Effect of a strength training program in young children with developmental coordination disorder

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Background and purpose

A strength training program was associated with changes in muscle strength, motor function, and proprioceptive position sense in a young child with poor body awareness and a diagnosis of developmental coordination disorder.

Patients and methods

This study included 80 children diagnosed with developmental coordination disorder. Their age ranged from 8 and 13 years. The children were divided randomly into two equal groups. The exercise group received a 3-month strength program that included upper limb, lower limb, and trunk and neck exercises as well as running three sessions per week The patients were evaluated and scored functionally, using the Behavior Rating Scale, and objectively, using a Biodex dynamometer, at different time intervals pretreatment and 3 months after the treatment program.

Results

The results showed a statistically significant improvement in the measured variables of both groups when comparing their pre-treatment and post-treatment mean values. A significant difference was found in favor of the study group (B) in comparison with group (A).

Conclusion

It can be concluded that a regular program of physical activities has a positive effect in improving the symptoms of developmental coordination disorder in children.

Keywords:

developmental coordination disorder, physical activity, strength program

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Introduction

School-based physical therapists carrying out exercise programs on children for 3 months encounter children who move in an uncoordinated manner, appear unaware of their body positions in relation to themselves and others, and cause classroom disruption. These behaviors can frustrate teachers, who then reach out to therapists for assistance. A child showing these behaviors may have an underlying sensory processing deficit contributing toward poor proprioception (American Psychiatric Association, 2000). According to Buzzard, 'Proprioception can be defined as the sense of the position and movement of the limbs and body in space'. Proprioceptive information is transmitted from receptors found in muscles, joints, ligaments, skin, and other soft tissues to the central nervous system' (Burt *et al.*, 2003).

Children who show sensorimotor deficits, including impaired proprioception, may also fit into the classification of developmental coordination disorder (DCD) (Bauermeister *et al.*, 2007). The prevalence of DCD in children 5–11 years of age is estimated to be 6% according to the American Psychiatric Association (Baumgardner *et al.*, 1996). The criteria for DCD, as described in the *Diagnostic and Statistical Manual of Mental Disorders* (Baumgardner *et al.*, 1996), assert that DCD is manifested by a marked impairment in the development of motor coordination that significantly interferes with academic achievement or activities of daily living. These impairments must not be associated with a general medical condition or a pervasive developmental disorder. If a child shows mental retardation, the motor skills should be delayed in excess of the child's mental age.

Although the etiology of DCD is yet to be identified specifically (Braun *et al.*, 2006), children with DCD of 3 months show signs of minor neurological dysfunction such as dysfunctional muscle tone regulation, reflex abnormalities, choreiform dyskinesia, coordination problems, poor fine motor manipulative ability, and miscellaneous rare disorders (Solanto, 2002). According to Solanto (2002), the percentage of cases of DCD that can be attributed to nervous system damage and whether these insults have occurred during prenatal, perinatal, or early postnatal development remain to be determined.

Controversy exists on the underlying deficits associated with DCD, including whether motor coordination deficits are a result of a physiological impairment or developmental delay (Paus *et al.*, 1999). Researchers debate whether the coordination difficulties observed in children with DCD are a result of a unisensory deficit or a multisensory deficit involving the visual, vestibular, and proprioceptive systems (Paus *et al.*, 1999). Even among the group of researchers who support the belief that coordination difficulties are a result of a unisensory problem, there is a lack of agreement as to which sensory system is involved (Paus *et al.*, 1999).

According to Voller and Heilman (1998), the major treatment approaches that have been used for children with a diagnosis of DCD can be categorized into deficit-oriented and task-oriented interventions. Deficit-oriented approaches include sensory integration, sensorimotor, and process-oriented approaches (Voller and Heilman, 1998). Deficit-oriented approaches promoted by Cantwell (1996) and Yadid *et al.* (2001) use sensory-based intervention and kinesthetic training, respectively, to facilitate skill acquisition. Deficit-oriented interventions focus on reducing impairments in sensory processing abilities or in performance components believed to be the cause of the motor coordination deficits (Cantwell, 1996; Conners *et al.*, 1998; Yadid *et al.*, 2001; Braun *et al.*, 2006; Taylor and Kuo, 2008) and focus on foundation skills (Taylor and Kuo, 2008).

