Title: Core stability exercise is as effective as task-oriented motor training in improving motor proficiency in children with developmental coordination disorder: a randomized controlled pilot study

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Running head:

Motor training in developmental coordination disorder

Abbreviated short title:

Comparing the effectiveness of core stability program versus a task-oriented motor program in improving motor function in developmental coordination disorder

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Abstract

Objective: To compare the effectiveness of a core stability program with a task-oriented motor training program in improving motor proficiency in children with developmental coordination disorder (DCD).

Design: Randomized controlled pilot trial.

Setting: Outpatient unit in a hospital.

Participants: Twenty-two children diagnosed with developmental coordination disorder aged 6-9 years were randomly allocated to the core stability program or the task-oriented motor program.

Intervention: Both groups underwent their respective face-to-face training session once per week for 8 consecutive weeks. They were also instructed to carry out home exercises on a daily basis during the intervention period.

Main measures: Short Form of the Bruininks-Oseretsky Test of Motor Proficiency (Second Edition), and Sensory Organization Test at pre- and post-intervention.

Results: Intention-to-treat analysis revealed no significant between-group difference in the change of motor proficiency standard score (p=0.717), and composite equilibrium score derived from the Sensory Organization Test (p=0.100). Further analysis showed significant improvement in motor proficiency in both the core stability (mean change (SD)=6.3(5.4); p=0.008) and task-oriented training groups (mean change(SD)=5.1(4.0); p=0.007). The composite equilibrium score was significantly increased in the task-oriented training group (mean change (SD)=6.0(5.5); p=0.009), but not in the core stability group (mean change(SD) =0.0(9.6); p=0.812). In the task-oriented training group, compliance with the home program was positively correlated with change in motor proficiency (ρ=0.680, p=0.030) and composite equilibrium score (ρ=0.638, p=0.047).

Conclusion: The core stability exercise program is as effective as task-oriented training in improving motor proficiency among children with developmental coordination disorder.

Keywords: task oriented practice; core stability training; developmental coordination disorder

Introduction

Developmental Coordination Disorder is one of the most common childhood disorders which affects 5 to 6 % of school-aged children.[1] Children with developmental coordination disorder are characterized by marked impairment in motor coordination.[2-4] The impairments in motor skills not only negatively interfere with activities of daily living and school life, but also impose an increased risk of overweight and obesity problems[5,6] and an adverse impact on psychosocial functioning.[7-9] There is a need to search for effective intervention to enhance motor skills and ability to function in everyday life among these children.

Only a few randomized controlled trials have examined the effects of motor training in children with developmental coordination disorder.[10-12] Sugden & Chambers[13] classified intervention approaches into two major categories, namely, process-oriented and task-oriented approaches. The former approach targets the underlying process or impairment which is necessary for the successful acquisition and performance of motor skills but is underdeveloped in the child. One of the key processes underlying deficits in motor proficiency in children with developmental coordination disorder may be postural control (i.e., the ability to maintain the centre of gravity within the base of support).[14,15] The ability to maintain body equilibrium in response to or in anticipation of perturbing forces not only requires effective integration of signals from different sensory systems (visual, somatosensory and vestibular), but also the generation of appropriate core muscle activity,[15-17] which is often impaired in children with developmental coordination disorder.[16,18] A core stability program may thus have potential for improving motor proficiency in these children.

Another intervention approach is the task-oriented approach, which is focused on teaching functional tasks without an emphasis on the underlying process.[13,19] Functional skills that are essential in daily life are trained. Over the course of the program, both the task and environmental context are modified so as to increase the challenge posed to the child. The Neuromotor Task Training program, which is based on the task-oriented approach, has been developed for children with developmental coordination disorder, and some positive results were reported.[10,11] Whether one approach is better than the other in improving motor proficiency in children with developmental coordination disorder is uncertain. In a meta-analysis, Pless & Carlson[19] showed that the task-oriented approach (mean effect size = 1.46) resulted in a larger effect size than the process-oriented approach (mean effect size = 0.21). However, this meta-analysis has major limitations because not all studies included are randomized controlled trials. In addition, none of the studies made a direct comparison between core stability exercise training and task-oriented motor training, despite the fact that core muscle exercises and functional activities are commonly used in clinical practice as part of the overall training regimen to improve mobility and functional level.

