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The effect of visual therapy on 7- to 8-year old children with Developmental Coordination Disorder (DCD)

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Abstract

Children with Developmental Coordination Disorder (DCD) are heterogeneous regarding underlying problems which includes ocular motor control deficiencies. Poor ocular motor control show relationships with motor coordination problems, which can contribute to academic problems and poor motor skill development needed for successful sport participation. Visual therapy is indicated as a possible way to address poor ocular motor control. The aim of this study was to determine the effect of visual therapy on the DCD status of 7- to 8-year old children. Thirty-two children with a mean age of 95.66 months formed part of the study. The Movement Assessment Battery for Children (MABC) was used to classify children into the different DCD categories (≤15th percentile), while the Sensory Input Systems Screening Test and Quick Neurological Screening Test II (QNST-II) was used to evaluate ocular motor control. A pre-test-post-test design was used. The 18-week visual therapy was executed once a week for 40 minutes during school hours. The results indicated that the visual therapy contributed to a significantly ($p<0.001$) improvement on the DCD status of all the children in the intervention group. Visual therapy is therefore recommended for school-age children with DCD who experience poor ocular motor control. It should be given as early as possible to prevent negative long term effects on academic performance and motor skill development.

Keywords: DCD, Ocular motor control, Visual functioning problems, visual therapy.

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Introduction

Developmental Coordination Disorder (DCD) is a motor-based learning disorder that is characterised by the executing motor skills and motor coordination that is well below the expected chronological age of the child and interferes with the well-being of a child (APA, 2013). This motor-based learning disorder could further lead to negative interferences at different areas including school, home, community and general well-being (APA, 2013). The occurrence of DCD world-wide are reported in 5% to 6% of school-age children (Blank, Smits-Engelsman, Polatajko & Wilson, 2012; APA, 2013), with more boys than girls likely to be diagnosed with this condition (Asonitou, Koutsouki, Kourtessis & Charitou, 2012; Cheng et al., 2014).

Children diagnosed with DCD are described as a heterogeneous group with regard to the underlying problems of this condition and could include neuro-motor problems concerning perception, visual skills and kinaesthetic tasks (Peens, 2005; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011; Blank et al., 2012). Problems associated with DCD could include perceptual problems (i.e. sensory) (Barrett, 2009; Savelsbergh et al., 2003), motor deficits (balance, co-ordination, bilateral integration, spatial orientation, motor planning or dyspraxia) (Rösblad & Von Hofsten, 1994; Pienaar, 2016; Westendorp et al., 2011), poor concentration during the performance of tasks, inadequate fine motor skills, academic problems (learning, reading, writing and mathematics) (Smits-Engelsman, Wilson, Westenberg & Duysen, 2003; Missiuna, Rivard & Pollock, 2004; Westendorp et al., 2011; Asonitou et al., 2012) and poor ocular motor control (accommodation, visual pursuit, convergence-divergence, fixation and ocular alignment) (Hurst, van de Weyer, & Smith, 2006; Barrett, 2009; Coetzee & Pienaar, 2013; Creavin, Lingam, Northstone & Williams, 2013; Robert, Ingster-Moati, Albuisson, Cabrol, Golse & Vaivre-Douret, 2014; Ferguson, Duysens & Smits-Engelsman, 2015; Rafique & Northway, 2015).