Task-oriented approaches include task-specific approaches, parent–teacher intervention programs, and cognitive orientation to a daily occupational performance program (Voller and Heilman, 1998). Task-oriented approaches promoted by Horn *et al.* (1987), Conners *et al.* (1998), and McKune *et al.* (2003) use a problem-solving process to facilitate functional skill acquisition. Task-oriented interventions are based on the dynamical systems theory and focus on motor learning principles and cognitive participation (Conners *et al.*, 1998; Voller and Heilman, 1998; Taylor and Kuo, 2008). Research focusing on task-oriented interventions has shown their effectiveness to be more positive compared with deficit-oriented approaches when addressing the needs of children diagnosed with DCD (Voller and Heilman, 1998; Taylor and Kuo, 2008).

When selecting a treatment strategy, however, a therapist should be flexible enough to take into consideration individual differences in the presentation and progress of children with DCD (Norris *et al.*, 1992). Therefore, a multilevel approach to the treatment of children with DCD is recommended (Norris *et al.*, 1992). In addition, the results of a study by Paluska and Schwenk (2000) support the use of interventions designed to improve self-efficacy in a child diagnosed with DCD.

Interventions of remediation of proprioception deficits are discussed most frequently in the sensory integration and sensory processing literature (Raglin and Morgan, 1987; American Psychiatric Association, 2000). Strategies of proprioception are placed into two categories: static or dynamic. Static strategies include the use of weighted items such as vests, beanbags, blankets, and cuff weights that can be worn during static as well as dynamic activities. Dynamic strategies require the child to actively participate in heavy muscle work such as pulling, pushing, or carrying heavy objects. Active heavy muscle work can also be generated through an individual's own body weight through activities such as wheelbarrow walking, facilitating weight shifts, partner-pushing activities, and climbing. Active heavy muscle work can also be achieved through structured strength training. According to the sensory integration theory, active muscle contraction against resistance is considered an effective strategy to facilitate the development of proprioceptive awareness (American Psychiatric Association, 2000). According to Potgieter (1997), strength training refers to the use of progressive resistance to augment performance by using submaximal amounts of weight. Evidence indicates that, when guidelines for strength training regarding children are strictly followed, no detrimental effects occur. According to the American College of Sports Medicine (Maddigan *et al.*, 2003) and many authors (Went, 2000; Tantillo *et al.*, 2002; Hoza *et al.*, 2003; Biederman and Faraone, 2005) (25-27) strength training in children is both safe and effective when provided by a trained professional who adheres to published evidence-based guidelines.

Participants, instrumentation, and procedure

Eighty students of both sexes (50 boys and 30 girls) and diagnosed with DCD participated in this study. Their age ranged from 8 to 13 years. All children were functionally independent, could understand and follow orders, and were cooperative. Students were excluded if they had (a) medical or systemic problems such as hypertension, hypotension, or diabetes, (b) musculoskeletal deformities (scoliosis, kyphosis, pes cavus), (c) neurological problems (sensory or motor deficit), (d) orthopedic problems (including a history of trauma before the study of at least 2 months, rheumatic fever), and (e) obesity.

Procedures

The aim and the procedures of the study were explained in detail to the school manager, parents, and teachers. A detailed explanation of exercise was provided to the students before start of the study. Ethical approval was received from the schools' administration for the participation of the children in the study. The children were assigned to two equal groups: control group and exercise group. The exercise group received an aerobic exercise program for 3 months with two sessions per week. The control group did not receive any study program.

Instrumentations for evaluation

Biodex dynamometer

The ratio of peak torque of quadriceps femoris muscle and the hamstring muscle of both lower limbs were measured using a dynamometer. The Biodex dynamometer (Nively, New York, USA) is a computerized device that was available for the current study in the Faculty of Physical Therapy, Cairo University. It has attachments and isolation straps for every part of the body. The position of the dynamometer can be controlled; it can be rotated horizontally, tilted, and its height can be adjusted according to the test. The system requires all information to be entered through a typewriter-style keyboard into its processor. It provides testing data, graph recording, and printed results of detailed information of torque, speed, time, motion, work, power, peak torque, ratio of peak torque to body weight, range of motion, and different ratios. The Behavior Rating Scale is a modified version of

Conner's Rating Scale (Conners *et al.*, 1998). The scale has been validated for screening and assessing behavior and psychological problems related to DCD (Fisher and Newby, 1991). The scale provides a reliable, accurate, and relatively brief measure of perception of children's disruptive behavior (Horn *et al.*, 1987). It consists of 25 behavior-related questions, subdivided into categories for attention, motor skills, task orientation, emotional and oppositional behavior, and academic and classroom behavior. The higher the score, the better behaved the child.