The present study was thus undertaken to address this knowledge gap, with the objective to compare the effectiveness of core stability program (based on the process-oriented approach) and task-oriented motor program (based on the task-oriented approach) in improving motor proficiency of children with developmental coordination disorder. The null hypothesis was that the change in motor proficiency in the core stability group and task-oriented group would demonstrate no significant difference after the 8-week treatment period.

Methods

This was a randomized controlled pilot study (registered in ClinicalTrials.gov; NCT01207544). Children with a diagnosis of developmental coordination disorder were recruited from the Paediatric Physiotherapy Outpatient Unit of a local hospital through convenience sampling. The inclusion criteria were: (1) diagnosis of developmental coordination disorder according to criteria described in Diagnostic and Statistical Manual for Mental Disorders, 4th Edition (DSM-IV)[1]; (2) Movement Assessment Battery for Children score $\leq$15 percentile, or any two or more of subtests in Bruininks-Oseretsky Test of Motor Proficiency Second Edition $<$ 1.5 SD; and (3) aged 6-12 years. Children were excluded if they had attended treatment for motor problems in the previous 6 months, or had any major co-morbid medical problems such as moderate to severe mental disability, profound visual or hearing impairment, or had any major behavioral problems. Ethics approval was granted by the ethics committee of the local University and the Institutional Review Board of the local hospital. All participants provided informed written consent prior to data collection. The parent was required to sign the consent form on behalf of his/her child if the age of the child was younger than 7 years.

The participants were randomly allocated to the core stability program or the task-oriented training program by drawing lots using sealed opaque envelopes using a 1:1 randomization sequence. The randomization was conducted by a researcher who was not involved in selection, assessment and treatment of the participants. Each program consisted of a one-hour training session per week for 8 consecutive weeks. An 8-week training duration was chosen, as a previous study showed that improvement in motor function could be induced after an 8-week motor training program.[12] All training sessions were conducted by another physiotherapist who had 10 years of working experience in the pediatric field and had no access to the assessment data. Each training session began with a 5-minute warm-up period and ended with a 5-minute cool-down period, in which the participants engaged in simple stretching exercises. For both programs, the level of difficulty was increased by increasing the complexity of the tasks, number of repetitions and duration of each exercise/activity and reducing the level of assistance or guidance. Throughout the training sessions, the performance of each child was monitored by the physiotherapist, who was responsible for giving appropriate instructions, manual guidance/assistance to ensure proper performance of the exercises. Each intervention session typically lasted for 60 minutes, during which the child was allowed to have intermittent rest periods as necessary.

In the core stability training group, a physioball (Fitball™, Fitball™ Therapy and Training Pty Ltd., Blackburn, Victoria, Australia) was used as the treatment tool. Previous studies have shown that exercise with a physioball can induce positive treatment effects on core stability, balance, strength and motor control in female college students[20], children with polyarticular arthritis[21], sedentary adults[22], seniors[23] and adults with chronic non-specific low back pain.[24] The physioball is also a tool that can be used for providing proprioceptive, tactile and vestibular stimulation, and may serve as an effective mean to address the core stability issues in children with developmental coordination disorder. The exercise protocol for the core stability group is documented in **Appendix 1**. Core stability exercises were performed in the supine, prone, sitting and standing positions. In these exercises, the children were instructed to focus on co-contracting the abdominal and back muscles to maintain the spine in a neutral position. Presumably, major trunk muscle groups (e.g. rectus abdominis, internal and external abdominal oblique, transverses abdominis, erector spinae, etc.) may be recruited during these exercises.

