'The effects of an eight week grouped exercise programme on gross motor proficiency in children with minimal motor dysfunction.'

Jackie Kolesky (BSc. Physio)

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Study Supervisor:

Dr M Unger (PhD. Physio)

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and I have not previously submitted it, in its entirety or in part, at any university for a degree.

Signed: ……………………………

Date: March 2017

DECLARATION

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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ABSTRACT

Background: During typical development of a child, experience and maturation both influence the development of neuromuscular and musculoskeletal systems, which enable children to explore their environment and develop and refine their motor skills. These skills develop in such a way, that when a child is ready to begin formal schooling, they have built up a repertoire of movement skills that, it is hoped, will be sufficient to function effectively in the classroom, on the playground, and at home. The reality is however, that some children do not arrive at school with the movement skills necessary for coping with the demands of a school environment. Most recently this group of children, given specific criteria, are now classified as having Developmental Coordination Disorder (DCD) according to the Diagnostic and Statistical Manual of Mental Disorders (4th edition) (DSM-IV). Scarce-skilled staff shortages has limited individual therapy and these children are often treated in groups, despite limited proven efficacy. This study aims to validate the current practice of group therapy in special schools by investigating whether group exercise physiotherapy does improve the gross motor function of children with minimal motor dysfunction/DCD aged four to fourteen years old.

Methods: The study took place in a special school in the Eastern Cape that caters for learners with average intellectual ability but present with barriers to learning. Thirty-seven children were assessed at pre and post intervention on the Bruininks-Oseretsky Test of Motor Proficiency (BOTM-P) as well as the Beery Test for visual-motor integration by a blinded research assistant and occupational therapist respectively. They were randomly allocated to either a control (N=19) or an intervention group (N=18). The intervention group was then further subdivided into groups of three to four per group to attend group exercise sessions of 30 minutes three times per week. Group exercises were aimed at improving hand-eye coordination, ball skills and balance by incorporating aerobic exercises and strengthening exercises.

Results: There was a significant increase (p=.004) in the total scores tested by the experimental group on the BOTM-P after the eight week intervention. Global motor proficiency skills (gross motor, response speed, upper limb co-ordination, visual-motor control and upper limb speed and dexterity) improved clinically, but not significantly (p=0.14). Beery scores showed clinical improvement, but were not statistically significant.

Conclusions: The results of this study support the hypothesis that an eight week group exercise program can improve the gross motor skills of children with DCD. It would seem that implementing such an intervention is a viable option, especially where resources limit the availability of one to one therapy.

OPSOMMING

Agtergrond: Kinders wat 'n gebrek aan motoriese koördinasie het om ouderdoms verwante take te verrig, gegewe dat hulle normale intellektuele vermoëns het en die afwesigheid van ander neorologiese abnormaliteite, word geklassifiseer as "Developmental Coordination Disorder" (DCD) volgens die DSM IV. Beperkte professionele menslike hulpbronne voorkom individele terapie en hierdie kinders word gewoonlik behandel in grofmotoriese groepe, ongeag dat daar min bewyse is dat dit 'n effektiewe behandelings metode is. Die doel van hierdie studie is om vas te stel of 'n fisioterapie groepsoefenprogram 'n effektiewe behandelingsvorm is om die grofmotoriese vaardighede in vier tot viertienjarige skool kinders, met 'n diagnose van DCD, verbeter.

Metodes: Sewe-en-dertig kinders was geassesseer met die "Bruininks-Oseretsky Test of Motor Proficiency (BOTM-P)" en die "Beery Test for visual-motor integration" deur 'n geblinde navorsingsassistent. Hulle is in twee groepe gedeel, 'n kontrole groep wat nie intervensie gekry het nie (N=18) en 'n eksperimentele groep (N=19) deur eenvoudige ewekansige toewysing. Die eksperimentele groep was verder onderverdeel in groepe van drie tot vier om groepsoefeningsessies by te woon drie keer 'n week vir 30 minute. Die doel van die groepsoefeninge was om die volgende areas te verbeter: handvaardigheid, balvaardigheid en balans deur die inkorporasie van balansaktiwiteite, spierversterkingsoefeninge en koördinasie oefeninge. Die deelnemers was weer geassesseer met die BOT-MP en 'Beery Test' na die agt weke lange intervensie program.

Resultate: Daar was 'n beduidende toename (p=.004) in die algehele telling deur die eksperimentele groep op die BOT-MP na die agt weke deelname. Globale motor vaardigheide (grof motories, reaksie spoed, boonste ledemaat koordinasie, visuele-motoriese beheer en boonste ledemaat spoed en behendigheid) het klienies verbeter, maar was nie statisties beduidende (p=0.14). Beery tellings het klinies verbeter, maar was nie statisties beduidende.

Gevolgtrekking: Die resultate van hierdie studie ondersteun die hipotese dat 'n doelgerigte groepsoefeningsprogram wel die grofmotoriese vaardighede van kinders met 'n diagnose van DCD verbeter. Fisioterapeute kan 'n groepsofeningsprogram met vertroue implementeer waar 'n tekort aan menslike hulpbronne een tot een terapie beperk.

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Chapter 1: Introduction

1.1 SETTING THE CONTEXT FOR THE STUDY

During typical development of a child, experience and maturation both influence the development of neuromuscular and musculoskeletal systems. These systems enable children to explore their environment and develop and refine their motor skills. The skills develop in such a way, that when a child is ready to begin formal schooling, they have built up a repertoire of movement skills that, it is hoped, will be sufficient to function effectively in the classroom, on the playground and at home.

The reality is however, that some children do not arrive at school with the movement skills necessary for coping with the demands of a school environment. These children, given specific criteria, are classified as having Developmental Coordination Disorder (DCD) according to the Diagnostic and Statistical Manual of Mental Disorders (4th edition) (DSM-IV) (Pienaar, Barhorst, & Twisk, 2014).

The primary researcher for the current study is employed in a state-owned school for learners with special education needs (LSEN) in the Eastern Cape. All learners are referred to the school via the local district office of Education Support Services. The main entrance criteria for admission is that the learner must be of average intelligence, despite any physical barrier to learning, as a mainstream curriculum is followed from grades R (reception or pre-school) to 12. Once placed in the school, each learner undergoes testing by the various disciplines, namely physiotherapy, occupational therapy, speech-and language therapy, audiology, psychology and remedial therapy. The learners are categorized as specific learning disabled, currently 70%, cerebral palsy 7%, physically disabled 7%, hearing impaired 2%, autistic spectrum disorder 7% and multi-disabled 6%.

The approach to physiotherapy in our special school is that treatment is focussed on children with the more severe physical disabilities and with medical conditions such as cystic fibrosis. This is also true for schools catering for children with special needs (LSEN) across South Africa (Salie, Statham & Unger 2009). These learners needs take priority and children with minimal motor dysfunctions are treated in groups due to time constraints. Despite therapist to learner ratios remaining high, we are still morally obliged to provide quality intervention for all learners presenting with motor dysfunctions, especially when there is increasing evidence that there is a link between better motor skills and improved academic performance (Haapala, 2013; Pienaar et al., 2014).