Evaluation procedures isokinetic

All tests were performed (Biodex dynaniometer) at the same time of the day for each child to reduce the effect of any variations. Age, height, and weight of each child were recorded, measured using a scale associated with the Biodex system. The dominant quadriceps femoris and hamstring muscles were determined by the child's leg preference in kicking (Tantillo *et al.*, 2002). Position of the child: each child was allowed a 5-min warmup before the evaluation. Then, the child was placed in the position seat with his/her hip and knee flexed at 110 and 90°, respectively. It was inferred that the most appropriate position for isokinetic knee testing is the sitting position with the hip and knee flexed at 110 and 90°, respectively (Raglin and Morgan, 1987). The child was placed in position after adjustment of the depth of the seat, the height of the dynamometer, and the length of the support lever that allows the axis rotation of the dynamometer to be aligned to the most inferior aspect of the lateral femoral epicondyle and the lower leg attached to the dynamometer lever arm above the medial malleolus by inches. A wide strap was placed diagonally on the child's chest. A thigh strap attached to the seat was used to stabilize the thigh (Yadid *et al.*, 2001). With each child, identical positioning of the seat, back rest, dynamometer head, and lower arm length was used before and after training (Taylor and Kuo, 2008). The children's data were entered into the computer program database and the test protocol was set from the software program; a concentric bilateral protocol with the extension and flexion of the knee range of motion was set from 90 to 0° and from 0 to 90° with angular velocities of 60 and 180°/s. The limb was weighed before testing using Biodex's automatic limb weighing system to correct for the gravitational effect on the torque value. Each child was asked to hold onto two sides of the chair with both hands during the testing procedures.

The child was allowed two trials before the actual test, and then was instructed to provide maximum voluntary concentric torque through verbal command to kick as hard and fast as he/she could, and then relax. This test procedure included three sets each set of one maximum concentric contraction of quadriceps femoris and hamstring muscles, with a rest of 1 min 30 s between each set. The mean ratio of peak torque to body weight of the three tests was determined.

The children were evaluated using the Behavior Rating Scale before and after the exercise program. Data for the scale were recorded by the interviewers from information provided by the teachers. During the study, the teachers were asked to observe the children for any changes, either positive or negative, in their behavior in school, psychological statement, and class concentration. The teachers helped in taking the suggestions of the children, and provide any ideas about the application of the session.

Exercises protocol

The moderate-intensity exercise program (McKune *et al.*, 2003) was carried out during three sessions per week. The exercise program included the upper limb, lower limb, and trunk and neck aerobic exercises, and running. Three repetition for each exercise increase with time, rest period 2 min between every (McKune *et al.*, 2003).

In the first 4 weeks

The session lasted for about 40 min, with 3 min of preparation and warmup, 20 min of aerobic exercise with submaximal amounts of weight, and 5 min of walking between exercises, at the end of which the children played around the school to cool down.

The following 6 weeks

The session lasted for about 50 min, with a 3-min warmup session, 30 min of physical activities with submaximal amounts of weight, 5 min of walking around the school building, and 5 min of slow walking and stretching to cool down. The cool-down phase included relaxation exercises. The aim of the relaxation exercises was to reduce the children's heart rates back to or close to resting levels.

Home program

Parents were instructed to start a home program for the study group from the sixth week and continue to the 10th week. The program included walking half an hour in the weekend.

Results

The raw data of the isokinetic measured and Behavior Rating Scale test in DCD children were statistically treated to determine the mean and SD of the measuring variable for the two groups before and after 3 months of treatment. As shown in Table 1 and Fig. 1, a significant improvement was observed in the mean value of isokinetics measured in group (A) at the end of the treatment compared with the corresponding mean value before treatment ($P < 0.0l$).

Also, Table 1 and Fig. 1 show a significant improvement in the mean value of isokinetic measured in group (B) at the end of treatment compared with the corresponding mean value before treatment ($P < 0.01$).

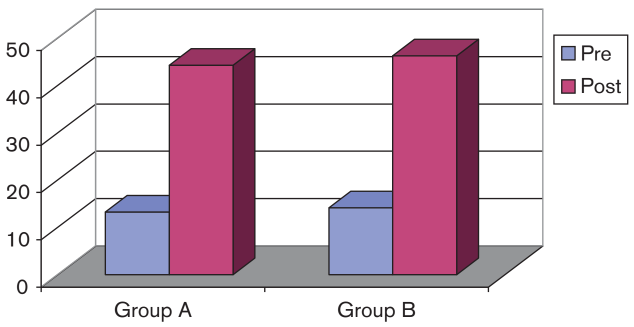
As can be seen from Table 2 and Fig. 2, a significant improvement was observed in the mean value of the Behavior Rating Scale measured in group (A) at the end of the treatment compared with the corresponding mean value before treatment ($P < 0.0l$).