In the task-oriented training group, the focus was on training functional tasks, which included those that involved mainly body stability (e.g., standing) and those that required body transport (e.g., walking, running, jumping, hopping, skipping and galloping).[25] Over the course of the training program, the complexity and difficulty of the tasks was increased by (1) incorporating inter-trial variability via changing the support surfaces, the width of the base of support, removing the visual input (e.g., eyes closed condition), or changing the demand with respect to the direction, speed and pattern of movement (e.g., sudden stops and turns during walking, jumping jacks); (2) adding a unilateral/bilateral upper limb or lower limb task so that the participant was required to do two tasks simultaneously. Thus, the participant not only needed to focus on those environmental features that were essential for regulating body orientation, but also the information concerning the relevant features of the objects to be handled. Examples were picking up an object while walking, bouncing and catching a ball while standing on a foam, and kicking a ball while running; (3) having the participants perform the task in an environment that was in motion and constantly changing (e.g., open tasks such as walking down a crowded corridor) rather than in a stationary environment (e.g., closed tasks such as jumping over obstacles of the same height).[25] The exercise paradigm of the task-oriented group is described in **Appendix 2.**

Both groups of children were instructed to do the exercises as taught in the face-to-face sessions on a daily basis. Home exercise sheets were given to the parents to reinforce the execution of the home exercise program. A physioball was provided to each participant in the core stability training group. An exercise log book was provided to each child, so that their compliance with the home program (in days per week) could be recorded.

All the participants were assessed for motor proficiency and postural control before the initiation of the intervention and after the termination of the 8-week training program. All assessments were conducted by the same independent assessor, who was a paediatric physiotherapist with more than 15 years of experience, and was blinded to group assignment.

The Bruininks-Oseretsky Test of Motor Proficiency 2 – Short Form was used as the primary outcome.[26,27] The Short Form is comprised of 14 test items selected proportionately from the 8 subtests of the Complete Form (fine motor precision, fine motor integration, manual dexterity, upper-limb coordination, bilateral coordination, balance, running speed & agility, and strength). The standard score reflects the overall level of motor proficiency compared to the normative sample, with a possible score ranging from 20 to 80 (mean =50, SD =10). The standard score and percentile rank were used for data analysis in this study.

The Sensory Organization Test was conducted to evaluate the sensory organization of postural control, which was the secondary outcome of this study. The Balance Master System (NeuroCom System Version 7.0.6, NeuroCom International Inc., Clackamas, OR, USA) was used. The Sensory Organization Test is a reliable and valid clinical instrument in assessing the postural control in the presence of sensory conflicts and is commonly used in research in children with developmental coordination disorder.[28,29] Each participant was asked to stand with the feet placed at specified positions on the force platform so that medial malleolus was aligned with the axis of rotation of the platform. To ensure safety, all participants wore a harness. Each participant was instructed to maintain the upright posture in six different test conditions (**Appendix 3**). The system detected the trajectory of the center of pressure in each trial, which lasted 20 seconds. For each participant, three trials of each of the six test conditions were performed after a practice trial, and the data were averaged. The equilibrium score, which represents the peak amplitude of the participant's anteroposterior sway relative to the theoretical limits of anteroposterior stability, was generated by the system.[30] The equilibrium score for each of the six sensory conditions was used to calculate the composite equilibrium score, which could range from 0 to 100, with a higher score indicating better postural control. In addition, the somatosensory, visual and vestibular ratio scores were also computed. A higher ratio score (e.g., approaching 100%) is indicative of better ability to utilize each of the respective sensory systems to maintain equilibrium (**Appendix 3**).[31]

A questionnaire was used to collect feedback of the parents concerning their view on the various aspects of the program (**Table 1**). The first three items were rated on a Visual Analog Scale (0-10) whereas the last two items consisted of a checklist, with space for the parents to provide comments. At the end of the final face-to-face exercise training session, the questionnaire was distributed to the parent of each participant. The completed forms were collected by an independent physiotherapist at the end of the session.