1.2 BACKGROUND

In 2001 the South African Ministry of Education released a landmark policy known as ***White Paper 6: Special needs education in building an inclusive education and training system*** (Department of Basic Education, 2001). The policy aimed itself at transforming mainstream and special schools into inclusive schools, known as full-service schools. The policy also promotes the rights of parents, learners and educators within a systemic framework. This was designed to reduce barriers to learning within all levels of education and training. The presiding Minister of Education, Professor Kader Asmal, introduced the paper by outlining that government aimed to incrementally make special schools part of the district support services where they can become a resource for all schools. He highlighted government's determination to implement the policy of inclusion by starting with 30 full-service school and college models and expanding up to 500 schools (DoBE, 2001). However, specific contextual factors as well as a lack of educator will to achieve this, has resulted in the situation remaining largely unchanged (Waghid & Engelbrecht, 2002). In 2016, the demand for specialised education in South Africa remains high. The University of North Carolina recently sent an education professor, Professor David Test, to assist with the call to address shortcomings in the South African specialised education system. This comes as part of a larger plan to overhaul South Africa's school system and curb the current high dropout rates. The professor leads a study team that includes experts from the University of Kansas, University of Connecticut and U.S. Department of Education (UNC, 2016).

Physiotherapists working in the public sector in South Africa, for either the Department of Health (DoH) or Education (DoE), can become overwhelmed by the patient load in these notoriously under-resourced facilities (Padarath, Ntuli & Berthiaume, 2003). In particular, schools for learners with special education needs (LSEN) are under tremendous pressure as the number of children enrolled in these schools are increasing while the posts for therapists are remaining the same or even decreasing (Hay, 2012). Special schools are currently being used as resource centres in the form of district–based support services. The therapists in these schools are now not only assessing and managing the learners placed in their schools, but also assess learners from the surrounding community at the request of Education Support Services to assist them with appropriate placement of the learners (Hay, 2012).

Many of the learners in these schools are not physically disabled but on assessment often lack the motor coordination to perform specific tasks (Salie et al., 2009). Some children have Developmental Coordination Disorder (DCD) (American Psychiatric Association, 2000), others Attention Deficit Disorder (ADD) - with or without hyperactivity (ADHD) (McLeod, Langevin, Goodyear & Dewey, 2014) and many children remain undiagnosed (Fliers, Franke, Lambregts-Rommelse, Altink, Buschgens, Nijhuis-Van der Sanden, Sergeant, Faraone & Buitelaar, 2010).

In South Africa we also have a high prevalence of lifestyle conditions including foetal alcohol syndrome (FAS) and Human Immunodeficiency virus (HIV). Children with these conditions have also been shown to present with motor dysfunction (Banks, Zuurmond, Ferrand, & Kuper, 2015; Blackburn & Whitehurst, 2010).

1.3 DEVELOPMENTAL COORDINATION DISORDER

Roughly 40% of children diagnosed with DCD in early childhood will continue to have the condition ten years later (Losse, Henderson, Elliman, Hall, Knight & Jongmans, 1991; Smits-Engelsman, Blank, Van der Kaay, Mosterd-Van der Meijs, Vlugt-Van den Brand, Polatajko & Wilson, 2012). It is not a childhood disorder that one outgrows and research indicates that these children show higher rates of social difficulties, low self-esteem and associated behavioural problems. In particular, those with combined attention deficit disorder (ADHD) and DCD display poorer outcomes in terms of academic achievement and psychosocial adjustment when assessed in early adulthood (Smits-Engelsman et al., 2012). This is supported by McLeod et al. (2014) who found that common neurophysiological substrates underlie both attention and motor problems**.** This stems from neuroimaging research which has described that children with DCD as well as those with ADD/ADHD both exhibit disruptions in motor circuitry. This possibly explains the frequent rate of co- occurrence of DCD and ADD/ADHD (McLeod et al., 2014).

Given the estimated prevalence of one in every ten children affected by motor dysfunction, and/or DCD (Gibbs, Appleton & Appleton, 2007), there has been a lot written about not just effectivity of interventions, but also approaches to interventions, allowing for the increasing numbers to receive treatment (Smits-Engelsman et al., 2012). One approach to address the physiotherapy-to-learner ratio is to offer therapy in group format. While there is good evidence for individual therapy for these learners (Hillier, 2007), the evidence for group intervention is also growing.

A systematic review of 20 studies published between 1996 and 2011 investigating the effects of interventions in children with minimal motor dysfunction concluded that there is good evidence for group-based intervention in this population (Smits-Engelsman et al., 2012). The review showed that any exercise-based intervention – whether task-orientated, traditional physiotherapy and occupational therapy, or process-orientated therapy - is better than chemical supplementation alone. The results also showed that task-orientated and traditional motor-training based therapies (group or individual) had strong treatment effects while the evidence for process-orientated intervention is weak.

Several studies support group therapy for improving motor functioning in pre-schoolers up to 11 years old (Bardid, Deconinck, Descamps, Verhoeven, de Pooter, Lenoir & d'Hondt, 2013; Peens. Pienaar & Nienaber, 2007; Peters & Wright, 1999; Salie et al., 2009). Bardid et al. (2013) more recently demonstrated that pre-school children with motor problems improved following a ten week bi-weekly 60 minute group session exercise programme run by teachers. Peters and Wright (1999) carried out a motor skill intervention in learners seven to eight years old. The intervention was led by a physiotherapist and a teacher. The intervention was prescribed as once weekly for ten weeks. The sessions were all an hour long. The intervention showed significantly improved motor scores (Peters & Wright, 1999). Salie et al. (2009) investigated the effects of a group exercise programme, run by a physiotherapist, in learners aged six to ten years old. The programme ran over eight weeks, three sessions per week of 30-45 minutes each. The study also concluded that a group-based exercise intervention programme is effective for improving motor proficiency in children with motor dysfunction**.** Another intervention devised by a biokineticist targeted learners seven to nine years old. The learners received bi-weekly 30 minute sessions for a period of eight weeks. The motor intervention group greatly improved their scores (Peens et al., 2007).

The evidence however for many of the above studies remains scant. Small sample sizes (Bardid et al., 2013; Peters & Wright, 1999), and lack of a control group (Peters & Wright, 1999) have weak internal validity and results are difficult to generalise to the wider school going population. In the study by Peens et al. (2007) the researcher was responsible for all the testing and intervention, which potentially threatens the objectivity of the results.

1.4 MOTOR SKILLS AND ACADEMIC PERFORMANCE

As has been mentioned before, there is increasing evidence that there is a link between better motor skills and improved academic performance (Haapala, 2013; Pienaar, Barhorst, & Twisk, 2014). The bridge between motor skills and better classroom functioning can be interpreted as the impact a child’s motor skill and coordination has on their visual-motor integration (Goodwin, 2015). Visual-motor integration (VMI) has been defined as the degree to which visual perception and finger-hand movements are coordinated (Beery & Beery, 2006). VMI is an integral part of a child’s development as it is associated with self-care as well as education-related activities such as hand writing, reading and mathematics (Lim, Tan PC, Koh C, Koh E, Guo, Yusoff, See & Tan T, 2014). A meta-analysis investigating the relationship between visual perceptual skills and reading achievement was carried out by Dr Kavale in 2001. A total of 161 studies were analysed. The results showed that visual perceptual skills were an important correlate in reading achievement

(Kavale, 2001). It is postulated that improved motor and visual motor performance can improve classroom functioning in learners with minimal motor dysfunction.