Various researchers reported that visual information and -processing plays an important role during the planning and execution of goal-directed movements which is important during the learning phase of new movements (Von Hofsten, 2002; van Waelvelde, de Weerdt, De Cock, & Smits-Engelsman, 2004; Reimer, Cox, Boonstra & Smits-Engelsman, 2008; Reimer, Cox, Nijhuis-Van der Sander & Boonstra, 2011; Botha, 2013; Ferguson et al., 2015). It is further reported that the ocular motor control system is essential for the execution complex motor tasks (Von Hofsten, 2002; Barrett, 2009; Reimer et al., 2011; Rafique & Northway, 2015; Palomo-Nieto, Psotta, Agricola, Abdollahipour & Valtr, 2015). Furthermore, various researchers reported that visual based problems such as visual feedback (Botha, 2013; Wilson, Ruddock, Smits-Engelsman, Polatajko & Blank, 2013), visual integration (van Waelvelde et al., 2004; Pieters, Desoete, Roeyers, Vanderswalmen, & Van Waelvelde, 2012; Cheng et al., 2014), visual perception (Schoemaker et al., 2001; van Waelvelde et al., 2004; Pieters et al., 2012), visual-motor problems (Rösblad & von Hofsten, 1994; Pieters et al., 2012; Cantin, Ryan & Polatojko, 2014) and eye movements or visual pursuit (Langaas, Mon-Williams, Wann, Pascal, & Thompson, 1998; Coetzee & Pienaar, 2013; Robert et al., 2014; Ferguson et al., 2015), could handicap children in their school work as well as during execution of movements which could contribute towards clumsiness (Langaas et al., 1998; Cheatum & Hammond, 2000; Missiuna et al., 2004; Asonitou et al., 2012; Botha, 20013; Pienaar, 2016). It therefore seems from the above literature that if there are delays in a child's motor skills, ophthalmic abnormalities could also be expected. Therefore well-developed ocular motor control or eye muscle functions are reported to play a significant role in gross motor- and perceptual skills such as balance, spatial orientation, body awareness, and co-ordination (hand-eye, foot-eye, hand-foot-eye co-ordination) (Langaas et al., 1998; Bouchard & Tetreault, 2000; Shin, Park & Mapels, 2011; Rafique & Northway, 2015; Palomo-Nieto et al., 2015; Pienaar, 2016).

In the literature it is clear that a child that is diagnosed with DCD should receive intervention as soon as possible, because early intervention minimizes delays in motor development, and if help is not received, these problems will continue into adolescence (Kirby, Sugden, Beveridge & Edwards, 2008; Missiuna, Moll, King, Stewart & Macdonald, 2008; Peens & Pienaar, 2007; Blank et al., 2012; Schoemaker, Lingam, Jongmans, Van Heuvelen & Emond, 2013). However, there is still controversial findings in the literature regarding which intervention method is the best to use and if all interventions is successful (Schoemaker, Hijlkema, & Kalverboer, 1994; Pless & Carlsson, 2000; Peens & Pienaar, 2007; Blank et al., 2012) or not (Miller, Polatajko, Missiuna, Mandich & Macnab, 2001; Peens, 2005; Peens & Pienaar, 2007). A reason for the poor intervention effect in some of the studies could possibly be because of more complex neuro-motor problems, of which ocular motor control could be one of the underlying factors that may be experienced by children that did not improve (Peens, 2005).

Visual therapy is defined as an individualized intervention programme that addresses a child's specific visual shortcoming, by making use of accommodation flippers, prisms and specialized visual apparatus (Barrett, 2009; AAO, 2011). According to some researchers visual therapy can improve and even correct visual shortcomings like binocularity and ocular motor control (Adler, 2002; Helveston, 2005; Aziz, Cleary, Stewart & Weir, 2006; Brautaset, Wahlberg, Abdi & Pansell, 2008; Barrett, 2009; Williams, 2009; Shin et al., 2011; Coetzee & Pienaar, 2013; Whitecross, 2013). Hurst et al. (2006) conducted visual therapy on a child with dyspraxia (this term is sometimes use as a synonym for DCD), and reported improvement in the ocular motor control, motor skills (co-ordination, vestibular function, balance, spatial orientation) and academic achievement (reading, spelling and attention span) as a result of the treatment. Cheatum and Hammond (2000) and Hurst et al. (2006) are of the opinion that the remedial treatment of the eye muscle functions may lead to the improvement of perceptual, gross motor (hand-eye co-ordination, balance, spatial orientation), fine motor (writing and reading) and visual skills (fixation, visual pursuit, accommodation, ocular alignment and convergence-divergence). Several researchers substantiate that the improvement of the visual system contributes to better motor skills and academic abilities (Bouchard & Tetreault, 2000; Orfield, Basa, & Yun, 2001; Helveston, 2005; Shin et al., 2011; Robert et al., 2014; Pienaar, 2016).

However, from the literature it seems that there are few reported research studies worldwide, and none being conducted with visual therapy apparatus in South Africa, with regard to the effect of visual therapy on the DCD status of children.

It is therefore important to investigate whether a visual stimulation program will improve the DCD status of children that has been diagnosed with visual problems. The aim of this study is therefore to determine the effect of a visual therapy on the status of DCD of 7- to 8-year old children.