IBM Statistical Package for Social Sciences for windows 19.0 (IBM, Armonk, NY, USA) was used for all statistical analysis. Boxplots were used to examine the distribution of data and identify the extreme values in the dataset. Extreme values were defined as those cases that had values more than 3.0 times the interquartile range below the 25th or above 75th percentile scores.[32] Intention-to-treat analysis (using the data of all 22 participants) was first conducted to preserve the original balance of random assignment and minimize the bias related to attrition.[33] The last observation carried forward method was employed here. Next, an on-protocol analysis was done, in which only those who completed all baseline and follow-up assessments were included. Non-parametric statistics were used as the data did not fulfill the criteria for normality (checked by Kolmogorov-Smirnov test and visual inspection of data). To compare the characteristics of the core stability and task-oriented groups at baseline, Mann-Whitney U tests and Chi-square tests were used for continuous variables and nominal variables, respectively. The attendance rate and home exercise compliance rate were compared between the two groups using Mann-Whitney U tests. The pre-test and post-test data of each of the two treatment groups were compared using Wilcoxon Signed Ranks tests. Mann-Whitney U test was used to compare the change score (post-test score minus pre-test score) of motor proficiency and Sensory Organization Test-derived scores between the two groups. Between-group difference of items 1-3 and items 4-5 of the parents' feedback questionnaire was analyzed using Mann Whitney U test and Chi-square test, respectively. To explore the association of the change in the outcome variables with attendance rate and compliance with the home program, Spearman's rho (ρ) was used. A level of significance of 0.05 was set, except for the within-group comparison of the pre-test and post-test data, where a more stringent level of significance ($p \leq 0.025$) was used to reduce the risk of making a type I error associated with multiple comparisons.[33] To estimate the number of children for the future trial, post-hoc power analysis was done using the GPower 3.1 software (Heinrich Heine Universitat Dusseldorf, Germany).[34]

Results

A total of 22 participants were enrolled in the study (**Figure 1**). Twenty of them (10 in the core stability group and 10 in the task-oriented group) completed both the initial and follow-up assessments (**Figure 1**). The mean composite equilibrium score was 55.8 (SD=11.1), which was considerably lower than that previously collected from a sample of 67 typically-developing children at a similar age (mean score = 65.0) by Fong et al.[28] All children in this study was able to ambulate independently in the community.

Overall, only 1 individual in the core stability group was considered to have extreme value in the pre-test somatosensory ratio. Intention-to-treat approach was first used to analyze the data, in which all 22 participants were included. There were no significant differences in demographic characteristics (**Table 2**), baseline motor proficiency and equilibrium scores between the two groups (**Table 3**). The attendance rate of the core stability group (10 participants; 6.2 ± 1.2 sessions) and task-oriented group (10 participants; 6.8 ± 1.0 sessions) did not demonstrate any significant difference ($p = 0.251$). The compliance with the home exercise program also showed no significant difference between the two groups (core stability: 2.9 ± 2.2 days per week; task-oriented: 1.8 ± 0.6 days per week) ($p = 0.333$).

In between-group analysis, the change in motor proficiency standard score and percentile rank as well as the equilibrium scores did not demonstrate any significant differences ($p>0.05$) **(Table 3)**. Within-group analysis revealed that both the core stability and task-oriented groups showed significant improvement in the motor proficiency standard score and percentile rank ($p < 0.010$) following the 8-week intervention period. The composite equilibrium score was significantly improved after the 8-week training period in the task-oriented group ($p = 0.009$), but not in the core stability group ($p = 0.812$). No significant change was found in the somatosensory, vestibular and visual ratios in both the core stability and task-oriented groups ($p>0.05$). On-protocol analysis was also conducted, in which only the data obtained from those 20 participants who completed all baseline and follow-up assessments were included. The results were similar to those derived from the intention-to treat analysis (not shown). Similar result on somatosensory ratio was also obtained after excluding the extreme value from the analysis (not shown).

No significant correlation was identified between the change in any of the outcome variables and number of face-to-face training sessions attended in both groups ($p>0.05$). In the task-oriented group, there was a significant correlation between compliance with the home exercise program and change in motor proficiency standard score ($\rho = 0.680$, $p = 0.030$) and percentile rank ($\rho = 0.643$, $p = 0.045$), and composite equilibrium score ($\rho = 0.638$, $p = 0.047$). No such correlations were found in the core stability group ($p>0.05$).

Ten parents of the core stability group and nine parents of the task-oriented group completed the feedback questionnaire (**Table 1**). The scores for item 1 (adequacy of frequency of face-to-face training sessions) and item 2 (feasibility of the home program) were satisfactory for both groups. Overall, as indicated by the mean score of item 3, the parents perceived that their children had benefited from the core stability program (mean (SD) = 7.0 (1.7)) and task-oriented (mean (SD) = 7.3 (1.7)) program. There was no significant difference in the ratings of all 5 items of the questionnaire between the two groups of parents, except that significantly more parents in the core stability group reported that the program had benefited their children in the area of outdoor activities ($p=0.020$). More than 80% of the parents, regardless of the group assignment, preferred group-based training than individual-based training.

