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PERCEPTUAL-MOTOR INTERVENTION FOR DEVELOPMENTAL COORDINATION DISORDER IN GRADE 1 CHILDREN

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ABSTRACT

Although different approaches, such as the bottom-up and the top-down approach, have been used as interventions to treat Developmental Coordination Disorder (DCD), there is controversy about the effectiveness of these approaches as interventions. The purpose of this study was to determine if a perceptual-motor intervention would improve the symptoms associated with DCD. Children (N=76) with DCD between the ages of five and eight years, participated in this study. The study had a pre-/post-test experimental design (n=36) with a control group (n=40). The Movement Assessment Battery for Children-2 was used to assess the motor proficiency levels of the children. The intervention comprised a 10-week programme of two 30-minute sessions per week. The dependent variables were all measurable on an interval scale. The Mann-Whitney U-test was used. After the intervention, one subtest, balance, showed a significant change (p=0.050), while manual dexterity (p=0.797) and aiming and catching (p=0.252), showed no significant changes. These three components contributed to the total test score, which revealed no significant difference (p=0.068) in the overall motor proficiency levels of the experimental group and the control group.

Key words: Perceptual-motor; Motor proficiency; Developmental coordination disorder; Intervention; Movement Assessment Battery for Children-2.

INTRODUCTION

Developmental Coordination Disorder (DCD) is recognised as one of the most common developmental dysfunctions during childhood (Ellinoudis *et al*., 2009), and a large number of children are identified with DCD between five and 11 years of age (APA, 2013). The literature indicates wide debate with regard to the prevalence of DCD (Giagazoglou *et al*., 2011), and varies according to the diagnostic criteria that are used (Carslaw, 2011). According to Gaines and Missiuna (2007), as well as Prado *et al*. (2009), DCD affects 5 to 6% of school-age children, while Wilmut *et al*. (2007) indicated the prevalence of DCD to be between 5 to 10%. However, it is estimated that 5 to 19% of children in America and Europe are struggling with DCD (Miller *et al*., 2001; Henderson & Henderson, 2002). In South Africa (Bloemfontein, Free State province), the prevalence was also high, with 15% of children having moderate to severe motor difficulties (De Milander *et al*., 2014).

According to Henderson and Henderson (2002), children will not outgrow this disorder, as was previously believed; however, children can be assisted by means of a five-step assessment process (Barnett, 2008). This process entails firstly the use of questionnaires for screening and identification of children with motor difficulties. The second step is the use of norm-referenced tests for measuring the child's motor performance, which are administered by professionals. The third step of this motor assessment process entails making a formal diagnosis of DCD. This is done by measuring the qualitative and quantitative performance in motor tasks. The fourth step focuses on understanding the nature of the condition. Finally, the fifth step is the planning of an intervention programme.

It follows that intervention programmes are a vital element of the assessment process for improving DCD. Sugden and Chambers (1998) proposed that most interventions are successful with a good number of children diagnosed with DCD. Researchers conventionally made use of a process-orientated approach by means of sensory integration and perceptual motor training in children with DCD (Bernie & Rodger, 2004; Sugden *et al*., 2008). The process-orientated approach is also known as the bottom-up or developmental approach. The aim of this approach is to improve the underlying process, which is not developed fully for the child's age. This includes sensory functions, attention and planning, which are considered prerequisite for the attainment of motor skill. This approach can, therefore, be considered to eliminate motor deficiencies (Sugden & Chambers, 2003; Bernie & Rodger, 2004).

According to Auxter *et al*. (2005), the underlying principle of this approach is to ensure that the supporting building blocks and integration processes are functioning optimally in order to facilitate skill development. This approach aims to improve children's processing abilities or performance components, and many therapists are still practising this as an intervention (Missiuna *et al*., 2006; Sugden *et al*., 2008). According to Hamilton (2002), the most frequently used interventions were sensory-integration therapy, kinaesthetic training, as well as perceptual-motor therapy, and all of these produced positive results more often than not.

Johnstone and Ramon (2011) state that perceptual-motor skills permit sensory information to be obtained successfully and to be understood, by reacting appropriately. Thus, "perceptual" refers to obtaining information and "motor" deals with the outcome of the movement (Gallahue & Ozmun, 2006). According to Gallahue and Ozmun (2006), perceptual-motor activities require children to use cognitive functions (memory, attention and awareness), and the body together in order to accomplish tasks. Johnstone and Ramon (2011) also state that meeting children's gross motor needs will improve their academic readiness, as well as their overall behaviour. Neural pathways are built by means of physical activity. This process refers to the connections by which information travels through the brain. A child with more neural pathways will be able to learn more easily, thus early intervention is very important in order to develop perceptual-motor skills.