1.5 STATEMENT OF THE PROBLEM

There are too few physiotherapists employed at schools for LSEN to manage the large group of learners that present with motor dysfunction with individual treatment. Theses learners are being treated in groups at our school, like many around the country, to accommodate all children. As is often the case in developing countries, we need to develop strategies that benefit as many learners as possible as cost-effectively as possible. Although there is evidence supporting group intervention for children with motor problems, there is still a lack of knowledge informing best practice guidelines.

The aim of this study was therefore to validate the use of group therapy within our South African school context. This was achieved by investigating the effect of an eight-week group-based intervention programme on gross motor performance and visual motor integration in learners attending a school for LSEN. The intervention was informed by the literature and the researcher's eleven years of clinical experience. A secondary objective was to determine whether the intervention would also impact visual-motor integration. The latter is a first attempt at investigating whether group intervention can affect scholastic performance as well.

In a group of learners attending a school for LSEN and who present with minimal motor dysfunction as determined by the Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP), the specific objectives of the study were thus to:

1. determine the effect of an eight-week group exercise intervention programme on the gross motor proficiency as determined by the BOT-MP
2. determine the effect of the intervention on visual motor integration as determined by the Beery Test
3. describe the relationship between demographic variables (gender, age, diagnoses, medication use) and motor outcome following participation in a group based intervention

Chapter 2: Literature Review

2.1 Introduction

When investigating a group of children with a specific dysfunction, a thorough knowledge base of both the dysfunction and the intervention possibilities is crucial. This chapter will thus elaborate on both the definition and clinical presentation of minimal motor dysfunction, as well as give more background on how the term DCD originated. The prevalence and aetiology is also described. The databases PubMed, Cinahl, Ebscohost, Google Scholar/Scopus and Cochrane were searched, using the main keywords 'developmental coordination disorder', 'motor dysfunction', 'group intervention' and 'physiotherapy' and 'special schools'. It is evident that researchers are trying to develop a better understanding of the development of motor function. There is also much description of the impact motor dysfunction has on the lives of these children. The latter half of this chapter will deal with traditionally prescribed intervention strategies, followed by further motivation for the current research.

2.2 Minimal motor dysfunction

2.2.1 Definition of minimal motor dysfunction

Children lacking the motor coordination to perform the tasks that typically should have been acquired at their age are increasingly being recognised. Over the decades there has been a wide variety of terminology used to describe these children:

1. 'Clumsy child' (Henderson & Henderson, 2003)
2. Motor dyspraxia (Gibbs, Appleton and Appleton, 2007)
3. Motor problems (Fliers et al., 2010; Bardid et al., 2013)
4. Minimal brain damage (Schellekens et al.,1983)

There are many conditions associated with minimal motor dysfunction. The largest group best described in the literature are children with DCD. Other diagnoses that also have associated minimal motor dysfunction include foetal alcohol syndrome (FAS) (Blackburn & Whitehurst, 2010) and Human Immunodeficiency Virus (HIV) (Banks et al., 2015).

The diagnosis of DCD is made using three criteria. Firstly, motor proficiency is significantly below expected levels for the child's age and appropriate opportunity for skill acquisition. Secondly, that the disturbance in criteria 1 interferes with activities of daily living (ADL) or academic achievement. Finally, that the motor impairment cannot solely be explained by mental retardation as well as the absence of any neurological or psychosocial disorders (Blank, 2012; Zwicker et al., 2012; Salie et al., 2009). This is according to the Diagnostic and Statistical Manual of Mental Disorders (4^{th} edition) (DSM-IV) (American Psychiatric Association, 2000).

2.2.2 Prevalence

DCD like many of the conditions mentioned above associated with minimal motor dysfunction, is often referred to as a 'hidden problem' and not always correctly diagnosed. The figures for DCD estimate a prevalence of 10% among the general paediatric population (Gibbs, Appleton & Appleton, 2007), while six -13 % has generally been accepted as the most likely (Missiuna & al, 2011). It is more common in boys than girls, with boys being up to four times more likely to present with the disorder (Zwicker et al 2013).

Children born prematurely (<37 weeks gestational age) and those with very low birth weights (VLBW: <1250g) have a significantly increased risk of demonstrating DCD (Gibbs, Appleton and Appleton, 2007; Zwicker et al., 2013). Zwicker et al (2013) examined a cohort of 157 children aged four to five years old who were seen at the British Columbia's Women's Hospital between 2005 and 2009. The children were all born with VLBW. They were examined using the Movement Assessment Battery for Children (M-ABC), an assessment tool commonly used to identify children with DCD. Results show that 42% of the cohort had DCD, making this condition very prevalent amongst prematurely born infants. The researchers also concluded that boys are significantly more affected by DCD (42/79; 53%) than girls (24/78; 31%) (Zwicker et al, 2013).

2.2.3 Diagnosis of motor dysfunction in children

There is some debate in the literature regarding the validity of outcome measures for identifying motor problems in the broader paediatric population. It seems that the Movement Assessment Battery for Children (M-ABC) is well-used. However, the M-ABC is not the only norm-referenced tool in use. The Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP) is also a standardized, norm-referenced measure used by Occupational Therapists, Physiotherapists and researchers to support diagnoses of motor impairment (Bruininks, 1978).

The European Academy for Childhood Disability (EACD) published a comprehensive review in 2012 entitled *Recommendations on the definition, diagnosis and intervention of developmental coordination disorder.* Although the recommendations in this article are based on the German-Swiss guidelines, these were approved at two consensus conferences where various leading medical and therapeutic societies were represented (Blank, 2012). The review states that the use of questionnaires (e.g. Developmental Coordination Disorder Questionnaire (DCDQ), Movement Assessment Battery for Children, 2nd version (M-ABC 2) checklist) is not recommended for population-based screening for DCD. This review recommends that clinical examination should be comprehensive and include the following:

- neuromotor status (exclude other movement disorders/neurological dysfunctions);
- medical status (e.g. obesity, hypothyreosis, genetic syndromes, etc.);
- sensory status (e.g. vision, vestibular function);
- emotional and behavioural status (e.g. attention, autistic behaviour, self-esteem);
- cognitive function should there be a history of learning difficulties at school

The assessment of intellectual functioning is to ascertain whether the child has a specific learning disability or has a global developmental delay. A specific learning disability is diagnosed when a child has average intelligence, but due to delays in specific underlying skills, is not performing to their potential in the classroom. A global developmental delay is defined as a disturbance across a variety of developmental domains that is defined as a significant delay (meaning two or more standard deviations) lower than the mean on objective norm-referenced, age-appropriate testing in two or more developmental domains (Shevell, 2008). Typically, there is delay across all domains. In other words, the intellectual assessment is below average, speech and language skills are below average as well as below average fine and gross motor skills (Shevell, 2008). A diagnosis of global developmental delay is therefore an excluding factor for DCD classification.