Discussion

The results suggested that both the core stability program and task-oriented motor program have similar effects on enhancing motor proficiency in children with developmental coordination disorder. Firm conclusion should not be drawn, however, due to the small sample size.

The motor proficiency of children in the core stability group and task-oriented motor training group had significant improvement after the intervention period (by an average of 6.3 points and 5.1 points respectively). However, the change in motor proficiency demonstrated no significantbetween-group difference, indicating that the effectiveness of the two programs in enhancing motor function is similar.

No study has directly compared the effectiveness of core stability exercise and task-oriented training in improving motor function in children with developemntal cooridnation disorder. Nevertheless, the positive results from the core stability group are generally in line with those of Kane & Bell[35], which reported a case series of 3 children with developmental coordination disorder who had undergone a core stability program, and improvement in motor proficiency was demonstrated in two of these children. Mounting research evidence has demonsrated impaired core muscle activation in children with developmental coordination disorder.[16-19] For example, Kane & Barden[17] showed that compared with the typically-developing children, children with DCD utilized anticipatory contractions of various core muscles (e.g., bilateral external oblique, and right transversus abdominis/internal oblique muscles) less frequently during various functional tasks (e.g., kicking a ball, climbing stairs). Increased core stability may be an important mechanism underlying the improvement in overall motor proficiency. However, this hypothesis needs further study, as core muscle strength/activation was not measured in our study.

We used a physioball as a tool to improve core stability in children with developmental coordination disorder in the core stability group. The positive effect of exercise training using physioball on enhancing core stability in other populations has been demonstrated in previous research.[20,36] However, Stanton et al.[36] reported that exercise training using physioball significantly improved core stability, but not running economy and running posture. It was concluded that the physioball exercise training may positively influence core stability without transfer of improvement in functional performance. Since the children in their study were all normal young athletes who did not present with major impairment in postural control, the subsequent improvement in the postural stability after training might not be large enough to lead to enhancement of functional performance.

The improvement observed in motor proficiency after task-oriented training was also consistent with previous studies.[19-11] For example, Niemeijier et al.[10] reported that those children who had received the Neuromotor Task Training, which was derived from the task-oriented approach, had significant improvement in motor skills after 9 weeks of training, as measured by the Movement Assessment Battery for Children and Test of Gross Motor Development-2. Moreover, it was also shown in their study that the test items that were more similar to those practiced during the training sessions demonstrated the greatest improvement.[10] Schoemaker et al.[11] also demonstrated similar results in that those children with DCD who had received 18 weeks of NTT showed significantly more improvement in MABC score than the control group. The task-oriented motor training program employed in this study focused directly on teaching a child’s common functional skills encountered in daily life. The high resemblance of the tasks practiced during treatment to daily activities may result in a better carryover of motor skills as captured by the Bruininks-Oseretsky Test, of which the test items were of high functional relevance.[26]

There was a tendency for children in the task-oriented program to show better results with the equilibrium score after treatment compared with the core stability group, although the between-group difference did not quite reach statistical significance (p=0.100). In the task-oriented program, almost all activities were performed in the upright standing position while the activities were performed in a variety of postures (prone, supine, sitting, standing) in the core stability group. It is thus not entirely surprising that the children in the former group may have a tendency to perform better in the Sensory Organization Test, which evaluates standing balance in different sensory conditions. The lack of significant change in the equilibrium score in the core stability group may also be due to the fact that other domains of postural control, such as flexibility, muscle strength/activation patterns, and dynamic balance (e.g., walking balance) were not captured by the Sensory Organization Test. As aforementioned, one contributing factor may be core muscle strength, which was not specifically evaluated in this study. The mechanisms underlying the improvement in motor proficiency after the two forms of training await further research.

Although we found an increase in motor proficiency score after the core stability and task-oriented programs, no firm conclusion can be made due to the small sample size and the lack of a no-intervention control group. We could not rule out that the improvement in motor proficiency after the intervention period could be due to some common factors that affect both groups (e.g., maturation and practice effects). We therefore could not draw any absolute conclusion as to whether the two programs were effective or ineffective. In this regard, our findings should be interpreted with caution. Further research should be required before we can recommend one program over the other for children with developmental coordination disorder.