A perceptual-motor intervention targets components such as laterality (unilateral, bilateral and cross-lateral activities), balance, body image, tracking, spatial relations (body, spatial, directional and temporal awareness), locomotor and manipulative skills (Gallahue & Ozmun, 2006; Johnstone & Ramon (2011). Taking part in perceptual-motor activities enables children to develop greater levels of body control and encourages greater effort in all areas of the school curriculum. Children with sufficient perceptual-motor skills enjoy better coordination, greater body awareness, stronger intellectual skills and a more positive self-image (Johnstone & Ramon, 2011).

Due to a lack of support for the bottom-up approach, new approaches emerged known as the cognitive or top-down approach (Bernie & Rodger, 2004). More researchers are in favour of this approach (Sugden *et al*., 2008). These new approaches were based on theoretical concepts of motor learning and cognition. Motor learning is based on a conscious understanding of the processes involved when a motor problem needs to be solved. Thus, the interaction between the task and environment, as well as the child needs should be taken into consideration (Perry, 1998). Cognitive approaches use direct skill teaching, but differ in the sense of the unique problem-solving framework, attempting to help children generalise from the learning of one skill to the next (Missiuna *et al*., 2006). According to Missiuna *et al*. (2006) and Sugden *et al*. (2008), although the task-specific approach aims at increasing various participations for children, it is preferable to consider how children can perform a specific task in a variety of real-life situations, rather than in one specific setting. Consequently, one should consider how to modify the task or to adapt the environment in order for children to participate and improve their learning capabilities.

PURPOSE OF RESEARCH

It is clear that controversies exist between these different approaches and there is still not enough evidence to substantiate that one specific intervention approach is superior to another (Miller *et al*., 2001; Miyahara *et al*., 2008). It is thus proposed that these two approaches (bottom-up and top-down) should be merged in order to care for children with DCD (Peters & Wright, 1999; Davidson & Williams, 2000). Thus, the aim of this study was to determine the efficacy of a perceptual-motor intervention for improving the motor proficiency levels of children classified with DCD.

METHODOLOGY

Participants

Initially 13 schools in the Bloemfontein area were targeted to take part in the research project, but only 7 schools eventually agreed to participate. The Department of Education of the Free State province, as well as the principal of each school gave permission for the research to be conducted on the school premises during the Physical Education periods. Approval had been obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS57/2012). The participants were treated in accordance with the ethical guidelines outlined by the Ethics Committee of the Faculty of Health Sciences. The parents/legal guardians of the participants completed an informed consent form for each child participating in this study. In addition, the children signed an assent form.

Recruitment was targeted at children with DCD via the 7 participating schools who had permission to take part in the study (inclusion criteria). Exclusion criteria included a child in the age group outside the expected range (younger than five and older than eight), parental permission not granted, the informed consent form not fully completed, or parents indicating that they would be relocating during the study. Children who were absent during the testing procedure were also excluded due to incomplete testing. Additionally, the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) (APA, 2013), was used to exclude children if they had associated symptoms according to the criteria for DCD as stated in the DSM-5. Children with motor difficulties should not meet criterion C (disturbance is not due to a general medical condition, for example, cerebral palsy, hemiplegia, or muscular dystrophy and does not meet criteria for a pervasive developmental disorder), or criterion D (if mental retardation is present, the motor difficulties are in excess of those usually associated with it). None of the children met the criteria and, therefore, all of them were included for further data analysis.

Study design

A pre-/post-test quasi-experimental design with a control group was applied as an empirical study, which made use of quantitative and qualitative data. The study involved 1 testing procedure by means of the Movement Assessment Battery for Children-2 (MABC-2 Test), in order to identify DCD among Grade 1 children. The participants were tested at their schools during the physical education periods by Kinderkineticists-in-training who were trained in the use of the instrument. Each Kinderkineticist-in-training was responsible for one subtest in order to have consistency across the study.

The cut-off scores used in this study were based on the recommendations of Henderson *et al*. (2007), which are as follows: performance at or below the 5^{th} percentile is classified as severe motor difficulties; performance from the 5^{th} to the 15^{th} percentile is classified as moderate motor difficulties; and performance above the 15^{th} percentile is classified as no motor difficulties. All the children took part in some form of intervention for 30 minutes twice a week over a period of 10 weeks. The control group followed a school programme (physical education classes), presented by personnel from the school. The personnel made use of the Curriculum Assessment Policy Statement (CAPS), according to the Department of Basic Education. The CAPS document with regard to Physical Education states that they should develop children's gross- and fine motor skills in addition to perceptual development (Department of Basic Education, 2011). The personnel focused on perceptual activities, which include aspects such as locomotor, rhythm, balance and laterality.

The experimental group followed a specific perceptual-motor intervention (see Appendix) implemented by a Kinderkineticist familiar with the motor development of young children. The perceptual-motor intervention was divided into four categories, namely unilateral-, bilateral-, contra-lateral- and combined activities. These categories consisted of spatial awareness; eye-hand as well as eye-foot coordination; body awareness; gross motor coordination; motor planning; directionality and dynamic balance in order to improve DCD. It can be concluded that both interventions include activities for perceptual-motor development, thus both groups followed a bottom-up approach. A post-test using the same procedure as the pre-test took place after the intervention process in order to observe if there was any improvement.