2.2.4 Co-morbidity in DCD

The recommendations in the Blank (2012) study are also very clear regarding careful history taking due to co-morbidity of DCD. Primarily these include attention deficit hyperactivity disorder (ADHD), autistic spectrum disorder (ASD) and specific learning disorder (SLD) (Blank, 2012). Kooistra et al (2005) investigated whether the likelihood of motor impairment in children with ADHD increases with the presence of other disorders, and whether the co-occurring diagnoses of reading disability (RD) and oppositional defiant disorder (ODD) account for the motor deficits seen in ADHD. A total of 291 children (218 boys, 73 girls) participated. Six groups of children were compared: ADHD only (n = 29); RD only (n = 63); ADHD and RD (n = 47); ADHD and ODD (n = 19); ADHD, RD, and ODD (n = 21); and typically developing control children (n = 112). Motor skills were assessed with the BOTMP and the Beery Test was used to establish levels of Visual-Motor Integration. The researchers found that the motor skills of the ADHD-only group did not differ from the typically developing control group. Secondly, that motor impairment in ADHD increased as a function of co-occurring disorders, suggesting that children with ADHD and motor dysfunction present with increasing co-morbidities. It is however unclear whether the co-morbidities are the casual mechanism for the motor dysfunction seen (Kooistra et al, 2005).

According to an article published in 2014, Canadian researchers conducted a study using seven children with DCD, 21 children with ADHD, 18 with DCD and ADHD and 23 controls. Resting-state connectivity of the primary cortex was compared between the control group and each diagnosed group. The researchers found that common neurophysiological substrates underlie both attention and motor problems. The results also indicated that learners with both diagnoses appear to have unique alterations in functional connectivity between the primary motor cortex and sensory networks compared to children with either ADHD or DCD alone (McLeod, Langevin, Goodyear and Dewey, 2014). These findings suggest that co-occurrence of neurodevelopmental disorders may have a distinct effect on the motor circuitry of these children. This may explain the high level of co-occurrence. The study results also support the hypothesis that DCD is a disorder of motor- sensory processing. The evidence to support motor-sensory processing problems in children with ADHD/ADD only is inconclusive at this stage (McLeod et al., 2014).

Due to core symptoms of impulsivity and hyperactivity, children with ADHD tend to be the least popular in their classes. Added to this the burden of poor motoric skills, clear identification of co-morbid conditions is imperative to predict appropriate treatment options (Fliers et al., 2010). Smits-Engelsman et al. (2013) conducted a combined systematic review on the efficacy of interventions to improve motor performance in children with DCD. The results showed that the use of attention/concentration medication (e.g. Methylphenidate) had a positive effect on both behavioural ADHD symptoms as well fine motor performance (Smits-Engelsman et al., 2013).

McNab et al., (2001) described subtypes within the umbrella diagnosis of DCD. They used cluster analysis and described these subtypes as seen in Table 1.

Table 1 Subtypes within the DCD population

SUBTYPE	**CHARACTERISTICS**
Subtype 1	These children display better gross motor than fine motor abilities, although both skills were still below normal.
Subtype 2	These children display very good upper limb speed and dexterity, visual motor integration and visual perception skills but poor kinaesthetic ability and balance.
Subtype 3	This group included children with the greatest overall motor involvement accompanied by difficulty in both kinaesthetic and visual skills.
Subtype 4	These children performed well on kinaesthetic tasks but performed poorly on tasks requiring visual and dexterity skills.
Subtype 5	These children demonstrated poor performance on measurements of running speed and agility but performed well in visual perception tasks

Visser (2003) conducted a review of the research on subtypes and co-morbidities in order to highlight the existence of not only co-morbidities, but also the subtypes with the DCD population. The author advocates that that more studies are needed to further distinguish subtypes in terms of underlying deficits and to examine the prognosis of children with different subtypes of DCD (Visser, 2003).

2.2.5 Impairments, activity limitations and participation restrictions in children with minimal motor dysfunction

Muscle weakness (Kane & Bell, 2009), incoordination (Chang et al., 2012) and poor balance (Fong et al., 2016) have all been reported in children with minimal motor dysfunction in varying degrees. A case-control study was conducted in South Africa which aimed at determining whether deficits in motor coordination would influence the performance of learners with DCD on physical fitness tests (Ferguson et al., 2014). The control group of typically developing learners (TD) as well as the DCD group underwent various tests. The tests used measured isometric strength, functional strength, aerobic capacity and anaerobic muscle capacity. Functional strength tests requiring more isolated explosive movement of the upper limbs showed no difference. However, items requiring repetitive muscle activity as well as those requiring whole body explosive movement were all significantly different. The results of the tests suggested that poor physical fitness performance in children diagnosed with DCD could partly be as a result of poor timing and coordination of repetitive movements (Ferguson, Aertssen, Rameckers, Jelsma and Smits-Engelsman, 2014).

These impairments result in functional and activity limitations which are well described by Missiuna et al. (2011) and Campbell (2000), and include the following:

1. The child may be clumsy or awkward in his/her movements. He/she may bump into, spill, or knock things over.
2. The child may experience difficulty with gross motor skills (whole body), fine motor skills (using hands), or both.
3. The child may be delayed in developing certain motor skills such as riding a tricycle/bicycle, catching a ball, jumping rope, doing up buttons, and tying shoelaces.
4. The child may show a discrepancy between his/her motor abilities and his/her abilities in other areas. For example, intellectual and language skills may be quite strong while motor skills are delayed.
5. The child may have difficulty learning new motor skills. Once learned, certain motor skills may be performed quite well while others may continue to be performed poorly.

6. The child may have more difficulty with activities that require constant changes in his/her body position or when he/she must adapt to changes in the environment (e.g. tennis).
7. The child may have difficulty with activities that require the coordinated use of both sides of the body (e.g., cutting with scissors, stride jumps, swinging a bat, or handling a hockey stick).
8. The child may exhibit poor postural control and poor balance particularly in activities that require balance (e.g. stair climbing, standing while dressing).
9. The child may have difficulty with printing or handwriting.

Motor dysfunction may have a severe impact on the daily activities of a child's life, and is a strong predictor of a child's self-esteem and peer acceptance (Fliers et al., 2010). Difficulties with the motor aspect of riding a bicycle, being able to tie your own shoelaces and poor handwriting and sporting abilities, further reduce social participation and these children become even more disadvantaged (Fliers et al., 2010). The poor balance often reported in these children is a major concern because it predisposes children to falls, affects their motor skill development and participation in activities (Fliers et al., 2010).

2.3 Interventions for children with minimal motor dysfunction

There are many approaches for treating and/ or managing children with motor dysfunction. However, the majority of these approaches to intervention can be divided into two categories, with some combining both camps: (1) process or deficit-oriented approaches; and (2) approaches that teach specific functional skills.

The first group of approaches are labelled process or deficit approaches. The primary objective of these approaches is to remediate some underlying process deficit with intervention targeted at a neural structure, such as the cerebellum or, sensory processes e.g. vision or proprioception. The rationale of these approaches is to remediate the underlying process/skill and the subsequent benefit will be seen in a number of everyday tasks connected to this structure or process.

The second group of approaches are referred to as functional skill approaches and typically engage the teaching of activities of daily living. These approaches are not aimed at remediating any particular structural or process deficit but rather to work on teaching the activities of daily living that the child needs to be able to perform. In some interventions, these tasks are taught as specific skills; in others, within the context of a problem-solving exercise or by linking groups of activities to promote generalization (Sugden, 2007).