Methodology

Participants

This study is a follow-up study of a research project undertaken in 2006. During the project in 2006, two Grade 1 classes from each of three mainstream primary schools, from Quintile 4, in the Potchefstroom area, North-West Province, South Africa were randomly selected to take part in the project. The total number of learners identified for the research project was 101 (48 boys and 53 girls between the ages of six and seven years). The distribution of the learners identified was representative of the North West Province population within the different population groups (37 white, 50 black, and 12 children of colour). Of this group who took part in the first part of the project in 2006, 49 learners (20 boys and 29 girls) without DCD and 52 learners (28 boys and 24 girls) with DCD were identified, of whom 29.3% (n=29) were classified in the moderate DCD categories and 23.2% (n=23) in the severe DCD categories (Wessels, 2007). The 52 learners who were identified with DCD were then invited in 2007 to participate in this follow-up study. Of this group, 12 had relocated, and the parents of eight did not return the informed consent forms; consequently, only 32 learners were available for this follow-up study. The composition of this group is displayed in Table 1. The children were eligible to participate in this study if they met the following criteria from the DSM-IV (APA, 2000): if their performance in daily activities, that require motor coordination, were substantially below that expected given the child’s chronological age and measured intelligence (criterion A), and the presence of these motor clumsiness or motor coordination problems significantly interfere with the child’s academic achievement or daily living as identified by the teacher or the parent (criterion B). If any of the children was diagnosed with any neurological condition such as cerebral palsy or any other medical disorder (criterion C) or if there were a possibility of mental retardation, reported by the teacher (criterion D) the learner were excluded from the project.

Measuring Instruments

Movement Assessment Battery for Children (MABC)

The MABC was used as the measuring instrument to determine the motor coordination of the children. Henderson and Sugden (1992) developed the MABC to evaluate the motor development of 4- to 12-year-old children. The

MABC exhibits good reliability and validity of 0.75 in different populations (Henderson & Sugden, 1992; Leemrijse, Meijer, Vermeer, Lambregts, & Ader, 1999). The MABC consists of three sub-sections that measure the following: manual dexterity (MD) (three test items), ball skills (BS) (two test items) and balancing skills (BLS) (three test items). Each sub-section can be calculated separately and jointly as a total DCD score. The test is a norm-based measuring instrument that classifies children with DCD. Children who are classified on and/or below the fifth percentile need remediation, and between the fifth and 15th percentile, the child is indicated as at risk of DCD, and remediation is recommended. When the MABC total and the scores of the three subsections are low, this indicates a better performance; thus, the lower the score, the better the person preformed in the MABC test. The respective test items of the MABC were administered by trained postgraduate students in Human Movement Science, specialising in Kinderkinetics. Although the researchers are aware that the MABC-2 was published at the time when this research was conducted, the new version weren't available in South Africa to use.

Sensory Input Screening Measuring Instrument and Quick Neurological Screening Test II (QNST- II)

Pyfer (1988) compiled the *Sensory Input Screening Measuring Instrument* that consists of the following test sections: equilibrium reaction, vestibular functioning, reflexes, bilateral integration, kinaesthetic and visual items. This criteria-based measuring instrument is suitable for use in age groups above 6 years. Only the visual test items of the aforementioned test battery were used for this study. Vision was analysed by testing the following ocular motor control functions: ocular alignment left and right (where the child must focus on an object for 10 seconds while one eye is closed), convergence-divergence (the child must focus on an object while the object is moved closer to and away from the nose from a distance of 45cm), fixating on an object for 10 seconds with both eyes open as well as with the left and right eye separately from a distance of 45cm away from the nose, and visual pursuit with both eyes open as well as with the left and right eye separately, using a 30cm x 30cm square from a distance of 30cm away from the nose. The visual pursuit of a horizontal as well as a vertical line with both eyes, which is part of the QNST II, was also tested (Mutti, Martin, Sterling & Spalding, 1998). This test battery shows a validity of r=0.81 (Mutti et al., 1998).