Measuring instruments

According to Henderson *et al*. (2007), the Movement Assessment Battery for Children-2 (MABC-2 Test) requires children to perform a series of motor tasks in a specified manner. In addition to age-related norms, the test also provides qualitative information on how children should approach and perform the tasks. The MABC-2 Test is used to assess the subject's motor proficiency levels and to diagnose DCD in children. The first assessment component of this test battery contains 24 items organised into 3 sets of 8 tasks. Each set is designed to use with children of a different age band. For the current study, age band 1 and age band 2 were used.

The 8 tasks are grouped under 3 headings, namely manual dexterity (MD), balance (B) and aiming and catching (AC) (Henderson et al., 2007). Age-adjusted standard scores and percentiles are provided, as well as a total test score for each of the 3 components of the test. The total test score can be interpreted in terms of a "traffic light" system. The green zone indicates performance in a normal range (>15th percentile), while the amber zone indicates that a child is at risk and needs to be carefully monitored (5th - 15th percentile). The red zone is an indication of definite motor impairment (≤5th percentile). Thus, high standard scores on the MABC-2 Test represent good performance. The MABC-2 Test is a valid and reliable tool to use with a reliability coefficient for the total test scores of 0.80 (Henderson *et al*., 2007).

Statistical analysis of data

Microsoft Excel was used to capture data from the MABC-2 Test electronically. A statistician performed data analysis using the Statistical Package for the Social Sciences (SPSS) for Windows (SPSS version 16.0, SPSS Inc., Chicago, IL). Regarding the size of the subgroups (Table 2), a non-parametric statistical technique was used to explore the objective stated. This was due to the small sample size, which could cause doubt regarding the assumptions of normality and homogeneity of variances. A bigger sample size could, however, not be obtained in order for the central limit setting to be implemented. The dependent variables are all measurable on an interval scale and, therefore, the Mann-Whitney U-test (Howell, 2012), being a counterpart of the *t*-test for independent variables, was considered. The 2 groups' were compared on the pre-recordings on the 4 dependent variables with the use of the Mann-Whitney U-test, where after it was recorded for the post-recordings. A probability level of 0.05 or less was taken to indicate statistical significance.

RESULTS

TABLE 1. **FREQUENCY DISTRIBUTION OF PARTICIPANTS**

Gender	**Race**		Total
	Caucasian	Black	
Boys	18 (56.3%)	24 (54.6%)	42 (55.3%)
Girls	14 (43.7%)	20 (45.4%)	34 (44.7%)
Total	32 (42.1%)	44 (57.9%)	76 (100%)

Table 1 shows that the group of 76 children (between the ages of 5 and 8 years) was made up of more boys (55.3%) than girls (42.1%). With regard to race, there were more Black children (57.9%) than Caucasian children (42.1%). The group consisted of 76 children, 36 of who formed the experimental group and the remaining 40 the control group (Table 2). With regard to gender, the control group consisted of 14 girls (18.4%) and 26 boys (34.2%), compared to the 20 girls (26.3%) and 16 boys (21.1%) in the experimental group.

TABLE 2. **EXPERIMENTAL AND CONTROL GROUPS: FREQUENCY DISTRIBUTION OF PARTICIPANTS**

Group	Caucasian boys	Caucasian girls	Black boys	Black girls	Total
Experimental	6 (33.3%)	10 (71.4%)	10 (41.7%)	10 (50.0%)	36 (47.4%)
Control	12 (66.7%)	4 (28.6%)	14 (58.3%)	10 (50.0%)	40 (52.6%)
Total	18 (23.7%)	14 (18.4%)	24 (31.6%)	20 (26.3%)	76 (100%)

The results in Table 3 indicate that there was no significant difference between the control group and the experimental group at the pre-test done before the intervention commenced, with regard to the various subtests, namely manual dexterity (p=0.737), aiming and catching (p=0.527), and balance (p=0.582), as well as the total test score (p=0.372).

Manual dexterity (MD) involves the coordinated use of the hands, guided by the visual system, within time limits (Henderson *et al*., 2007). For this subtest the post-test average scores for the experimental and the control group improved in the total group, Caucasian children and Black children, as well as for the girls and boys. The results for the total group indicate that, although there was no significant difference (p=0.068) between the two groups after the intervention, the average scores for both groups did increase. The increase was found with regard to the total group and for boys, girls, Caucasian children and Black children independently. Furthermore, although both groups improved on their average scores, the improvement was found to be greater in the experimental group than in the control group.