Physiotherapy or Occupational Therapy involves training individuals with DCD in the most important fundamental gross motor and fine motor skills (hopping, jumping, throwing, and catching; cutting, drawing, writing), and in the basic motor abilities that are believed to be prerequisite for other skills (e.g. trunk stability for certain fine-motor skills) (Smits-Engelsman et al., 2013). These approaches combine underlying process-oriented approaches with direct skill training; the underlying rationale is that motor skills are developed in a sort of hierarchical fashion. Basic abilities (such as postural control, in-hand manipulation, visual–perceptual skills) need to be consolidated as well as teaching complex motor skills (Smits-Engelsman et al., 2013). The modalities used in this approach range from strength training (Ferguson et al., 2014; McKay & Henschke, 2012), balance-targeted interventions (Fong et al, 2016) and aerobic exercise (Schott et al, 2007) to whole body vibration (WBV) (Cardinale & Wakeling, 2005; Saquetto et al., 2015).

2.3.1 Strength training

Strength training is a common component of physical fitness training in children. Strength training programmes may include resistance modalities such as elastic tubing or bands, weight machines, free weights or makes use of the child’s own body weight. Strength training has been shown to be beneficial to various aspects of health. These measurable health indices include cardiovascular fitness, body composition, bone mineral density, blood lipid profiles and mental health (American Academy of Pediatrics, 2007). There is evidence that strength training in children that are not athletic, e.g. children with cerebral palsy, also benefit with increased strength, overall function, self-esteem and mental well-being (American Academy of Pediatrics, 2007; Dahab & McCambridge, 2009).

A meta-analysis conducted by Dahab and McCambridge (2009) concluded that children can improve strength by 30% to 50% after just eight to twelve weeks of a well-designed strength training programme.

The primary concerns regarding strength training in children are safety and its effectiveness. Various well-respected health care professional bodies, including the American Academy of Pediatrics, agree that a supervised strength training programme that follows the recommended guidelines and precautions is safe and effective for children (Dahab & McCambridge, 2009).
The programme developed for the current study included activities where free weights and the learners own body weight were used to build up strength.

2.3.2 Plyometric exercise

Plyometric exercise, otherwise known as jump related activity, is defined as a group of specific exercises that begin with an eccentric phase with a rapid stretch of a muscle followed by a rapid shortening or concentric phase (Johnson, 2011). These exercises have shown that they can potentially enhance speed of movement in a child who has low motor competency. Research has shown that this approach to training in children is safe and effective if used with sound teaching guidelines (Konukman et al., 2008). Plyometric exercise has been shown to enhance a child's speed of movement, running speed, power production and jumping ability. (McKay & Henschke, 2012).

A systematic review (McKay & Henschke, 2012) conducted to evaluate the safety and efficacy of plyometric training in children with low motor proficiency included studies which described plyometric programmes which consisted of jumping, hopping, skipping, bounding and jumping over hurdles. Resistive exercises, footwork and sprint drills, sprints and throws, or strengthening and balance were additional elements included in some studies. Seven of the eight included studies found statistically significant effects for improving motor performance (McKay & Henschke, 2012). Research by Konukman et al (2008) recommended following specific guidelines when teaching children plyometric exercise. These include a proper warm up before any plyometric training. Plyometric training should be performed early in the session, before fatigue sets in. It was also recommended that plyometric training should not be performed after very high intensive training (Konukman et al., 2008).

2.3.3 Balance-targeted interventions

Inclusion of balance targeted interventions are recommended in all intervention strategies/programmes for children with minimal motor dysfunction (Fong, Cheng, Yam, MacFarlane, Guo, Tsang, Liu, & Chung, 2016). Many of the same authors concluded in another study that task-specific balance training improved the somatosensory function and balance performance in learners with DCD (Fong, Guo, Liu, Ki, Louie, Chung & MacFarlane, 2016). Task-specific training is a term that has evolved from the literature on movement science and motor skill learning. It is defined as training or therapy where the patient practices context-specific motor tasks and receive some form of feedback (Hubbard et al., 2009).

2.3.4 Aerobic interventions

Children with developmental coordination disorder have been shown to be less physically fit when compared to their typically developing (TD) peers (Farhat et al., 2015; Ortega et al., 2015). Physical fitness is comprised of a set of attributes that are health-related, skill-related or both (Committee on Sports Medicine & Fitness, 1994). Thus health-related physical fitness is defined as a multi-dimensional construct, including cardiopulmonary fitness, body composition, flexibility and muscular fitness (which includes muscle power and muscle endurance). Health-related fitness is thus a state characterized by the ability to perform vigorous activities of daily living (Li et al., 2011).

A study by Schott et al. (2007) examined 261 children between the ages of four and twelve. The physical fitness of children diagnosed with DCD was compared with that of their typically developing peers. The study concluded that there were significant differences in the physical fitness of the children with DCD compared to their peers. Not only did the DCD children demonstrate poor performance in the physical fitness test, but the researchers also noted a much higher demand on coordination, when compared to the TD children (Schott et al., 2007).

Li et al. (2011) investigated the concomitant changes in motor coordination and health-related physical fitness of children (with and without DCD) over a three-year period. The Movement Assessment Battery for Children (Movement ABC) test was used to evaluate motor coordination. The testing was done by an experienced paediatric physiotherapist. The health-related physical fitness testing included several core components: (1) body mass index (BMI), (2) sit and reach forward, (3) long jump, (4) sit-ups, and (5) 800-m run. Both tests were repeated once per year for three years. Twenty-five children, aged nine to eleven years old, with DCD and 25 TD children, matched by age and gender participated in this study. Overall, children with DCD were significantly less physically fit than their TD peers as they grew older, and there was an underlying correlation between motor coordination ability and physical fitness. The study also advocated that interventions for children with poor motor coordination and physical fitness, should be have an integrated approach which emphasizes the improvement in motor skills and pays more attention to both the training (conditioning) of health-related physical fitness and the overall enhancement and promotion of the active lifestyle for children with DCD (Li et al., 2011).

2.3.5 Coordination exercises

Coordination exercise has been defined as complex movements involving multiple degrees of freedom, as well as interaction with other body parts for goal-directed behaviours (Chang et al., 2012). These authors tested the effects of a coordination-centred exercise programme on kindergarten children comparing different intensities. The study showed that, regardless of intensity, the exercise intervention resulted in shorter reaction times and higher response accuracy (Chang et al., 2012).

2.3.6 Whole body vibration (WBV)

This therapeutic modality is a neuromuscular training method that uses oscillatory motion around an equilibrium point (Cardinale & Wakeling, 2005). Exercises are performed while standing on a vibrating platform. The relatively fast gains in in force-generating capacity have been attributed to the neural process. It is postulated that vibration training increases the sensitivity of the stretch receptors, which initiates muscle contractions (Rehn et al., 2006).

Although no studies could be found in which this mode of exercise was used in children with minimal motor dysfunction, a review by Saquetto et al (2015) recommended its use in children or persons with strength and motor/balance problems. WBV has been shown to be effective for improving strength and posture (Cardinale & Wakeling, 2005), gait and standing function in children with CP (Saquetto et al., 2015).

2.4 Differences between boys and girls

From the literature it is evident that boys and girls may respond differently to interventions aimed at improving motor performance. A study conducted in Belgium which investigated the efficacy of a ten-week fundamental motor skill programme for pre-schoolers found that girls did better than boys. This study highlighted the need for early motor skill intervention with a gender-specific approach (Bardid et al., 2013). The study used the Test of Gross Motor Development 2nd edition (TGMD-2) which is divided into locomotor and object control skills. The locomotor skills include displacement of the centre of gravity from one location to another and include galloping, hopping, leaping, horizontal jumping and sliding. The object control skills involve transport, interception, or projection of objects and include striking a stationary ball, stationary dribbling, catching, kicking, overhand throwing and underhand rolling.

