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EARLY CHILD DEVELOPMENT AND CARE
2022, VOL. 192, NO. 9, 1349–1358
https://doi.org/10.1080/03004430.2021.1881074

The effectiveness of gross motor interventions in improving motor function in childhood apraxia of speech

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ABSTRACT

Children with Childhood Apraxia of Speech (CAS) often present motor co-ordination difficulties accompanying their speech and sound delays. Therefore, the aim of this study was to investigate the effect of a paired versus a small group gross motor intervention on selected pre-school children, pre-identified with CAS. Children pre-identified with CAS (*N* = 20) were assessed with the Movement Assessment Battery for Children (MABC-2) and the Test of Gross Motor Development (TGMD-2) during the baseline-, pre- and post-tests. The participants were randomly divided into two groups and completed a 12-week gross motor intervention (two 45-minute sessions per week). There were significant improvements in the total motor proficiency of the MABC-2 as well as overall gross motor quotient (GMQ) of the TGMD-2 in both groups post-intervention. This study highlights the need for further research in gross motor interventions to improve the quality of movement of children, pre-identified with CAS.

ARTICLE HISTORY
Received 16 June 2020
Accepted 20 January 2021

KEYWORDS
Motor-coordination; pre-school children; TGMD-2; MABC-2

Introduction

Motor development is defined as the progressive transformation of movement throughout the human lifespan. This is especially prominent in infants, young children and adolescents, characterized by the vast growth and maturation of the nervous system, which is required to perform gross and fine motor skills (Van Biljon & Longhurst, 2011, p. 441). Early identification of children with developmental delay, including in the gross motor domain, is critical as early intervention may enhance function and minimize or prevent further delay (Majnemer, 1998, p. 62).

There is a strong relationship between childhood motor and communication skills. The inter-relatedness of motor and speech/language skills are evidenced by delayed communication being a risk factor for motor difficulties later in life. Half of pre-school children suffering from language delays develop motor delays and difficulties later in life (Wang, Lekhal, Aarø, & Schjølberg, 2012, p. 77).

Dyspraxia is variously defined as the failure to have ever acquired the ability to perform age-appropriate complex motor actions (Vaivre-Douret et al., 2011, p. 615), and the inability to plan and execute motor tasks, usually known as poor motor planning (Pienaar, 2014, p. 116). Apraxia is inconsistently defined as an acquired disorder that leads to the loss in the ability to accomplish previously learned skills (Vaivre-Douret et al., 2011, p. 615), and as a movement that has been planned but not executed (Pienaar, 2014, p. 116). Childhood apraxia of speech (CAS), formerly known as

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developmental apraxia of speech (Murray, McCabe, & Ballard, 2014, p. 486), is not an acquired disorder and does not involve loss of skills. Another former name of CAS is developmental verbal dyspraxia (Pema, 2015, p. 46), is therefore fitting. CAS is characterized by the inability to plan an appropriate motor command (Murray et al., 2014, p. 486).

The incidence of CAS is 3-5% in children (Tükel, Björelius, Henningsson, McAllister, & Eliasson, 2015, p. 1), and 3 to 4 times more common in boys than girls (Maas, Gildersleeve-Neumann, Jakielski, & Stoeckel, 2014, p. 197). CAS is often accompanied by impairment in domains other than speech and language (Teverovsky, Bickel, & Feldman, 2009, p. 100). As with many neurological and behavioural disorders, the precise aetiology for CAS is still unknown (Souza, Payão Mda, & Costa, 2009, p. 78), although multiple single genes and specific copy number variants associated with other neurodevelopmental conditions have been identified in some children with CAS suggesting a genetic aetiology (Morgan & Webster, 2018, p. 1090). Children diagnosed with CAS thus have speech irregularities because of poor brain co-ordination of the function of the pharynx, mandible and tongue (Pema, 2015, p. 46). A recent study by Tükel *et al*. stated that parents and teachers often report concurrent overall motor co-ordination difficulties in children with CAS, which result in clumsiness (Tükel et al., 2015, p. 1).

Another example of the correlation between motor and communication dysfunction is developmental co-ordination disorder (DCD), a known co-morbidity of speech or language learning disabilities. Explanations for the co-morbidity of DCD and speech or language learning disabilities include problems with generalization and praxis, cerebellar deficits, inter-hemispheric deficits and atypical brain development (Gaines & Missiuna, 2007, p. 326).