Aiming and catching (AC) entails coordinating body movements when receiving moving objects, as well as performing throwing tasks accurately (Henderson *et al*., 2007). Similar to the results of the subtest for manual dexterity, the post-test average scores for aiming and catching increased for both the control and the experimental group. The increase was also obtained in all the categories researched and again the improvement was found to be greater in the case of the experimental group. It is interesting to note that the boys had a higher average pre-test score (Mean=9.31) than their female counterparts (Mean=8.45). These results support the fact that boys have better ball skills than girls.

The *balance* subtest (B) involves static and dynamic balance, where the child has to keep the body upright against gravity while standing on one leg and performing hopping and jumping movements (Henderson *et al*., 2007). In the case of the total group, balance is the only subtest indicating a significant difference between the pre- (p=0.582) and the post-test (p=0.050). The experimental group (Mean=8.86) had a significantly higher average score than the control group (Mean=7.80) at the post-test (Table 3).

TABLE 3. **PRE- AND POST-TEST SCORES FOR EXPERIMENTAL AND CONTROL GROUPS: TOTAL GROUP, BOYS & GIRLS, CAUCASIAN & BLACK CHILDREN**

			Total Group (N=76)			**Boys** (n=42)			**Girls** (n=34)		
Variable	**Test**	**Gr.**	M±SD	*U*	p	M±SD	*U*	p	M±SD	*U*	p
MD	Pre	Exp	4.14±1.48	688.5	0.737	3.75±1.34	196.0	0.751	4.45±1.54	121.5	0.522
		Con	3.99±1.51			3.90±1.45			4.14±1.66		
	Post	Exp	6.42±2.43	611.0	0.252	5.87±2.36	205.0	0.937	6.85±2.46	100.5	0.169
		Con	5.75±2.42			5.77±2.60			5.71±2.13		
AC	Pre	Exp	8.83±1.95	660.5	0.527	9.31±2.41	205.5	0.947	8.45±1.43	126.5	0.641
		Con	9.05±2.06			9.42±1.65			8.36±2.59		
	Post	Exp	10.64±2.49	695.5	0.797	11.25±2.79	187.0	0.581	10.15±2.16	132.0	0.796
		Con	10.33±2.79			10.54±2.98			9.93±2.43		
B	Pre	Exp	7.25±1.34	668.0	0.582	7.13±1.36	186.5	0.570	7.35±1.35	135.0	0.877
		Con	7.17±1.88			6.96±1.68			7.57±2.21		
	Post	Exp	8.86±2.73	533.0	**0.050**	8.50±2.78	177.0	0.416	9.15±2.72	82.0*	0.043
		Con	7.80±2.97			8.08±3.12			7.29±2.70		
TTS	Pre	Exp	5.42±0.77	642.0	0.372	5.25±0.93	203.5	0.899	5.55±0.61	117.0	0.436
		Con	5.25±0.84			5.27±0.78			5.21±0.98		
	Post	Exp	7.97±2.72	546.0	0.068	7.69±2.36	172.0	0.348	8.20±3.02	89.5	0.077
		Con	6.82±2.71			7.00±3.01			6.50±2.14		
			Total Group (N=76)			**Caucasian children** (n=32)			**Black children** (n=44)		
Variable	**Test**	**Gr.**	M±SD	*U*	p	M±SD	*U*	p	M±SD	*U*	p
MD	Pre	Exp	4.14±1.48	688.5	0.737	5.06±1.53	107.0	0.445	3.40±0.94	223.5	0.685
		Con	3.99±1.51			4.44±1.50			3.69±1.47		
	Post	Exp	6.42±2.43	611.0	0.252	7.63±1.78	99.5	0.287	5.45±2.48	234.5	0.896
		Con	5.75±2.42			6.75±2.52			5.09±2.16		
AC	Pre	Exp	8.83±1.95	660.5	0.527	8.56±2.39	95.5	0.224	9.05±1.54	225.0	0.716
		Con	9.05±2.06			9.38±2.19			8.83±1.99		
	Post	Exp	10.64±2.49	695.5	0.797	10.94±2.57	125.5	0.926	10.40±2.46	234.0	0.886
		Con	10.33±2.79			10.69±2.55			10.08±2.96		
B	Pre	Exp	7.25±1.34	668.0	0.582	6.81±1.38	87.0	0.128	7.60±1.23	219.5	0.622
		Con	7.17±1.88			6.06±1.18			7.92±1.91		
	Post	Exp	8.86±2.73	533.0	**0.050**	9.31±2.92	72.0	**0.035**	8.50±2.58	215.0	0.552
		Con	7.80±2.97			7.31±2.41			8.13±3.30		
TTS	Pre	Exp	5.42±0.77	642.0	0.372	5.63±0.50	81.0	0.080	5.25±0.91	223.5	0.668
		Con	5.25±0.84			5.06±0.85			5.38±0.82		
	Post	Exp	7.97±2.72	546.0	0.068	9.00±2.78	76.5	**0.050**	7.15±2.43	206.0	0.419
		Con	6.82±2.71			7.19±2.37			6.58±2.94		