After the assessment of each of the ocular motor control functions, the signs/deviations were then sub-divided into three classes, namely Class 1 – no ocular motor control deviations; Class 2 – one to three ocular motor control deviations; Class 3 – more than three ocular motor control deviations. For the purpose of dividing the visual deviations into the three different classes some of the visual deviations were considered less severe or overlapping deviations, and as a result only one point was obtained regardless if more than one of the signs/deviations were present. These visual signs/deviations includes the following: eyes that are rubbed, eyes that burn, eyes that are blinked often, eyes that are red as well as tear/watery. Furthermore, if the child used compensating movements during the execution of the different ocular motor control functions, one point were obtained for each deviation/sign and it was seen as more severe visual deviations, which include the following: turning the head to the left or right, moving the head side to side, or up and down during visual pursuit, eyes jumping over the midline, eye jerkiness, eyes not following the object/lose the object

Intervention programme

The visual therapy was conducted on an individual basis for 18 sessions, once a week for 40 minutes during school hours, at the three different schools which form part of this study. During the visual therapy, certain perceptual and motor activities (balance, hand-eye coordination, bilateral integration, and vestibular integration) were combined with the visual exercises, which focused on the improvement of ocular motor control. During the sessions, attention was paid to “near vision” and “far vision” activities during alternating sessions, while attention was paid to both “near” and “far” visual activities in some of the sessions. “Near vision” sessions consisted of eight to 10 visual activities, which were performed at a desk, while the “far vision” sessions consisted of six to eight visual and gross motor activities. Use was further made of various visual as well as motor devices during the intervention programme. During the visual therapy, work was done progressively in three different, but consecutive phases, namely: *monocular* (left eye and right eye were exercised separately): Lessons 1 to 6; *bi-ocular* (both eyes are open, but the left eye does not see the same as the right eye): Lessons 7 to 12; and, lastly, *binocular* (both eyes are open and see exactly the same): Lessons 13 to 18. The intervention program was conducted by a postgraduate student in Human Movement Science, specialising in Kinderkinetics, who was trained by on optometrist to give the visual stimulation programme.

Research design

A pre-test–post-test design was followed to determine the effect of the visual stimulation programme on the DCD status of 7- to 8-year-old children.

Data Collection Procedure

Ethical approval for the study was granted by the ethics committee (nr. 06M04) of the North-West University, Potchefstroom Campus, as well as the North West Department of Education. An appointment was arranged with the respective school principals, during which the aim and protocol of the study were explained to them. Written informed consent was obtained from the parents/legal guardians for each learner, before he/she was allowed to take part in the research. A discussion was held with the learners to explain the aim and protocol of the study, and they had to give ascent to participate in this study. These learners were evaluated with regard to their DCD status with the MABC and their visual deviations with the *Sensory Input Screening Measuring Instrument and QNST-II*.

The data collection occurred at the beginning of 2007, after which the intervention program (visual therapy) started. The 32 learners, who participated in the study, were then randomly divided into two groups. The intervention group (n=16) received the visual therapy for 18 individual sessions, while the control group (n=16) did not receive any intervention program. The parents/legal guardians of the learners were asked not to let their children participate in any other form of visual- or motor therapy while they were part of this study. After the 18 individual sessions, the two groups were re-tested (PoT) with the MABC to analyse the effect of the visual therapy on the learners' performance of the motor tasks. During the post-test the researchers conducting the MABC did not know which learners were assigned to which group.

Data analysis

The "Statistica for Windows 2015" computer programme package was utilized for the data processing (StatSoft, 2015). Data were first analysed for description purposes by means of means (M), standard deviations (SD) and minimum and maximum values. Secondly, an independent *T*-test and a Mann-Whitney U Test were applied to determine the pre- and post-testing differences with regard to the intervention programme between the two groups. A *p*-value of less or equivalent to 0.05 was accepted as significant. Furthermore, use was made of a Two-way frequency table to compare the DCD classifications during the PrT and PoT of the intervention and the control groups. The Pearson Chi-square served to indicate the significance of the results and the accepted level of statistical significance was set at $p \leq 0.05$. The strength of the correlations are represented by the phi-coefficient with $w>0.1$ indicating a small effect, $w>0.3$ a medium effect and $w>0.5$ a large effect (Steyn, 2002). Effect sizes (ES) were calculated by subtracting the means (M) divided by the largest standard deviation (SD), to determine the practical significance of the results. For the interpretation of practical significance, the following guidelines set by Cohen (1988) were used, namely, $d \sim 0.2$ indicates a small effect, $d \sim 0.5$ indicates a medium effect, and $d \sim 0.8$ indicates a large effect.

Results

Table 1 displays the descriptive information of the subjects in the intervention– and control group. Independent *T*-testing was firstly conducted to determine any significant differences between the intervention and control group before and after the visual therapy, and secondly a Mann-Whitney U test was also conducted to see if any differences in the results occurred (see Table 2).