The current study and the intervention thereof were based on the Dynamic Systems Theory (DST). The DST was selected due to the understanding that children with apraxia struggle with motor planning (Murray et al., 2014, p. 486). In this case, the DST allowed the child to select their own motor plan to execute a movement by referring to the task, their environment and their individual constraint. When integrating the current study into the DST, the neuro-developmental delay, in this case the (CAS), is an individual constraint influencing the child's movement. As the 3 constraints influence each other, the other 2 constraints could be manipulated to create an appropriate motor movement. Therefore, the activities (tasks constraints) in the intervention were broken down to very simple movement patterns in order to compensate for the individual constraint. The difficulty of the activities (tasks constraints) gradually progressed.

Gross motor intervention programmes and research thereof for children with speech and language disorders, more specifically CAS, is lacking. High quality intervention trials are required to determine which interventions are most effective at improving gross motor function in children with developmental delay (Lucas et al., 2016, p. 193). Developmental delay should be identified in the early developmental phase so that early intervention can take place to minimize delay, correct functional deficits if possible and prevent further deterioration. Early intervention is a critical element in childhood development to improve motor coordination and active daily functioning so that an enduring healthy lifestyle can be maintained (Utley & Astill, 2007, p. 80).

Due to the dearth of research exploring motor and communication skills simultaneously and the appropriate gross motor intervention thereof, the current novel study investigated a specific gross motor intervention in children diagnosed with CAS.

Problem statement

A paucity of research exists for gross motor skill programmes for children diagnosed with CAS or related motor coordination disorders such as DCD. This study, therefore aimed to investigate the comparative effect of a paired- versus a small group gross motor intervention programme on selected pre-school children, pre-identified with CAS.

Null hypothesis (H_0):

The outcomes of the gross motor intervention will be the same when the programme is implemented in paired- or small groups.

Research hypothesis (H_1):

The outcomes of the gross motor intervention will not be the same when the programme is implemented in paired- or small groups. The programme will have a larger effect when it is presented in paired groups.

Methodology

Study design

The current study followed a quasi-experimental design to evaluate the impact of the intervention programme on a target population (Grimshaw, Campbell, Eccles, & Steen, 2000, p. 15), and to strengthen the design, the participants were randomly divided into two groups (paired groups and a small group) (Rockers, Rottingen, Shemilt, & Baringhuasen, 2015, p. 513). It also followed the format of empirical research and can be classified as quantitative, because the gross motor capabilities studied could be measured and quantified. A double-blind testing procedure which protects the study against the Hawthorne effect – the tendency of the participants to act differently if they think they are being singled out, was selected (Donley, 2012, p. 19). Furthermore, the current study was also based on a comparative effectiveness research design (CER), which focuses mainly on medicine as science.

Sample

The participants were 3 to 7-year-old pre-school learners from a selected government hospital school in the Bellville area in the Western Cape Province, South Africa, which caters for children pre-identified with CAS by Speech-therapists as well as learners who are patients in the hospital. A purposive sample ($N = 20$) included boys ($n = 18$) and girls ($n = 2$), implying a male:female ratio of 9:1. The participants were randomly divided by an external 3rd party into two groups: pairs and small group. Consequently, there were 5 paired groups ($n = 10$), 5.10 years (IQR 4.95–6.45 years) and one small group ($n = 10$), 6.10 years (IQR 5.40–6.50).

Testing procedures

Primary data were collected using the Movement Assessment Battery for Children – 2nd Edition (MABC-2) and the Test for Gross Motor Development – 2nd Edition (TGMD-2) at three evaluation stages (2 weeks each): (1) baseline-; (2) pre-; and (3) post-tests as these tests are widely used in the literature for evaluation of motor function of children The baseline tests were used as a control to eliminate the possibility of the effect of natural maturation, as well as other therapies received during the intervention period. Thereafter, they received a 'rest period' of 10 weeks matching the length of the actual intervention. After the school holiday, the pre-test commenced.

The MABC-2 is a standardized test which identifies and describes motor function impairments in children aged 3- to 16-years and has frequently been used by practitioners to diagnose children with DCD (Henderson, Sugden, & Barnett, 2007, p. 50). The total motor proficiency is the total summary of the MABC-2 and consists of: (1) manual dexterity; (2) aiming; and (3) catching and balance and takes approximately 20–40 minutes to administer. It is a valid and reliable test and the intra-rater and test-retest reliability scores exceed 0.95 (Henderson et al., 2007, p. 50, 134).