Gr= Group; M= Mean; SD= Standard Deviation; p≤0.05; Exp= Experimental Gr.; Con= Control Gr.
MD= Manual dexterity; AC= Aiming and catching; B= Balance; TTS= Total test score

Similar findings were obtained for the Caucasian children. The experimental group (Mean=9.31) achieved a significantly higher average score than the control group (Mean=7.31), indicating that their balancing skills improved significantly (p=0.035). In addition, the girls also improved on their average score, the experimental group (Mean=9.15) performing better than the control group (Mean=7.29), resulting in a significant difference (p=0.043) between the two groups. This indicates that the perceptual-motor intervention did aid in the improvement of the balancing skills of some of the children. However, no significant differences were observed for the Black learners or the boys (Table 3).

The sum of the three categories of the MABC-2 Test produced the *total test score* (TTS). Although the average total test score improved in all the categories, the only significant difference was found for the Caucasian children. The results in Table 3 indicate that the experimental group (Mean=9.00) had a significantly higher total test score than the control group (Mean=7.19) in the post-test. Thus, a significant difference (p=0.050) was observed. The results indicate that the perceptual-motor intervention did improve the overall motor proficiency of Caucasian children.

The distribution of the children according to the traffic light system (degree of motor difficulty), before and after the perceptual-motor intervention is shown in Figures 1. Note that only children classified as borderline or with severe motor impairment took part in the intervention. As stated previously, the total test score is derived from the 3 subtests and can be interpreted in terms of a traffic light system. The green zone indicates performance in a normal range, the amber zone indicates a child as being at risk and the red zone is an indication of definite motor impairment. After the pre- and post-tests, the total test scores of the 76 children were interpreted and placed according to the traffic light system.

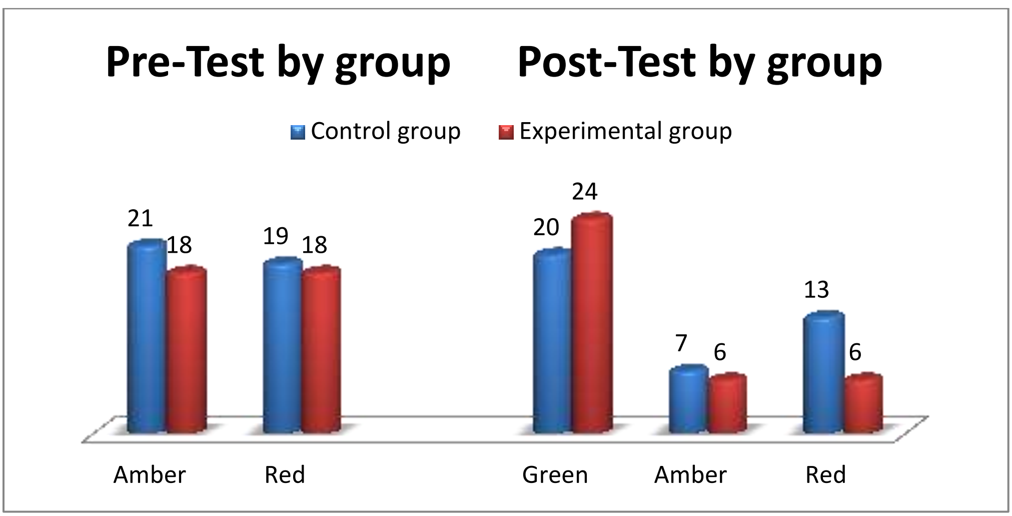

FIGURE 1. **TEST PLACEMENTS USING TRAFFIC LIGHT SYSTEM BY GROUP**

Figure 1 indicates the placement in terms of the traffic light system prior to and after the intervention. The results clearly indicate that all the participants had some form of motor problems prior to the intervention. Of the control group, 21 children fell in the amber zone and 19 children in the red zone. Of the experimental group, 18 children fell in the amber zone and another 18 in the red zone.

In addition, subsequent to the intervention, the experimental group performed better than the control group. The distribution according to the traffic light system was as follows: the majority of the children in the control group improved, with 20 children placed in the green zone (no motor difficulties). Similar results were observed for the experimental group, where 24 children improved after the intervention and could be placed in the category, 'no motor difficulty'. Furthermore, the results show that seven children from the control group and six of the experimental group remained in the amber zone. Finally, of the 19 children in the control group who were initially in the red zone, 13 remained after the intervention. This confirms that children will not outgrow their motor problems. Of the intervention group, only six children remained in the red zone. The findings of this study indicate that the motor proficiency levels of children with DCD improved not only due to their participation in a perceptual-motor intervention, but also by taking part in physical education classes presented by their teachers (Figure 1).