Zask et al. (2012) undertook to investigate whether early childhood intervention for motor skill impairments would be sustained in a three-year follow-up. The researchers used the Test of Gross Motor Development 2nd edition (TGMD-2) to ascertain whether the intervention group maintained their higher score advantage in comparison to the control group (Zask et al., 2012). The TGMD-2 is a norm-referenced measure of common gross motor skills which assesses six locomotor skills (running, galloping, hopping, leaping, horizontal jumping, sliding) and six object control skills (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing, and underhand rolling).
Overall, the intervention group had higher scores than the control in terms of object control skills. In particular, it was clear that girls in the intervention group had retained their higher scores in object control better than those in the control group. The boys in the control group however had caught up to the boys in the intervention group. Thus it seems that boys who do not receive pre-school motor skill intervention may attain these skills through environmental opportunities provided by school, home and community life. Girls however require specific intervention as the study demonstrated that girls do not develop these skills organically (Zask et al., 2012).

The above study was based on the works of Okley and Booth (2004) where children in early elementary school were tested in terms of object control skills (catch, kick, throw and strike). The boys in the study performed better than the girls and the authors suggested that the reason for this is that girls are not provided with the same opportunities for developing these skills (Okley & Booth, 2004).

2.5 Dosage of intervention

Another confounder affecting decision making around choice of intervention and which most likely is the reason for the varied outcomes reported concerns the differences in dosage parameters. The following studies informed the selection of exercises included in the current study:

Dosage parameters for strength training

Strength training for typically developing children indicates that strength gains are the result of improved neural pathways and motor unit recruitment, as opposed to actual muscle hypertrophy (Menz, Hatten & Grant-Beuttler, 2013) and as such the recommendations for strength training in children with minimal motor dysfunction call for a high number of repetitions and low resistance. This approach provides the opportunity for blocked practice of isolated, simple joint movements, controlled force generation, and repeated motor planning, with appropriate stabilization at surrounding joints (Menz, Hatten & Grant-Beuttler, 2013).

Supervision

Different programs have been supervised by various persons and range from therapists –led/supervised to teacher and home-based supervised programs. Peters and Wright (1999) conducted an interdisciplinary (teacher and physiotherapist) study where children with motor dysfunction were exposed to a group programme. The programme was supervised by the teacher and the learners in the study, as tested on the MAB-C, improved their motor competence (Peters and Wright, 1999). This study gave encouraging indications that educators, supported and advised by a physiotherapist, are able to make a change in the motoric skills of children with DCD. This type of collaboration can offer an answer to the constant question of how can we help more children affected by minimal motor dysfunction?

In 2009 Salie et al. tested the efficacy of a self-designed group exercise programme for children with minimal motor dysfunction. The programme was devised and supervised by a physiotherapist using best experience principles as well as clinical experience. The learners showed significantly improved gross motor proficiency after the physiotherapist-led classes (Salie et al, 2009).

Another teacher led programme is described in Zask et al. (2012) who undertook to assess four year old children from 31 (18 intervention; 13 control) pre-schools in New South Wales, Australia in 2006. The children were then exposed to a gross motor programme. The programme consisted of two terms of ten sessions with each session repeated twice per week. Preschool staff received one day of training and were given a kit with program notes and 30 laminated cards for each of the games to run the programme. Although the programme did yield positive outcomes, the teacher-led programme did need to run over a protracted period (Zask et al., 2012).

A Biokineticist was the supervisor in a study conducted by Peens et al (2007) who ran a motor intervention/program for learners with DCD in the North West province of South Africa (Peens et al., 2007). Although a biokineticist is trained in exercise, a physiotherapist or occupational therapist involvement is also to identify any underlying or additional neurological problems that may need referral to a specialist.

Occupational therapists and physiotherapists are educated and trained in analysing and interpreting motor skill development (Missiuna, Rivard & Pollock, 2011). They are also skilled in determining the ability of a child to cope with the demands and activities of everyday life. For these reasons, both these professions are uniquely suited for making recommendations for the management of a child with motor dysfunction (Missiuna, Rivard & Pollock, 2011).

Frequency and duration

Frequency and duration also vary considerably between studies making it difficult to conclude optimal exposure in terms of these parameters. Pless & Carlson (2000) conducted a meta-analysis (which included all studies published 1979 to 1996) to determine whether there was any evidence to support motor skill intervention for children with DCD or equivalent conditions and reported that a frequency of at least three to five times per week is recommended to improve the motor skills of children with DCD (Pless & Carlson, 2000). Salie et al. (2009) led an intervention programme that ran over eight weeks with three sessions per week. Peters and Wright's program was carried out over ten weeks in the form of a weekly class lasting an hour (Peters and Wright, 1999). All studies reported significant improvement in motor performance after the intervention period.

Summary

Group exercise programmes supervised by a trained health care professional such as a physiotherapist, biokineticist or occupational therapist seem to be most effective for improving motor skills in children.

2.6 Motor performance and scholastic achievement

There seems to be increasing evidence that motor function and scholastic achievement are related. A review by Haapala (2013) found that better motor skills are related to more efficient cognitive functions including inhibitory control and working memory. The review also concluded that higher cardiorespiratory fitness and better motor skills are associated with better academic performance (Haapala, 2013).

Pienaar et al (2013) examined the relationship between academic performance and perceptual-motor skills in first grade South African learners. A total of 812 grade one learners in the North West Province (NW) of South Africa. The Beery-Buktenica Developmental Test of Visual-Motor Integration-4 (VMI) was used to assess visual-motor integration, visual perception and hand control while the Bruininks Oseretsky Test of Motor Proficiency, short form (BOT2-SF) was used to assess the overall motor proficiency. Academic performance in math, reading and writing was established with the Mastery of Basic Learning Areas Questionnaire. A strong relationship was established between academic performance and VMI, visual perception, hand control and motor proficiency with a significant relationship between a clustered academic performance score, visual-motor integration and visual perception (Pienaar, Barhorst, & Twisk, 2014).
Kadesjo and Gillberg (1999), two psychiatrists from Sweden, studied a group of seven year old children using individual examination as well as parent and teacher interviews. These children were followed up at ages eight, nine and ten. The doctors found that approximately half of the children with DCD had moderate to severe symptoms of ADD/ADHD. The study also described that a diagnosis of DCD at age seven, predicts DCD at age eight. They also found a restricted reading comprehension at age ten (Kadesjo & Gillberg, 1999).

The evidence is clearly pointing to the fact that besides decreased level of participation in social and recreational activities, there adverse academic implications if these children are left untreated (Hillier, 2007).

2.6.1 Physical fitness in school children

Chiodera et al (2008) gathered data from a programme run by professionally guided physical exercise teachers in primary school children before and after the academic year of training. Four thousand five hundred children (6–10 years) were enrolled in the Scandinavian study. The results demonstrated that the trained children had developed their perceptual motor skills and consequently could better process information regarding their place in space and time (Chiodera et al., 2008). According to Schott et al. (2007) and Ferguson et al. (2014), children with movement difficulties have low levels of aerobic fitness. Studies have also shown that the differences in fitness increased with increasing age between children with motor dysfunction and typically developing groups (Schott et al., 2007).