The TGMD-2 is widely used as a research tool to assess children's gross motor development in the early development period (3- to 10-years old). The GMQ for the TGMD consists of locomotion and object control. The TGMD-2 is a valid and reliable test that assesses children's gross motor abilities in the early developmental period (3-to-10 years-old) and takes 15–20 minutes to administer. The reliability coefficient is high and above 0.80 for the Gross Motor Quotient (GMQ), locomotor and object control (Ulrich, 2000, p.3, 5, 8, 32, 40).

The researchers (presenting the intervention) and the assessors (collecting the data from the participants), were trained postgraduate students in Pediatric Exercise Science (designated as the Kinderkinetics honours programme at the local institution) and were randomly assigned by the main researcher. The same assessors collected the data from the same child during all 3 testing opportunities.

Intervention programme

A similar 12-week intervention followed the pre-test and was presented for 45 minutes, twice a week for the pairs and small group. The programme consisted of more or less the same warm-up and cool-down throughout the intervention to ensure that the participants followed a routine. As the participants were very young, this also helped with the discipline and organization of the participants. The warm-up consisted of a lot of aerobic activities to prepare the participants' bodies for the activities that were to follow. The cool-down consisted of passive movements to gradually calm the participants down. Four activities (included progressions) were created with a main focus but also underlying focusses. The participants could progress according to the discretion of the main researcher after receiving feedback from the researchers implementing the intervention programme.

Statistical analysis

Data analysis was performed using Statistica data analysis software system, version 13 (TIBCO Software Inc., 2018). Mixed model repeated measures ANOVA was used to test for differences in the effects of the intervention on the two groups. The participants were entered into the model as a random effect specifically to model the within subject correlation of repeated measurements over the different time points. Treatment (program), time (pre- and post-test) and treatment*time interaction were entered as fixed effects. The main focus was to investigate treatment*time interaction effects. Post hoc testing was done using Fisher least Significant Difference (LSD) testing. Normality was checked by inspecting normal probability plots, and were judged to be acceptable. For summary statistics means, standard deviations and 95% confidence intervals was reported. Effect sizes were calculated using Hedges' D. A 5% significance level ($p < 0.05$) was used as a guideline for significant results.

Ethical aspects

The Research Ethics Committee of the institution approved the research project (SU-HSD-004463). Before the study commenced, each child completed an assent form with the help of the teacher and each parent or legal guardian collected and completed a consent form. The consent form had the contact details of the main researcher and the parent or legal guardian were encouraged to contact the main researcher if they had questions. The principal from the selected school, as well as the Department of Education provided written permission to conduct the study.

Results and discussion

Overall comparison between groups

The proposed manuscript aimed to investigate the effect of a paired- versus a small group gross motor intervention on selected pre-school children, pre-identified with CAS. The researchers accept the H_0 which states that the outcome of the gross motor intervention will be the same for both groups. All the participants participated in the three testing opportunities (baseline, pre-test, post-test) and all the participants completed the required amount of intervention sessions. Baseline-testing was used to eliminate the possible effect that natural maturation and other therapies could have had on the participants during the 12-week intervention (Brenner, 2008, p. 9). There were no significant differences when comparing baseline and pre-test assessment time points, which possibly indicates that natural maturation and other therapies did not affect the participants' gross motor capabilities.

Significant improvements in the overall scores for both the MABC-2 and the TGMD-2 were identified in both pairs and small group at post-test assessment. Specific differences were observed between the paired groups and the small group in the balance subtest of the MABC-2 at post-test ($p = 0.02$) and the locomotor subtest of the TGMD-2 at pre-test ($p \leq 0.05$) (Table 1). It is postulated that this was due to the participants receiving more individual attention and feedback in the paired groups compared to the small group, as well as less distractions of a larger group. No differences between pairs and the small group were observed for total motor proficiency, manual dexterity and aiming/ catching skills. It is proposed that these findings were due to the specific gross motor intervention being administered similarly to pairs and the small group, with similar benefits. As there were minimal differences at post-testing between pairs and the small group, it is proposed that this was due to the similar outline of the intervention and therefore that this specific gross motor intervention is beneficial irrespective of presentation to pairs or a small group.