DISCUSSION

There has been an abundance of published research concerning various interventions for children with DCD. According to Smits-Engelsman *et al*. (2013), interventions in general have proved to be beneficial for children with DCD, implying that any intervention is better than no intervention at all. It must be mentioned that literature available with regard to the bottom-up approach has become somewhat outdated. This might be due to the criticism towards this approach (Bernie & Rodger, 2004), since more researchers are in favour of the top-down approach (Sugden *et al*., 2008). A combined systematic review and meta-analysis was conducted by Smits-Engelsman *et al*. (2013), reviewing studies published between 1995 and 2011 on various interventions for children with DCD. The researchers concluded their study indicating that the comparison between various interventions showed strong effects for the task-oriented intervention (dw=0.89), in addition to physical and occupational therapies (dw=0.83), whereas the process-oriented intervention was weak (dw=0.12).

The results with regard to *manual dexterity* indicated no significant difference (p=0.252) between the two groups after the intervention was completed. This is similar to a study conducted by Pienaar and Lennox (2006), who determined that the fine motor skills of children between five and eight years from two farm schools did improve, but not significantly. Furthermore, Peens *et al*. (2008) also found no improvement after a motor intervention. In the current study, the perceptual-motor intervention did not focus on fine motor development; however, both groups did improve. This might be due to the exposure in the classroom, where children took part in writing and cutting activities, as well as beading.

With reference to *aiming and catching*, it is interesting to note that the control group had a higher average score during the pre-test, although the difference was not significant (p=0.527). Both groups improved with regard to aiming and catching. Although the intervention group improved more based on the average score, the results do not indicate a significant difference (p=0.797) between the pre- and post-tests of the two groups. The findings of Pienaar and Lennox (2006) were of a similar nature. In contrast, Peens *et al*. (2008) used a motor-based intervention and found a significant improvement. Another reason for improvement in both groups might be the fact that these children participated in a variety of object manipulative skills at school and in sports.

The results for *balance* indicate a significant difference (p=0.050) between the two groups after the intervention was completed. The improvement of the experiemtal group correlates with the findings of Pienaar and Lennox (2006), as well as that of Peens *et al*. (2008), who found that a motor intervention improved the balance sub-test of the Movement Assessment Battery for Children. The results of this study indicate that the perceptual-motor intervention contributed to the improvement of balance.

Although there was an improvement in the average score of the *total test score*, there was no significant difference (p=0.068) between the groups after the intervention. It was also apparent that the participants of the current study were a heterogeneous group and it is necessary to address the individual needs of each child. Missiuna *et al*. (2006) also confirm this statement. Based on the current study, a perceptual-motor intervention did not lead to a significant improvement with regard to overall motor proficiency. This correlates with Pienaar and Lennox (2006), who also found no significant difference in motor performance after conducting a motor intervention with 32 children between five and eight years of age. In contrast, Peens *et al*. (2008) found that a motor-based intervention did improve the total test score of 20 children between the age of seven and nine years.

The results of the current study show that the children who followed the perceptual-motor intervention, conducted by a Kinderkineticist-in-training familiar with the development of children, had a 67% improvement (24/36). Furthermore, the results indicate that the physical education classes conducted by the teachers also improved the motor proficiency of the children in the control group by 50% (20/40). This indicates that a majority of the children in both groups achieved scores above the 15^{th} percentile during the post-test. The improvement illustrates that interventions conducted by other people, such as teachers, can also be helpful.

This statement is supported by findings from Sugden and Chambers (2003), observing that interventions done by parents and teachers can also be successful. The researchers found that a seven-week intervention (task-orientated approach), conducted by parents and teachers helped the majority of children to obtain scores above the 15^{th} percentile. Miyahara *et al*. (2008) made use of university students in a clinical setting to apply a task-orientated approach and found that 40% of the participants improved beyond the cut-off scores. Intervention by means of a combination of the bottom-up and top-down approaches through intense physical activity conducted by Watemberg *et al*. (2007), concluded that 50% of the participants with DCD scored above the cut-off scores (>15^{th} percentile) after a four-week intervention.

The implications of the results indicate that although both groups improved in general with regard to the average scores, the experimental group improved more compared to the control group. Therefore, the results indicate that a perceptual-motor intervention can be used as an appropriate intervention for children identified with DCD.

CONCLUSIONS

When children are identified with DCD, it is important to implement intervention programmes. Intervention programmes have proven to enhance the motor proficiency of these children (Peens *et al*., 2008). The results of the current study suggest that a perceptual-motor intervention did not improve the motor proficiency levels of children with DCD. From the point of view of a therapist, no two children are the same, especially children identified with DCD, since they are not a homogeneous group.

LIMITATIONS

One of the major limitations was the fact that the control group was exposed to physical education classes. This could have contributed to the improvement of their motor proficiency levels and influenced the results. Since this was a population-based sample, criterion B of the diagnostic criteria for DCD, which states that the academic performance of the children should also be considered (APA, 2013), was not used. It should also be recognised that the current study recruited children from the Bloemfontein metropolitan area only. Hence, a replication of this study in different provinces and regions in South Africa is recommended to provide more generalised and robust results. Another limitation of the study was the fact that the children were tested on age band 1 (age six) during the pre-test. The majority of the children turned seven during the intervention, and, therefore, had to be tested on age band 2, implying that they had to perform more difficult activities than for age band 1.