Table 1: Characteristics of the two groups according to gender, race, age, and DCD classification

Variables	**Intervention Group (n=16)**			**Control Group (n=16)**		
	Boys	**Girls**	**Total**	**Boys**	**Girls**	**Total**
White	5	2	7	5	1	6
Black	4	4	8	5	4	9
Mixed ancestors	1	0	1	0	1	1
Total	10	6	16	10	6	16
Mean age in months (M)	95.90	95.83	95.87	95.10	96.00	95.55
Standard deviation (SD)	3.07	4.07	3.34	2.51	5.66	3.83
Possible risk for Moderate DCD	0	1	1	1	0	1
Possible Risk for severe DCD	10	5	15	9	6	15
Total	10	6	16	10	6	16

In the MABC test, a higher value is indicative of poorer performance, Table 2 indicates no statistical significant differences between the two groups with regard to the MABC-total (p=0.323), ball skills total (p=0.616), and static and dynamic balance skill total (p=0.669) before the start of the intervention program. Statistical and practical significance did however occur between the intervention and control group with regard to the manual dexterity skill total (p=0.047 and d=0.73), with the control group showing a lower mean value (20.31 vs. 22.09) during the Pre-Test.

Table 2: Differences between the intervention- and control group during PrT and PoT with regard to the MABC total and the sub-sections

	Intervention Group (n=16)		Control Group (n=16)		Significance of difference				
Variables	M	SD	M	SD	t	df	p	Mann-Whitney p	d
Pre Test (PrT)									
MABC total	22.09	5.54	20.31	4.69	0.98	30	0.334	0.323	0.32
MD total	9.53	2.57	7.66	2.51	2.09	30	0.045*	0.047*	0.73#
Ball skills total	5.25	2.68	5.72	2.75	-0.49	30	0.628	0.616	0.17
Balance total	7.28	3.27	6.94	2.51	0.33	30	0.741	0.669	0.10

Post-Test (PoT)									
MABC total	3.78	1.71	19.53	4.45	13.22	30	<0.001*	<0.001*	3.54#
MD total	1.94	1.09	6.41	3.31	5.13	30	<0.001*	<0.001*	1.35#
Ball skills total	0.69	1.08	5.41	1.45	10.44	30	<0.001*	<0.001*	3.26#
Balance total	1.09	0.99	7.47	2.32	10.11	30	<0.001*	<0.001*	2.75#

M – Mean; SD – standard deviation; df – degrees of freedom; n – number of learners; MD – Manual Dexterity; * Statistical significance for Independent *T*-test and Mann-Whitney U test at *p*-Value – 0.05. # Practical significance at d-Value – 0.8.

With regards to the MABC-total ($p \leq 0.001$ and $d=0.78$), manual dexterity total ($p \leq 0.001$ and $d=0.82$), ball skills total ($p \leq 0.001$ and $d=3.26$), balance skills total ($p \leq 0.001$ and $d=2.75$), the intervention group performed statistically and practically significantly better than the control group during PoT, after receiving the visual therapy.

Figure 1 indicates the performance of the individual learners in the different groups. Only the MABC Total score will be given because the trend is exactly the same in all the sub-sections of the MABC. This figure gives a clear indication of the improvement after the visual stimulation program was received by the intervention group.

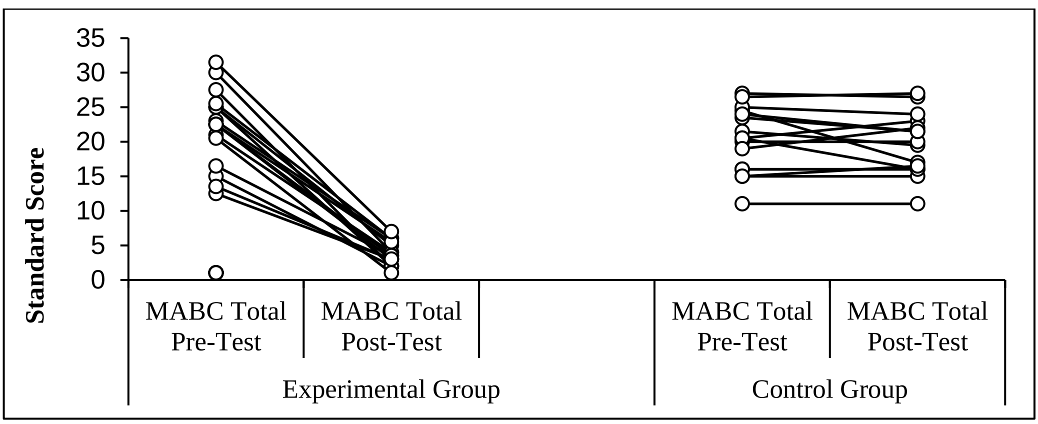

Figure 1: Differences between the intervention- and control group during Pre-Test and Post-Test with regard to the MABC total