Movement assessment battery for children 2nd edition (MABC-2)

Total motor proficiency

A statistically significant difference was shown in both the paired groups ($p < 0.01$) and the small group's ($p < 0.01$) pre- to post-tests' results for the total motor proficiency of the MABC-2 (Table 2). The overall significant improvement in both pairs and the small group is probably due to the intervention methods selected. A South African study by Pienaar and Lennox (2006, p. 73), with a similar intervention to the current study, found similar results. The intervention focused on perceptual skills, proprioception and sensory aspects for children diagnosed with DCD. Their participants were 5–8 years old, which is similar to the current study's age range. Their intervention sessions were also 45 minutes long and presented twice a week for eight weeks. A significant improvement in the total motor proficiency of children diagnosed with DCD after an eight-week intervention was found (Pienaar & Lennox, 2006, p. 73).

Manual dexterity

In the small groups pre- to post-test results, no statistically significant difference ($p = 0.09$) was found ($g = 0.51$ [medium effect]) (Table 2). However, there was a statistically significant difference ($p < 0.01$) in the paired groups' pre- to post-test results (Figure 1). The results suggest that a 12-week gross motor intervention was beneficial to children, pre-identified with CAS, and could improve their

Table 1. Comparison of mean scores (baseline, pre-test and post-test) between the paired and small group using (MABC-2 AND TGMD-2)

Test component	Baseline *p*-value	Pre-test *p*-value	Post-test *p*-value
MABC-2: Total motor proficiency	0.28	0.35	0.07
MABC-2: Manual dexterity	0.59	0.79	0.09
MABC-2: Aiming and catching	0.14	0.14	0.51
MABC-2: Balance	0.38	0.69	0.02
TGMD-2: GMQ	0.33	0.14	0.48
TGMD-2: Locomotor	0.12	0.05	0.87
TGMD-2: Object control	0.92	0.83	0.25

Table 2. Differences in mean scores between baseline to pre-test, and pre-test to post-test within the paired and small group using (MABC-2 AND TGMD-2).

Test component	Baseline mean (SD)	Pre-test mean (SD)	Post-test mean (SD)	Baseline to pre-test *p*-value	Pre-test to post-test *p*-value	Pre-test to post-test Effect sizes
Pairs						
MABC-2: Total motor proficiency	6.40 ± 3.53	6.40 ± 1.58	10.30 ± 4.03	1.00	<0.01	1.22 (Very large)
MABC-2: Manual dexterity	5.30 ± 3.68	5.60 ± 3.03	9.40 ± 4.17	0.74	<0.01	1.00 (Large)
MABC-2: Aiming and catching	8.70 ± 3.27	8.80 ± 2.04	10.70 ± 3.23	0.92	0.06	0.67 (Medium)
MABC-2: Balance	8.20 ± 2.15	8.10 ± 1.66	10.80 ± 3.49	0.91	<0.01	0.95 (Large)
TGMD-2: GMQ	86.20 ± 12.43	86.20 ± 12.90	106.00 ± 13.11	1.00	<0.01	1.46 (Huge)
TGMD-2: Locomotor	8.20 ± 2.53	8.80 ± 1.69	10.80 ± 3.33	0.51	0.03	0.73 (Medium)
TGMD-2: Object control	7.20 ± 2.20	6.60 ± 2.91	11.10 ± 1.85	0.29	<0.01	1.77 (Huge)
Small group						
MABC-2: Total motor proficiency	5.00 ± 2.16	5.20 ± 2.04	7.90 ± 2.96	0.80	<0.01	1.02 (Large)
MABC-2: Manual dexterity	4.50 ± 2.76	5.20 ± 2.70	6.80 ± 3.29	0.44	0.09	0.51 (Medium)
MABC-2: Aiming and catching	6.90 ± 2.38	7.00 ± 2.45	9.90 ± 2.56	0.92	0.01	1.11 (Very large)
MABC-2: Balance	7.10 ± 1.60	7.60 ± 3.06	7.80 ± 3.77	0.57	0.82	0.06 (Negligible)
TGMD-2: GMQ	80.80 ± 10.70	78.10 ± 9.17	102.10 ± 13.93	0.43	<0.01	1.95 (Huge)
TGMD-2: Locomotor	6.30 ± 2.50	6.30 ± 2.63	10.60 ± 3.17	1.00	<0.01	1.41 (Very large)
TGMD-2: Object control	7.30 ± 1.70	6.40 ± 1.51	10.00 ± 2.21	0.11	<0.01	1.81 (Huge)