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Appendix: Perceptual-motor Intervention Programme for Experimental Group

Week 1: Unilateral activities

Skills developed	**Activity**
Laterality, motor planning, gross motor coordination	Do a unilateral crawl from cone to cone by using your right hand and right leg at the same time and then your left hand and left leg at the same time. As you pass each cone, say what is shown on the card for that cone. Once you reach the last cone, do a backward unilateral crawl to your original starting point by using your left hand and left leg at the same time and then your right hand and right leg at the same time.
Laterality, locomotor skills, spatial awareness, motor planning	Hop along the mat using only your left foot. With each hop, say what is shown on the card for the square you are landing in. Repeat the activity using only your right foot. Continue in this way hopping along the mat on your left foot, then hop on your right foot, then back to the left, and so on.
Spatial awareness, eye-hand coordination, body awareness, gross motor coordination	Crawl around the outside of the hoop while rolling the ball around inside the hoop with the fingertips of one hand; repeat the activity using the elbow; reverse the direction of the crawl, using the other side.
Laterality, locomotor skills, motor planning	Hop to the first of 3 rings, saying the letter shown on the card for each ring as you land in it. Then hop to the next ring and say what is shown in the picture on the card. Continue on to the next letter-picture sequence.

Week 2: Bilateral activities

Skills developed	**Activity**
Locomotor skills, motor planning, spatial awareness	Frog-jump randomly from cone to cone. When you get to each cone, touch it and say the colour and number shown on its card.
Locomotor skills, motor planning, spatial awareness	Touch your body parts with your hands and name the different parts.
Laterality, motor planning, gross motor coordination	Stop on the stomp board with feet at once to project the beanbag into the air. Catch the beanbag with 2 hands and say the colour of the beanbag. Try 5 times. Repeat the activity, clap once and catch the beanbag with 2 hands. Try 5 times.
Spatial awareness, gross motor coordination	Starting at the first hoop, say the shape and colour shown on the card in the hoop. Then use a 2-handed dribble to dribble the ball in the hoop 5 times, counting from 1 to 5 as you dribble. Move to the next hoop and repeat.

Week 3: Cross-lateral activities

Skills developed	**Activity**
Locomotor skills, motor planning, spatial awareness	Crawl from cone to cone. Along the way touch each cone and say the number shown on the card for that cone.
Cross-laterality, directionality, balance, eye-hand coordination; midline crossing	Hold the ball and walk forward on the line using a crossover step: On each step with your right foot, step to the left of the line; do the same with the opposite foot; continue this pattern to the end of the line. After each step, bounce the ball with either hand.
Eye-hand coordination, gross motor development	Stop on the stomp board with right foot to project the beanbag into the air. Catch the beanbag with the left hand and count. Try 10 times. Repeat the activity, with the opposite foot. Progression, clap once and catch the beanbag. Try 10 times; repeat the opposite side.
Dynamic balance, spatial awareness	Walk forward on the beam from one end to the other. Along the way, step over the hurdle and through the hoop.

Week 4: Combined activities

Skills developed	**Activity**
Laterality, locomotor skills, motor planning	Step onto the box; jump from the box over the hurdle and into hoop 1, from 1 to 2 and step through the last hoop.
Locomotor skills, motor planning, eye-hand coordination	Jump on the mini trampoline for 5 times; lie facing forward on our tummy on the scooter board and use both arms together to propel yourself forward to the rope; jump over the rope from front to back and then back to front 5 times; walk to the hoop and bounce the ball in the hoop 5 times with both hands together.
Cross-lateral awareness, dynamic balance, eye-hand coordination	Walk on the rungs of the ladder; leap into and then out of each hoop; stomp on the board with your right foot to launch the beanbag, the catch it with your left hand; opposite side as well.
Cross-lateral awareness, dynamic balance, eye-hand coordination	Lie on your tummy on the scooter board; use alternating hands to propel yourself forward through the tunnel; kneel on the scooter board and use alternate hands to weave through the cones; sit on the scooter board and use alternating feet to propel yourself backward through the space between the noodles or ropes.

Week 5: Unilateral activities

Skills developed	Activity
Laterality, locomotor skills, motor planning, spatial awareness	Hop sideways through the mat using only your left foot. With each hop, say what is shown on the card for the square you are landing in. Repeat with right foot.
Laterality, motor planning, gross motor coordination	Lie on your torso on the scooter board and use the rope to pull yourself forward with only your right hand; repeat using left hand; sit on the scooter board and pull with right and then left hand.
Laterality, eye-foot coordination	Walk between the 2 rows of bricks, kicking the black ones over with your left foot and kicking the white ones over with your right foot.
Laterality, motor planning, coordination	Toss the disc into the target using your right hand and stepping with your right foot, do the same with your left hand and foot.