Also, Table 2 and Fig. 2 showed a significant improvement in the mean value of the Behavior Rating Scale measured in group (B) at the end of treatment compared with the corresponding mean value before treatment ($P<0.01$).

Table 1 Comparison of post-treatment mean values of isokinetic-measured (g/cm^2) groups A and B in extension at 60°

	Group A		Group B	
	Pretreatment	Post-treatment	Pretreatment	Post-treatment
$X\pm$SD	13.22±3.9	44.26±40.5	14.12±3.7	46.22±4.5
t-test	4.98	–	5.01	–
P-value	0>0.01	–	0>0.01	–

Figure 1



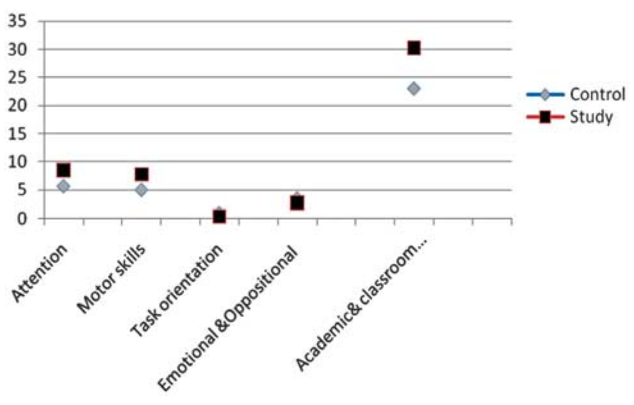
Pretreament and post-treatment mean values of isokinetic measured (g/cm^2) for groups A and B.

Table 2 Comparisons between the mean values of behavior after exercise program of both groups (study and control)

	Mean±SD		
Variables	Study group	Control group	*P*-value
Attentiveness	8.56±3.61	5.42±7.15	0.005*
Motor skills	7.87±3.96	4.85±6.07	0.04*
Task orientation	0.35±0.61	0.84±2.83	0.78
Emotional and oppositional behavior	2.81±3.14	3.49±2.68	0.421
Academic and classroom behavior	30.55±7.27	23.11±5.83	0.001*

*Significance.

Figure 2



Mean values of the Behavior Rating Scale items after an exercise program in the study and control groups.

Discussion

Researchers have noted the positive role of exercises in the treatment of anxiety (Norris *et al.*, 1992; Paluska and Schwenk, 2000), depression, stress (Raglin and Morgan, 1987), and enhancing general mood state (Potgieter, 1997). On the basis of these previous researches, it was hypothesized that an exercise program would significantly improve behavior in children with DCD compared with that of nonexercised controls. The present study therefore examined alterations in the behavior of children with DCD after a moderate-intensity exercise program. There were significant improvements in the behavior (three items of five from Teacher's Conners Scale) of the exercise group.

Maddigan *et al.* (2003) concluded that exercise therapy would be effective in reducing symptoms or medication dose in attention deficit hyperactivity disorder in school age children who were already stabilized on medication. The improvement in attentiveness was also supported by Went (2000), who reported that there was a positive shift in concentration among children with DCD after they participated in therapeutic movement therapy. The results showed positive improvements in working speed, and social and behavioral problems.

The possible explanation for improved behavior may therefore be that the exercise sessions encouraged cooperation in group situations and fostered tolerance and acceptance of other children (Biederman and Faraone, 2005). Hoza *et al.* (2003) have reported that forging friendship is associated with improved behavior in DCD children. The social interactions in the exercise group during the exercise sessions as well as during school with the control group may therefore have resulted in improved behavior. Most children tended to be more excited, active and inattentive at the end of the program. The children in the exercise group stated that they enjoyed this activity and the parents found this to be of benefit for them.

The results of the present study are in agreement with the results of Tantillo *et al.* (2002), who suggested that exercise is beneficial to children with DCD. However, the results are not in agreement with a few studies that have been published in this area and have either been case reports of only one or a few children, or failed to test valid behavioral measures.

Conclusion

It was found that the behavior of children with DCD improved over 3 months of an exercise program. Therefore, exercises may be considered as an additional treatment required to improve behavior in children with DCD.

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Conflicts of interest

There are no conflicts of interest.

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