were assessed using an isokinetic machine (with low, moderate and high movement velocities), a motor control test (MCT) and a unilateral stance test (UST), respectively. A repeated measures MANCOVA revealed a significant group through time interaction effect in isokinetic outcomes at 180°/s and in the UST outcome. Post hoc analysis demonstrated that DCD-TKD children's isokinetic knee muscle strength, specifically at 180°/s, was as high as that of the normal control children ($p > 0.0083$) after TKD training. Moreover, UST body sway velocity was slower in the DCD-TKD group than in the DCD control group ($p < 0.001$), and was comparable to that of the normal control group ($p > 0.05$) after TKD training. However, no such improvement in balance was observed in the MCT ($p > 0.025$). The results show that children with DCD who undergo a 3-month program of intensive TKD training experience improvements in isokinetic knee muscle strength at 180°/s and static single-leg standing balance control, but do not benefit from improved reactive balance control.

1. Introduction

Developmental coordination disorder (DCD) is a relatively common sensorimotor disorder affecting approximately six percent of primary school-aged children worldwide. Children with DCD present a number of motor problems including marked delays in achieving motor milestones and poor coordination and body balance (APA, 2000). It has been reported that 73% to 87% of DCD-affected children have postural control deficits (Macnab, Miller, & Polatajko, 2001). Most of the studies

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conducted to date in this field stress the importance of how sensory deficits in children with DCD affect their static balance control, but de-emphasize the reactive and motor aspects of postural control (Cherng, Hsu, Chen, & Chen, 2007; Fong, Lee, & Pang, 2011; Grove & Lazarus, 2007; Inder & Sullivan, 2005). Only one recent study has examined reflexive postural muscle activation patterns in children with DCD subject to unexpected perturbation (Geuze, 2003). The results show that the onset of muscular response and the amplitude of the response were similar between the DCD and control groups. However, the total time taken to recover from postural disturbance (a more functional outcome measure of reactive postural control) was not reported (Geuze, 2003). Because reactive postural control is essential for many daily activities such as standing in a moving bus, and is the first line of defense against a fall following unexpected external disturbances to balance (NeuroCom, 2008; Shumway-Cook & Woollacott, 2007; Stout, 2006), it is important to investigate functional reactive balance ability in children with DCD.

It is well-known that strengthening the lower limb muscles can improve standing balance control and thus prevent falls in older adults (Moreland, Richardson, Goldsmith, & Clase, 2004; Tsang & Hui-Chan, 2005). Similar to older adults, children with DCD have weaker lower limb muscles (e.g., lower isokinetic peak torque during knee extension and flexion at moderate to fast angular velocities) than their typically developing peers (Raynor, 2001). This may predispose them to instability and falls. We postulated that some kind of exercise training or sports activity aimed at improving muscular strength may enhance the various balance abilities in this particular group of children. Taekwondo (TKD) is a popular sport among young people (Park, Park, & Gerrard, 1989). Due to the fast kicking and spinning it involves, it has been found to be beneficial to DCD-affected children in terms of sensory organization and single-leg standing balance control (Fong, Tsang, & Ng, 2012b). Moreover, a previous study conducted in our laboratory has demonstrated that the duration of TKD training is positively associated with isokinetic knee extensor and flexor muscle strength (body-weight-adjusted peak torque at 240°/s) in typically developing adolescents (Fong & Tsang, 2012). Therefore, we hypothesized that TKD training might also improve lower limb muscle strength, and hence postural stability, in children with DCD.

This randomized controlled trial was aimed at (1) identifying the developmental status of reactive and static balance control and isokinetic knee muscle strength in children with DCD in comparison with children with normal motor development; (2) investigating the effect of short-term intensive TKD training on isokinetic knee muscle strength and reactive and static balance control among children with DCD compared with non-trained DCD-affected children and typically developing children; and (3) determining the association between knee muscle strength and balance performance in children with DCD after short-term TKD training.

2. Methods

2.1. Design overview

The study reported in this paper consisted of a randomized, single-blinded, stratified, controlled trial. Children with DCD were randomly assigned to either the 3-month TKD intervention group or the control group. Two blinded assessors measured outcomes in all participants both before and after the 3-month training period. Because the participants and their parents were not blinded to group allocation, they were requested not to inform the assessors of their group assignments during measurement to avoid potential bias (Fong et al., 2012b).

2.2. Participants and calculation of sample size

To the best of our knowledge, this study was the first to investigate the effect of TKD training on muscle strength and postural control in children with DCD. Therefore, power calculations were based on those of the nearest comparable study (Schoemaker, Hijlkema, & Kalverboer, 1994) as reported by Pless and Carisson (2000). In their meta-analysis, the reported effect size for gross motor training in improving the motor proficiency, including the balance performance, of individuals with DCD was 0.83. Hence a minimum sample size of 14 was necessary to achieve a statistical power of 0.8 in pre- and post-test measurements among the two DCD groups, with alpha set at 0.05. Anticipating a possible dropout rate of 30% (Hiller, McIntyre, & Plummer, 2010), a total of at least 19 children with DCD were needed for the trial.

Participants with DCD were recruited from local hospitals and child assessment centers (CACs). These are the major institutions that provide developmental assessment services for children in Hong Kong. The inclusion criteria were: (1) a formal diagnosis of DCD according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (APA, 2000); (2) aged between six and twelve years; and (3) studying within a regular education framework. Individuals with any of the following were excluded from this study: (1) a formal diagnosis of emotional, neurological or other movement disorders; (2) a significant congenital, musculoskeletal or cardiopulmonary condition that might influence postural control; (3) intellectual impairment; (4) receiving physical or occupational therapy; (5) receiving regular or intensive training in sports; (6) demonstrated excessive disruptive behavior during screening; or (7) unable to follow instructions. Children with normal development were recruited from the community through a convenience sampling method adopting the same inclusion and exclusion criteria, although they could not have any history of DCD. They were then screened by an experienced pediatric physiotherapist using the Movement Assessment Battery for Children-2 (MABC-2) before being assigned to the normal control group (Fong et al., 2012b). Children with an MABC-2 total percentile score at or below the 15th percentile (i.e., children at risk of significant movement difficulty) were excluded from the sample (Henderson, Sugden, & Barnett, 2007).