SD: standard deviation.

manual dexterity, more so when participants worked in pairs. It can be speculated that more individual attention and feedback could be given to participants when working in pairs versus a small group. The effect of a 10-week group physical activity programme in children aged 7–8 years, diagnosed with DCD, by Peters and Wright (1999, p. 203) also used the MABC-2 as an assessment tool. These researchers demonstrated a significant improvement in manual dexterity (Peters & Wright, 1999, p. 203). In a similar study by Pienaar and Lennox (2006, p. 73), but participants were in a group, significant improvement in manual dexterity was determined (Pienaar & Lennox, 2006, p. 73).

Aiming and catching

In the paired groups' pre- to post-test results, no statistically significant difference ($p = 0.06$; $g = 0.67$ [medium]) was found. However, there was a statistically significant difference ($p = 0.01$) in the small group's pre- to post-test results (Table 2). A 12-week gross motor intervention benefits children pre-identified with CAS and improves aiming and catching skills, when administered in a small group. It can be speculated that aiming and catching skills of the small group demonstrated more improvement over pairs due to the competitive nature of a larger group. In a previous study, a significant improvement in the aiming and catching skills of children aged 7–8 years, diagnosed with DCD, was found (Peters & Wright, 1999, p. 203). Pienaar *et al.* investigated a comparable 8-week motor intervention in children diagnosed with DCD. No improvement in aiming and catching skills in a group setting was found, contrary to our study's small group findings (Pienaar & Lennox, 2006, p. 73).

Balance

The small group's pre- to post-test results indicated no statistically significant difference ($p = 0.57$; $g = 0.06$ [Negligible]). However, there was a statistically significant difference ($p < 0.01$) in the

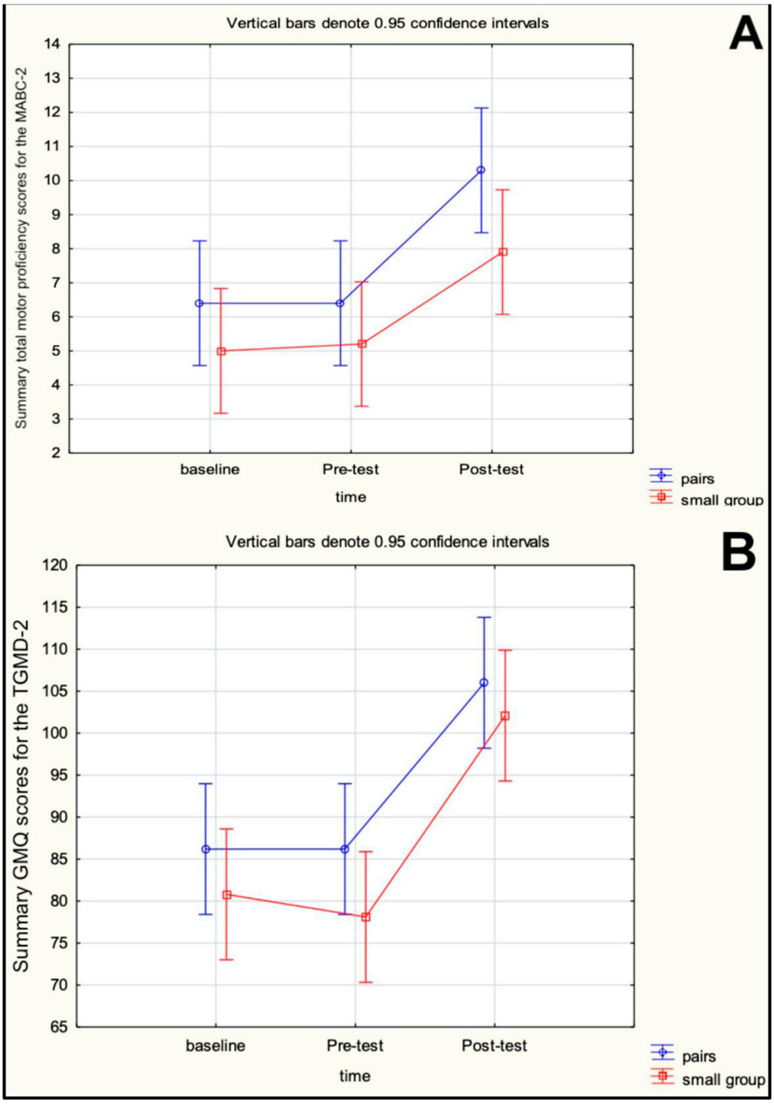

Figure 1. Summary scores for MABC-2 and TGMD-2. The figure illustrates A. Total motor proficiency scores for the MABC-2. B. GMQ scores for the TGMD-2.