Cairney et al. (2006) explored the reasons for perceived inadequacy regarding performance in physical activity as aerobic fitness tests typically require minimal coordination skills. Children who feel they are inadequate are unlikely to persist at a task and may give up sooner on these tests of endurance. The study used a large community based sample of children ages nine through 14 (n=586), and examined whether differences in aerobic fitness (assessed by performance on a 20-m shuttle run test) between children who meet the criteria for DCD (n=44) and those who do not (n=542) is due to differences in perceived adequacy toward physical activity. The results showed that one-third of the effect of DCD on VO_2 (a measure of the maximum volume of oxygen that a subject can use), can be attributed to differences in perceived adequacy. These results suggest that at least part of the reason children perform less well on tests of aerobic endurance is because they don't have faith in themselves to be as adequate as other children at physically activity (Cairney et al., 2006).

2.7 Group vs. individual targeted exercise

Tidy's Physiotherapy (Porter, 2013) described that the competitive element of group exercise may increase a participant's performance. It is possible to present a variety of exercises which can be fun if properly organized. Participants may feel less isolated when interacting with others with similar problems, also providing social support. Group settings provides a good opportunity to educate and inform multiple participants about the condition.

Conversely, an inexperienced physiotherapist may find it difficult pitching the exercises at the correct level for all participants as well as monitoring all of the participants all the time (Porter, 2013). There may also be the temptation to include inappropriate individuals to save time and relieve overburdened staff.

The evidence for group therapy has been well-established. Besides the physical benefits to the learners, the psycho-social ramifications for the participating learners has been well described as a positive side effect of the programmes (Peters & Wright, 1999). Currently there are too few physiotherapists employed at schools for LSEN to manage the large group of learners that present with motor dysfunction with individual treatment. As is often the concern in developing countries, how do we benefit as many learners as we can as cost-effectively as we can? Group exercises classes, run by physiotherapists, as opposed to individual targeted therapy can provide a cost effective solution to school-based physiotherapy.

2.8 Standardized tests and outcome measures (OM)

The importance of movement can often be taken for granted as it is such a natural part of human life. In reality, movement is vital for a child's physical, cognitive and social development. The experience of movement supports the learning and development of fundamental movement skills. The foundations of these skills are developed early in a child's life and play a vital role in encouraging a physically active lifestyle. These fundamental movement skills can be examined with several assessment tools.

The type of test chosen will depend on the context in which the assessment is planned. Cools et al, (2009) summarised selected OMs (Table 2) to assist with decision making regarding selection of appropriate measures for assessment and identification of motor problems in children/general population.

Table 2 Motor Assessment Tools used in typically developing children

Motor Assessment tool	**Purpose**	**Assessment**	**Ages (year: month)**
PDMS	Motor development assessment and programming for young children with disabilities	In-depth assessment and training/remediation of gross and fine motor skills	0; 0-6:11
BOT-MP	Identification of deficits in individual with light to moderate motor coordination problems	Profile analysis to evaluate individual's strengths and weaknesses. Clinical validity studies on Asperger's disorder, DCD and mild to moderate cognitive impairment.	4:0-21; 0
M-ABC	Identify and describe motor impairments in daily life	Screening of motor difficulties. Level measurement, evaluation of treatment	4:0-12:0
TGMD-2	Identify children who are significantly behind their peers	Identify, plan and assess changes in relation to age or experience, assess changes after intervention or instruction	3:0-10:0

PDMS: Peabody Developmental Motor Scales
BOT-MP: Bruininks- Oseretsky Test of Motor Proficiency
M-ABC: Movement Assessment Battery for Children
TGMD-2: Test of Gross Motor Development-second edition

2.8.1 Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP)

The Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP) and its revised version the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) are tools to assess fine and gross movement skill development. They are used to identify individuals with mild to moderate motor coordination deficits. The items in every subtest become progressively more difficult. A short form of the BOT-2 can be used as a screening tool to achieve rapid and easy scoring reflecting overall motor proficiency. The BOT-2 Short Form comprises a subset of 14 items of the BOT-2 Complete Form and was constructed from data gathered in standardization (Bruininks & Bruininks, 2005). The Short Form features items from all subtests. A high correlation (~r = 0.80s) was found between the short and long form of the BOT-

2 (Cools et al, 2009). Motor skills are normed for ages four years five months up until fourteen years five months (Deitz et al, 2007). The BOT-MP is the most common measure used to assess children for minimal motor deficits or DCD in North America (Crawford et al, 2001) (Larkin & Rose, 2005) but has also been used extensively in South African studies (Pienaar, Barhorst, & Twisk, 2014).

In 2005, ten schools were randomly selected in Canada, as a part of a larger study, to validate the BOT-MP and the M-ABC in field-based settings. Three hundred and forty grade four learners underwent testing using the BOT-MP and the M-ABC. The tests were performed on the same day by blinded, trained non-clinicians. Results of the study led the researchers to recommend that The M-ABC was less useful in field-based settings when compared to the BOT-MP (Spironello et al, 2009). Cairney et al. undertook a study in 2009 to validate the BOT-MP-SF against the M-ABC and found good correlation when used to detect DCD in children (Cairney et al, 2009).

2.8.2 Peabody Developmental Motor Scales

This assessment tool identifies motor developmentally delayed and dysfunctional children from those that are typically developing. The PDMS-2 is a revision of the original test that was first published in 1983. It consists of six subtests, four involving gross motor skills and two for fine motor skills (Cools et al., 2009). Vanvuchelen et al. (2003) investigated the reliability of the PDMS, which used American normative data, on five-year old Flemish children. The study concluded that the PDMS was not reliable enough to discriminate between children with motor dysfunction and those that are typically developing. According to the authors, the test is consistent enough to conclude on a child's general fundamental motor skills status, however they recommend more thorough standardization of the test due to dependence on observer interpretation (Vanvuchelen et al., 2003).

2.8.3 Movement Assessment Battery for Children (M-ABC)

This test assesses the developmental status of a child's fundamental motor skills. The focus of the test is to detect delay or dysfunction in the movement development (Salie et al., 2009; Cools et al., 2009). The test is a revision of the Test of Motor Impairment (TOMI) and is based on the Oseretsky scales of motor capacity of children (Simons, 2004). Unlike the Bruininks-Oseretsky test, which measures the child's strengths and weaknesses over an extensive range of movement skills, the M-ABC is limited to movement skills in a specific age band (Cools et al., 2009).

2.8.4 Test of Gross Motor Development-second edition (TGMD)

This test measures gross motor performance based upon qualitative aspects of movement skill patterns. The test is aimed at identifying children that are significantly delayed when compared to their peers (Cools et al., 2009). The test is also used as the basis for developing intervention programmes to improve the motor skills of the assessed learners (Cools et al., 2009; Wong & Yin, 2010).