Week 6: Bilateral activities

Skills developed	Activity
Laterality, locomotor skills, motor planning	Start at the pointed end of the mat; jump across this first section of the mat with both feet and say the number shown on the card for that sections; move to the next section to the right and jump across every remaining sections until you reach the end. Do not need to make the distance.
Motor planning, gross motor coordination, locomotor skills	Do frog jumps from one shape to another; after each jump and starting with A, work your way through the alphabet, start again if you get to the end; repeat by jumping sideways.
Eye-hand coordination, tracking skills	Sit facing the wall and roll the ball to the wall with 2 hands, after each roll, say the alphabet, roll as many times as possible in the allotted time; stand on line and toss the ball with 2 hands against the wall, let it bounce 1 time after hitting the wall, catch with 2 hands, repeat the toss but catch without the bounce.
Locomotor skills, motor planning, spatial awareness	Jump over the line on the floor with both feet; with hands on your hips, jump over the line slowly for 5 times and the quickly; jump across the line high, then turn around and jump across the line, repeat and jump low; repeat the activities and recite the alphabet while jumping.

Week 7: Cross-lateral activities

Skills developed	Activity
Cross-lateral awareness	Take a 3m approach, run up to the ball without slowing and use your right foot to kick the ball at the brick between the cones; when kicking with your right foot, extend your left arm forward; repeat with your left foot and right arms; repeat 5 times.
Laterality, motor planning, gross motor coordination	Lie on your tummy on the scooter board and push yourself from cone to cone, alternate side in pushing, as you pass each cone, say what is shown on the card; repeat the activity by sitting on the scooter board.
Laterality, motor planning, gross motor coordination	Crawl from beanbag to beanbag, putting each one in the bucket with the matching colour. When picking up a beanbag from the floor, use whichever hand is closest to it and use that same hand to put the beanbag in the bucket.
Cross-lateral awareness, dynamic balance	Start at a line 3m from the mat and leap across the mat; start at the narrow end and work your way to the wide end; emphasise using good leaping form; on landing say what is shown on the card for the section.

Week 8: Combination activities

Skills developed	Activity
Eye-hand coordination, unilateral awareness	Hop from shape to shape, at each shape bounce the ball in the shape 5 times with your right hand and then the left hand; while bouncing the ball say the shape and colour.
Eye-hand coordination, motor planning, dynamic balance	Hop 5 times in each hoop; get on the beam and slide sideways to the right to the end of the beam, as you go bounce ball once in each hoop with right hand, repeat with the left hand.
Bilateral awareness, eye-hand coordination, motor planning	Jumping from hoop to hoop by taking off and landing with both feet simultaneously; lie on your tummy on the board and use both hand at the same time to propel yourself forward to the beanbag; toss and catch the beanbag 5 times with both hands.
Cross-lateral awareness, motor planning	Crawl up the incline mat onto the step box; jump off the box into the hoop on the floor; step through the vertical hoop and say “through”; crawl under the hurdle and say “under”.

Week 9: Unilateral activities

Skills developed	Activity
Locomotor skills, motor planning	Hop from cone to cone, at each cone, say the letter or picture shown on the card for that cone. Repeat activity using your other foot.
Spatial awareness, gross motor coordination	Roll the ball to the wall with your dominant hand; be sure you step forward with the same foot as the hand you use to roll the ball, while it rebounds off the wall, say the letter shown on the card posted on the wall, catch the ball on the rebound, repeat with non-dominant hand.
Laterality, eye-hand coordination	Toss the scarf up into the air with your right hand, then catch it with your right hand using the lion's claw catch; as you toss the scarf, say "toss up" and catch "catch down"; repeat with the left hand until music stops.
Balance	Put your belly on the ball and try to balance yourself without touching the floor; with belly on ball, lift right arm and right leg and try to balance, repeat with left side.

Week 10: Bilateral activities

Skills developed	Activity
Laterality, locomotor skills, motor planning	Jump forward from hoop to hoop while saying 1 letter in alphabetical order after each jump; repeat activity backwards.
Laterality, dynamic balance	Hold a noodle horizontal in both hands with palms up at chest level and walk forward for the length of the beam; carry a noodle over your head with both hands and walk forward for the length of the beam.
Eye-hand coordination, spatial awareness, coordination	While standing, place the ball on the floor between your legs and roll it (with both hands together) at a cone, say the letter on the cone, retrieve the ball and repeat until you have rolled the ball 5 times; turn and face away from the cone, roll the ball backward between your legs at the cone.
Directionality, locomotor skills	Activity may be done without the inclined mat, use a mat to crawl up to the jump box; get on the jump box and assume proper jumping position, with knees bent and your arms extended behind your body, jump into the hoop, making a quarter-turn to the right, repeat it to the left.

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