Discussion

The purpose of this study was to determine the effect of visual therapy on the DCD status on 7- to 8-year old children. The results showed that the mean scores of the intervention group's MABC-total (22.09 to 3.78), manual dexterity total (9.53 to 1.94), ball skills total (5.25 to 0.69) and static and dynamic balance skills total (7.28 to 1.09) were significantly reduced after completion of the visual therapy. Furthermore it was evident that all 16 of the subjects in this group that were classified with risk for moderate (n = 1) and/or risk for severe (n = 15) DCD before the start of the intervention, moved to the normal category with regards to the MABC-total, manual dexterity total and the balance skills total. When performance of the individual subjects improvements were analysed directly after the completion of the intervention, there were two subjects that moved from the risk for severe DCD category (0.5) to the risk for moderate DCD category (3.5 and 2.5) with regard to the ball skills total. Only one similar study could be found in the literature to compare the results, which was conducted by Hurst et al. (2006) on an 8-year old child with dyspraxia (also known as DCD). These researchers achieved similar results after an eight month period where the ocular motor control (accommodation, fixation, visual pursuit and convergence), motor skills (co-ordination, vestibular function, balance, spatial orientation) and academic skills (reading, spelling and attention span) of this child were improved.

This finding further agrees with those of other intervention studies on DCD children, which showed that intervention, even if not focusing on visual therapy, has a positive influence on the DCD status of children (Smits-Engelsman et al., 2003; Peens & Pienaar, 2007; Kirby et al., 2008; Missiuna et al., 2008; Blank et al., 2012; Schoemaker et al., 2013). Some South African studies that included some basic visual exercises in there interventions, also reported positive results after the completion of the intervention (Pienaar, 1993; Peens & Pienaar, 2007; Pienaar & Ernst, 2007).

Compared to the control group, all of the children in the intervention group showed improvement in the MABC-total and the sub-sections after the completion of the visual therapy. A possible reason for the improvement in the motor skills of these learners could be the fact that their ocular motor control improved because of the visual therapy. The effect of visual therapy on the ocular motor control of learners has been confirmed in varies studies (Adler, 2002; Helveston, 2005; Aziz et al., 2006; Brautaset et al., 2008; Barrett, 2009; Williams, 2009; Shin et al., 2011; Coetzee & Pienaar, 2013; Whitecross, 2013). According to various researchers the visual information received by the eyes and visual processing in the brain, plays an important role during the planning and execution of motor skills (Von Hofsten, 2002; van Waelvelde et al., 2004; Reimer et al., 2008; Reimer et al., 2011; Botha, 2013; Ferguson et al., 2015). Furthermore, it has been reported that the ocular motor control system plays an essential role during the performance of visually guided tasks (Von Hofsten, 2002; Barrett, 2009; Reimer et al., 2011; Rafique & Northway, 2015; Palomo-Nieto et al., 2015) which includes gross motor- and perceptual skills such as balance, spatial orientation, body awareness and co-ordination (hand-eye, foot-eye, hand-foot-eye co-ordination) (Langaas et al., 1998; Bouchard & Tetreault, 2000; Orfield et al., 2001; Helveston, 2005; Shin et al., 2011; Robert et al., 2014; Pienaar, 2016).

Because of the small sample size, certain limitations need to be taken into account. Although the results of study are significant and clear, study results cannot be generalised. A control group without problems were not utilized. Subsequently, recommendations for further studies are that more in-depth research should be done to substantiate the effect of visual therapy on the DCD status children in all the different age groups.

Conclusions

The findings of this present study generated keen knowledge regarding the value of a visual therapy for children of 7- to 8 years of age diagnosed with DCD, and especially regarding the sustainability of the effects of such intervention. It was clear that the visual therapy had an immediate on all the children that participated in the intervention. The findings also provided new knowledge concerning the need for new intervention programmes, such as visual therapy, to improve the DCD status of children with ocular motor control deviations.
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