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Taekwondo training improves sensory organization and balance control in children with developmental coordination disorder: A randomized controlled trial

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ABSTRACT

Children with developmental coordination disorder (DCD) have poorer postural control and are more susceptible to falls and injuries than their healthy counterparts. Sports training may improve sensory organization and balance ability in this population. This study aimed to evaluate the effects of three months of Taekwondo (TKD) training on the sensory organization and standing balance of children with DCD. It is a randomized controlled trial. Forty-four children with DCD (mean age: 7.6 ± 1.3 years) and 18 typically developing children (mean age: 7.2 ± 1.0 years) participated in the study. Twenty-one children with DCD were randomly selected to undergo daily TKD training for three months (1 h per day). Twenty-three children with DCD and 18 typically developing children received no training as controls. Sensory organization and standing balance were evaluated using a sensory organization test (SOT) and unilateral stance test (UST), respectively. Repeated measures MANCOVA showed a significant group by time interaction effect. Post hoc analysis demonstrated that improvements in the vestibular ratio ($p = 0.003$) and UST sway velocity ($p = 0.007$) were significantly greater in the DCD-TKD group than in the DCD-control group. There was no significant difference in the average vestibular ratio or UST sway velocity between the DCD-TKD and normal-control group after three months of TKD training ($p > 0.05$). No change was found in the somatosensory ratio after TKD training ($p > 0.05$). Significant improvements in visual ratios, vestibular ratios, SOT composite scores and UST sway velocities were also observed in the DCD-TKD group after training ($p \leq 0.01$). Three months of daily TKD training can improve sensory organization and standing balance for children with DCD. Clinicians can suggest TKD as a therapeutic leisure activity for this population.

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1. Introduction

Approximately six percent of school-aged children are known to have developmental coordination disorder (DCD). These children experience difficulty in daily activities due to their marked motor impairments including poor postural control (APA, 2000). Previous studies have reported that 73–87% of children with DCD actually have balance problems (Macnab, Miller, & Polatajko, 2001). The ability to maintain postural stability in children with DCD is an important area that needs to be addressed because any impairment in postural control may limit the child's activity participation (Fong, Lee, & Pang, 2011a; Fong et al., 2011b; Smyth & Anderson, 2001), increase their risk of falling, hinder motor skills development (Grove & Lazarus, 2007) and have a negative impact on their psychosocial functioning (Cantell, Lee, & Pang, 1994; Skinner & Piek, 2001).

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The control of posture involves efficient use of information from the somatosensory, visual and vestibular systems (Nashner, 1997). Children with DCD have below-normal balance ability together with wide-spread impairment in their sensory organization (Fong et al., 2011a; Inder & Sullivan, 2005). Their ability to rely on vestibular input to maintain standing balance is worse than that of children with normal motor development (Grove & Lazarus, 2007). Without proper intervention, the balance and motor deficits that arise from DCD may persist into adolescence and even adulthood (Fitzpatrick & Warkinson, 2003; Losse et al., 1991). Early intervention to enhance motor and balance performance is thus very important.

Sports training is often a viable and enjoyable way of improving the balance of children with DCD (Hung & Pang, 2010; Mercer, Sahrmann, Diggles-Buckles, Abrams, & Norton, 1997). Indeed, a survey shows that physiotherapists often refer children with motor dysfunctions to participate in sports activities (Westcott, Murray, & Pence, 1998). Taekwondo (TKD) is a popular sport among children and adolescents (Park, Park, & Gerrard, 1989). It is renowned for its swift kicks and fast action. Practitioners have ample opportunity to practise single leg standing while maintaining body balance (Pieter, 2009). Previous studies in our own laboratory have demonstrated that participation in TKD can enhance postural control and sensory organization in typically developing adolescents. TKD practitioners rely primarily on visual and vestibular inputs to maintain standing balance (Fong, Fu, & Ng, 2011c; Fong & Ng, 2010; Leong, Fu, Ng, & Tsang, 2011). The potential benefits of TKD may exactly address the balance difficulties and sensory organization deficits experienced by children with DCD. However, the training effect of TKD has not been investigated formally with a DCD population.

This randomized controlled study aimed (1) to investigate the effect of short-term (three months) intensive TKD training on the sensory organization and balance performance of children with DCD, and (2) to identify the developmental status of balance and sensory organization in children with DCD, both with and without TKD training, as compared to children with normal motor development.

2. Methods

2.1. Study design

This was a single-blinded, stratified, randomized and controlled trial. The outcome assessors were blinded to the group allocation. Since the participants were not blinded to group assignment, they were instructed not to inform the assessors about their group assignments to avoid possible bias during measurement.

2.2. Participants

According to a meta-analysis by Pless and Carisson (2000), the minimal effect size for gross motor training (group training) in improving the motor proficiency, including balance ability, of persons with DCD is 0.54. Therefore, a sample of 29 participants was necessary to achieve a statistical power of 0.8 in pretest and post-test measurements of two DCD groups with the alpha level set at 0.05. Anticipating a possible dropout of 30% (Hiller, McIntyre, & Plummer, 2010), 38 children were needed (i.e., 19 per group).

Participants with DCD were recruited from local child assessment centres (CACs) and hospitals. 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 nine years; (3) study in a regular education framework; and, (4) no intellectual impairment. Exclusion criteria were: (1) a formal diagnosis of emotional, neurological, or other movement disorders; or (2) a significant congenital, musculoskeletal or cardiopulmonary condition that might influence balance performance; or (3) were receiving physical or occupational therapy training; or (4) demonstrated excessive disruptive behavior; or (5) could not follow instructions thoroughly (Fig. 1). Children with normal motor development were recruited from the community by convenience sampling to form a normal control group using the same inclusion and exclusion criteria except that they did not have any history of DCD. Each child in the normal-control group was screened by an experienced pediatric physical therapist using the Movement Assessment Battery for Children-2 (Movement ABC-2). Children with a Movement ABC-2 total percentile score at or below the 15th percentile (i.e., those at risk of significant movement difficulty) were excluded (Henderson, Sugden, & Barnett, 2007).

A no-training DCD-control group was also included to account for the effect of maturation and to track whether the balance deficits of those with DCD might recover spontaneously over time. The normal children were included as another control group to determine whether or not short-term TKD training can improve the balance ability of children with DCD to normal standards.

Ethical approval was obtained from the Human Subjects Ethics Review Subcommittee of the Hong Kong Polytechnic University. The study was explained to each participant and their guardian, and written informed consent was obtained. Data collection was performed by pediatric physical therapists. All procedures were conducted in accordance with the Declaration of Helsinki.

2.3. Randomization

The eligible participants with DCD were stratified by gender and then randomly assigned to either the DCD-TKD training group or the DCD-control group. This ensured an approximately equal number of boys and girls in each group. The randomization procedure was done by drawing lots and was completed by a person independent of the study. Twenty-one

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