paired groups pre- to post-test results (Table 2). It is speculated that the greater improvement in pairs is due to the individual attention and feedback given to participants. Our study is in line with similar balance findings in children diagnosed with DCD (Peters & Wright, 1999, p. 203; Caçola, Romero, Ibana, & Chuang, 2016, p. 175; Farhat et al., 2016, p. 17; Maharaj & Lallie, 2016, p. 5).

Test of gross motor development 2nd edition (TGMD-2)

Gross motor quotient (GMQ)

A statistically significant difference was found in both the paired groups ($p < 0.01$) and the small group's ($p < 0.01$) pre- to post-test results. A 12-week gross motor programme on children aged 5–12 years diagnosed with DCD, was investigated with the conclusion of significant improvement in the overall scores for the TGMD-2 (GMQ) (Burns, Fu, Fang, Hannon, & Brusseau, 2017, p. 1127).

A study with a similar intervention to ours, found similar improvement in gross motor quotient. The intervention focused on perceptual skills, proprioception and sensory aspects for children diagnosed with DCD, aged 5–8 years. Sessions for the intervention were also 45 minutes, twice a week for eight weeks (Pienaar & Lennox, 2006, p. 73).

Locomotor subtest

A statistically significant difference was found for the locomotor subtest in both the paired groups ($p = 0.03$) and the small group ($p < 0.01$) pre- to post-test. Yu et al. (2016, p. 142) found significant improvements in locomotor skills, similar to our study, among children diagnosed with DCD who participated in a 6-week fundamental movement skills programme (Yu et al., 2016, p. 142). However, Pienaar and Lennox (2006, p. 73) did not demonstrate an improvement in a comparable 8-week motor intervention in children diagnosed with DCD (Pienaar & Lennox, 2006, p. 73). We speculate that enhanced improvement in locomotor skills may be enabled by a prolonged, intensive intervention programme.

Object control subtest

A statistically significant difference was found for object control in both the paired groups ($p < 0.01$) and the small group's ($p < 0.01$) pre- to post-test results.

The researchers postulate that the kinaesthetic intervention method encouraged the children to use the perception of their body parts, movement and weight to learn a new skill. Additionally, any attempt to improve overall proprioception will enhance improved object control. Similar to the current study, Yu *et al*. and Pienaar *et al*. found significant improvement in object control skills in children diagnosed with DCD (Pienaar & Lennox, 2006, p. 73; Yu et al., 2016, p. 142).

Recommendations and limitations

A limitation is the small sample size, which is determined by the number of children with CAS in specified classes. Due to CAS being more diagnosed in boys rather than girls, the sample size ($N = 20$) consisted of only 2 girls. A larger sample, possibly multi-site, would strengthen the findings. Additionally, more schools need to be included from different socio-economic environments so that a larger sample of the population can be represented. Another possible limitation is the absence of a speech therapist in the study. As CAS is foremost a speech disorder, it is recommended that future research should be with speech therapy collaboration to assess speech at baseline, pre- and post-test. This study did not include a control group. It is strongly suggested to use a control group for both pairs and the small group to strengthen the conclusion that other therapies received, and natural maturation did not have an effect during the intervention period. In this study 5 different researchers presented to the same pair over a 12-week period. This can be seen as a limitation and it is highly recommended that the same researcher present the programme to each of the different pairs to ensure that the delivery of the intervention is consistent. There is limited research on deficits in the gross motor skills of children pre-identified with CAS. From the latter, it is evident that more in depth multidisciplinary research in this field, is needed.

Conclusion

To our knowledge, this novel study was the first research conducted of its kind in children pre-identified with CAS. The findings that were discussed, could not be accurately compared to the findings of other studies (conducted in the same method – paired groups versus a small group).

This study demonstrated that the specific gross motor intervention resulted in significant improvements in the gross motor capabilities of the children pre-identified with CAS, ultimately increasing their active daily functioning. It is anticipated that these novel findings will guide further research and intervention programmes.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by National Research Foundation [grant number SFH160726182107].

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