This pilot study did provide useful estimation of the number of children needed for the large-scale trial to detect significant between-group difference in motor proficiency. Our results yielded a small standardized effect size for the Bruininks-Oseretsky Test percentile rank score (Cohen's d =0.27) with limited power (0.09). A total of 426 children (213 per group) will be required for the future trial to detect a significant between-group difference in this outcome, assuming a power of 0.80, and alpha of 0.05. Although the difference in change in the equilibrium score between the two groups yielded a decent standardized effect size (Cohen's d =

0.84), it did not quite reach statistical significance (p=0.100). Our post-hoc power analysis revealed that we only achieved a power of 0.47. To detect a significant between-group difference in equilibrium change score with an effect size of 0.84, power of 0.80, and alpha of 0.05, a minimum of 24 children per group will be required for the future trial.

The parents' feedback on the two programs was generally positive. Most parents found the home program easy to carry out at home. For both programs, no significant relationship between the attendance rate of the face-to-face training session and outcomes was found. Rather, there was a significant association of the improvement in motor proficiency and postural control with home exercise compliance in the task-oriented training group. As the face-to-face session was only held once a week, the success of the program may largely depend on how often the children performed the exercises at home. The significant relationship between compliance with home exercise program and motor outcomes highlights the importance of engaging the children and parents in the home program. In this study, the mean compliance rate was about 2 days per week. Future studies should consider more effective strategies to promote compliance with the home exercise program.

If they were given the option, most parents preferred a group-based, rather than an individual-based exercise training program. In a randomized controlled study, Hung & Pang[12] found that the group-based and the individual-based motor training programs induced similar gain in motor function in children with developmental coordination disorder, and that the parental satisfaction level was also comparable. Considering many challenges faced by rehabilitation practitioners such as heavy workload and time constraints, the group-based training approach used in this study seems to be a feasible option.

There were several limitations in the present study. First, the Bruininks-Oseretsky Test of Motor Proficiency 2 – Short Form was used as the assessment tool. A more comprehensive picture of the motor proficiency could have been obtained, had the Complete Form been used. However, the Complete From requires about one hour for completion and would not be feasible in typical pediatric out-patient settings where time constraint is often a concern. Second, the Ssensory Organization Test evaluates only the contribution of the different sensory systems in postural control. However, postural control involves multi-dimensional systems which include not only sensory, but also neuromotor and biomechanical systems. Other assessment tools should be included in future studies to measure changes in different aspects of postural control. Third, our outcome meausres are mainly related to the “Body functions/ structures” and “Activities” domains as decribed in the International Classification of Function, Disability and Health (ICF) as endorsed by the World Health Organization.[37] Future studies should incorporate outcomes that measure “Particpation” (i.e., involvement in a life situation) such as participation in school activities. Finally, this was a pilot study. The long-term effects of the core stability program and task-oriented program are also uncertain. Nevertheless, the results showed that the training programs used here are feasible, and the outcomes are quite promising. A multi-center trial incorporating a larger sample size and long-term follow-up assessments is warranted before one can recommend the task-oriented over core stability program and vice versa.

Clinical messages

- The increase in motor proficiency was similar after core stability training and task-oriented motor training among children with developmental coordination disorder.

- The number of children required for the large-scale trial to detect significant between-group difference in motor proficiency and body equilibrium was 426 and 48, respectively.

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Author contributions

Au MK: designing the study, collecting the data, reviewing the manuscript

Chan WM: designing the study, implementing the training protocol, reviewing the manuscript

Lee L: designing the study, analyzing the data, reviewing the manuscript

Chen TMK: designing the study, reviewing the manuscript

Chau RMW: designing the study, reviewing the manuscript

Pang MYC: designing the study, analyzing the data, writing the manuscript

Conflict of Interest Statement

None declared.

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FIGURE Legends

Figure 1. CONSORT Flowchart

Twenty-two children with developmental coordination disorder were enrolled in the study.

Twenty of them completed all baseline and follow-up assessments.

Table 1. Parents' feedback questionnaire

Item		Core stability program (n = 10)	Task-oriented program (n = 9)	p-value
1	Do you think the frequency of the group exercise sessions (once per week) is adequate? (0: inadequate; 10: very adequate)	7.4± 2.1 (4-10)[a]	6.0±1.7 (4-8)	0.160
2	Do you think the home exercise is easy to carry out at home? (0: not easy at all, 10: very easy)	6.6±2.8 (0-10)	5.6±1.7(4-8)	0.147
3	Do you think this group exercise program has benefited your child? (0: not beneficial at all, 10: very beneficial)	7.0±1.7 (4-8)	7.3±1.7(4-10)	0.740
4	In which of the following areas do you think this group exercise has benefited your child?			
	a. Activities of daily living, n	5	3	0.650
	b. School activities, n	4	2	0.628
	c. Outdoor activities, n	7	1	0.020[b]
	d. Motivation to participate in activities, n	3	3	1.000
5	Do you prefer a group-based or individual-based exercise program?			
	Group-based, n	9	7	0.582
	Individual-based, n	1	2	

[a]Mean±SD (range) presented unless indicated otherwise

[b] indicates significant difference between the core stability and task-oriented groups ($p \leq 0.05$)

Table 2. Characteristics of participants

Variable	Core stability program (n=11)	Task-oriented program (n=11)	p-value
Age, months	95.2 ±12.1 (74-115)[a]	91.5 ± 13.0 (76-112)	0.450
Sex (male/female), n	7/4	8/3	1.000
Height, cm	125.3 ± 7.0 (116-137)	124.6 ± 9.1 (109-138)	0.869
Co-morbid conditions			
Attention deficit hyperactive disorder, n	3	0	0.214
Dyslexia, n	2	2	1.000
Taking Ritalin, n	2	0	0.214

[a]Mean±SD (range) presented unless indicated otherwise

Table 3. Outcome measures: Intention-to-treat analysis

	Core stability group (n=11)			Task-oriented group (n=11)			p-value (between-group comparison of change score)
	Baseline	**Follow-up**	**Mean change (95%CI)**	**Baseline**	**Follow-up**	**Change score (95%CI)**	
BOT-2 Standard score (20-80)	40.6±6.2[a] (33-51)	46.9±8.4 (35-61)	6.3 (2.7, 9.9)[b]	39.7±3.9 (35-46)	44.8 ±5.5 (37-54)	5.1 (2.4, 7.8)[b]	0.717
BOT-2 Percentile rank	21.5±17.0 (5-54)	40.8±27.2 (7-86)	19.4 (7.7, 31.1)[b]	17.0±9.7 (7-35)	32.2±19.1 (10-66)	15.2 (6.5, 23.9)[b]	0.621
SOT Composite score (0-100)	55.3±9.1 (41-68)	55.3±11.1 (33-74)	0.0 (6.5, 6.5)	56.3±13.3 (32-75)	62.3±11.9 (45-80)	6.0 (2.3, 9.7)[b]	0.100
SOT Somato-sensory ratio (%)	92.5±6.6 (75.8-99.3)	92.3±8.0 (72.9-103.9)	-0.3 (-4.2, 3.6)	94.4±8.2 (73.3-102.3)	96.7±3.7 (92.9-104.2)	2.3 (-2.9, 7.4)	0.431
SOT Vestibular ratio (%)	33.0±17.9 (0.0-53.9)	40.2±17.4 (15.3-68.4)	7.2 (-1.4, 15.8)	37.6±18.1 (10.7-70.9)	47.1±17.3 (15.4-69.8)	9.4 (-0.8, 19.7)	0.895
SOT Visual ratio (%)	64.4±14.9 (34.4-86.8)	61.1±13.3 (42.1-86.2)	-3.3 (-15.8, 9.1)	65.1±19.3 (33.8-86.1)	71.9±17.6 (38.4, 97.3)	6.8 (0.5, 13.2)	0.066

BOT-2 = Bruininks-Oseretsky Test of Motor Proficiency Second Edition; SOT=Sensory Organization Test
[a]Mean±SD (range) presented unless indicated otherwise
[b] indicates significant change from baseline ($p \leq 0.025$)

Appendix 1. Core stability program

Position of participant	Example of exercises
Supine	• Physioball placed under the legs. Move ball side to side, forward/backward.[a] • Physioball placed under the legs. Lift the buttocks off the supporting surface and keep the ball stationary for 5 seconds.[a,b] • Physioball placed on top of abdomen. Keep chin tucked in. Use both hands to push the physioball. Flex the spine and lift the head and shoulders off the supporting surface. Hold for 5 seconds.[b]
Prone	• Assume four-point kneeling posture. Physioball placed under the abdomen. Extend the left leg and hold for 5 seconds. Repeat on the right side. [a,b] • Assume four-point kneeling posture. Physioball placed under the abdomen. Extend the neck, and upper trunk and raise both arms off the supporting surface. Hold for 5 seconds. [a,b] • Physioball placed under the lower legs and feet, with arms extended to support the body weight. Move the ball side to side, forward/backward. [a] • Physioball placed under the lower legs and feet, with arms extended to support the body weight. Walk on hands. [a]
Sitting on Physioball	• Use one hand or both hands to lift an object and move the object in different directions. [a] • Throw and catch a ball. [a] • Kick a ball using the left leg. Repeat on the right side. [a] • Rotate the body and look behind the left shoulder. Repeat on the right side. [a] • Extend the left knee and raise the foot off the ground and hold for 5 seconds. Repeat on the other side. [a]
Standing	• Physioball placed between a wall and lower back. Use both hands to lift and move an object in different directions. [a] • Physioball placed between a wall and lower back. Perform partial squats by flexing the knees up to 90 degrees while keeping the Physioball in place. Hold for 5 seconds. [a] • Place the left leg on top of the ball. Hold for 5 seconds. Repeat on the right side.[a]

[a]The participant was instructed to focus on co-contracting the abdominal and back muscles to maintain the spine in a neutral position.
[b]The holding period was progressively increased up to 15 seconds throughout the course of the program.

Appendix 2. Task-oriented program

Task	Description
Body stability: standing	• Maintaining standing balance on different surfaces (firm surface, foam, balance beam, Dynadisc). • Maintaining standing balance with increasingly narrow base of support, including tandem stance and single-leg-stance. • Changing sensory inputs while doing the above tasks (e.g., eyes closed, in a busy corridor) • Addition of a unilateral/bilateral upper limb task (e.g., catching and throwing and bouncing a ball of varying sizes, picking up objects placed in different positions, transferring objects from one hand to the other) to the above tasks. • Addition of a lower limb task (e.g., kicking a ball).
Body transport: • Walking • Running • Hopping • Skipping • Galloping	• Walking/running/jumping/hopping/skipping/galloping on different surfaces. • Walking/running/jumping/hopping/skipping/galloping in different directions. • Stops, turns and changing speed while walking/running/jumping/hopping/skipping/galloping. • Changing sensory inputs while doing the above tasks (e.g., eyes closed, in a busy corridor) • Jumping over obstacles of different heights. • Addition of an upper limb task (e.g., catching and throwing and bouncing a ball of varying sizes. picking up objects placed in different positions, jumping jacks at varying speeds) to the above tasks. • Addition of a lower limb task (e.g., kicking a ball while running) to the above tasks.

Appendix 3. Sensory Organization Test

Variable	**Description**
Condition 1	Eyes open, in which all sensory systems were operating
Condition 2	Eyes closed, in which visual information was made unavailable and only the somatosensory and vestibular systems were operating
Condition 3	Sway- referenced visual surround, in which conflicting visual information was presented
Condition 4	Sway-referenced surface, in which conflicting somatosensory signals were experienced
Condition 5	Eyes closed and sway-referenced surface, in which visual input was unavailable and conflicting somatosensory signals were provided
Condition 6	Sway-referenced visual surround and surface, in which conflicting visual and somatosensory information were experienced
Somatosensory ratio	Indicates the ability of the child to use the somatosensory system to maintain equilibrium (Condition 2/condition 1).
Visual ratio	Indicates the ability of the child to use the visual system to maintain equilibrium (Condition 4/Condition 1).
Vestibular ratio	Indicates the ability of the child to use the vestibular system to maintain equilibrium (Condition 5/Condition 1).

Figure 1. CONSORT Flowchart