2.8.5 Beery Test of Visual-Motor Integration (VMI)

The Beery test is a norm-referenced measure which was developed and standardized in America. The test has been standardized on five occasions since 1960 in studies that have involved over 11 000 children (Lim et al., 2014). The test assesses the ability of children ages 4 to 18 years to reproduce a developmental sequence of 24 geometric forms. This test was developed to identify possible areas of difficulties that children may have in specific areas of visual-motor integration (VMI). VMI is defined as the degree to which visual-perception and finger-hand movements are co-ordinated (Pienaar, Barhorst, & Twisk, 2014). VMI is an integral part of a child's development as it is associated with self-care as well as education-related activities such as hand writing, reading and mathematics (Lim et al., 2014). A meta-analysis investigating the relationship between visual perceptual skills and reading achievement was carried out by Dr Kavale in 2001. A total of 161 studies were analysed. The results showed that visual perceptual skills were an important correlate in reading achievement (Kavale, 2001). It has been postulated that improved motor and visual motor performance can improve classroom functioning in learners with a minimal motor dysfunction.

2.9 Summary of the Literature

Currently there are too few physiotherapists employed at schools for LSEN to manage the large group of learners that present with motor dysfunction with individual treatment. As is often the concern in developing countries, how do we benefit as many learners as we can as cost-effectively as we can? From the literature review it is evident that group exercises classes, run by physiotherapists, as opposed to individual targeted therapy may provide a cost effective solution to school-based physiotherapy in the South African context.

2. 10 Research question

What is the effects of an eight-week group-based exercise programme on the motor function of children aged four to fourteen with minimal motor dysfunction? Will an improvement in motor function have an effect on the visual-motor integration skills of the children?

2.10.1 Objectives of the study

In a group of learners attending a school for LSEN and who present with minimal motor dysfunction as determined by the Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP), the specific objectives of the study were to:

1. determine the effect of an eight-week group exercise intervention programme on the gross motor proficiency as determined by the BOT-MP
2. determine the effect of the intervention on visual motor integration as determined by the Beery Test
3. explore relationships between demographic variables (gender, age, diagnoses and medication use) and motor performance outcome after participation in the intervention

Chapter 3: Methodology

This chapter will explain the methodology that was used in the study. A description of the study structure, study population and study sample including the inclusion and exclusion criteria is given. An explanation of the instrumentation and intervention programme follows. The statistical methods used and the ethical aspects considered throughout this study concludes this chapter.

3.1 Study Structure

The study has taken the form of a quasi-experimental design. Quasi-experimental research designs test causal hypotheses, much like experimental designs. In both experimental (i.e., randomized controlled trials or RCTs) and quasi-experimental designs, the programme or policy is viewed as an ‘intervention’ in which a treatment is tested for how well it achieves its objectives, as measured by a pre-specified set of indicators. A quasi-experimental design by definition lacks true random assignment. Quasi-experimental designs identify a comparison group that is as similar as possible to the treatment group in terms of baseline (pre-intervention) characteristics. The comparison group captures what would have been the outcomes if the intervention/programme had not been implemented (i.e., the counterfactual). Hence, the programme or intervention can be said to have caused any difference in outcomes between the treatment and comparison groups (White & Sabarwal, 2014). This study fits this design as not all learners in the school were given the opportunity to participate in the study. Only those that met all the criteria then had equal opportunity to be assigned to one of two groups – either the intervention or the control group. The process of randomisation was done by drawing names from a hat (Figure 1).

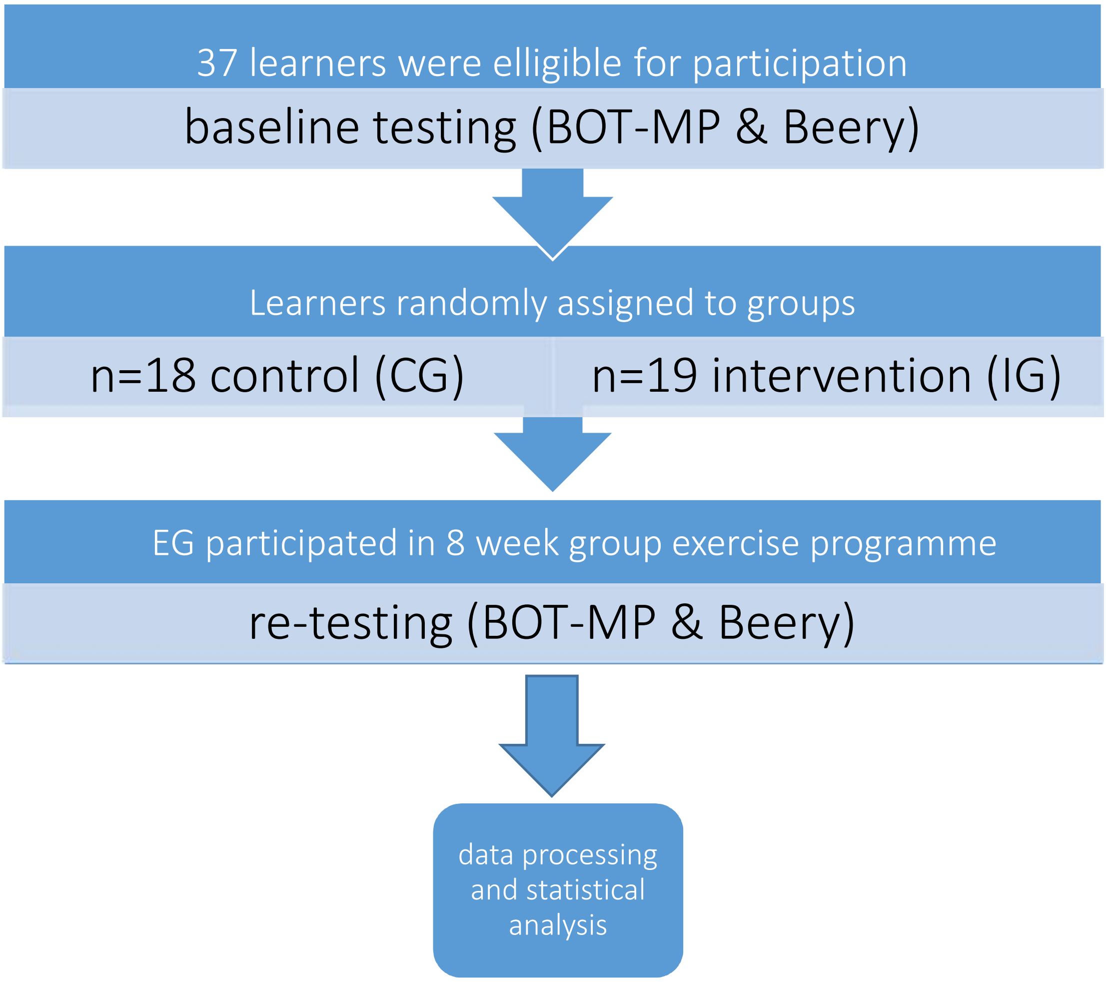

Figure 1 Study design

3.2 Study population

The study population included all learners aged four to 14 years old in the Eastern Cape identified with minimal motor dysfunction or DCD. Our school[1] is the largest and best-resourced in the Eastern Cape (DoE, 2016), and has a hostel to accommodate out-of-town learners. As this school serves as a resource for the entire province, and has children with special needs from all over the Eastern Cape enrolled there, only one school was selected for participation in this study.

1 Cape Recife High School, Summerstrand, Port Elizabeth

3.2.1 Sampling

Purposive sampling was used in the study. The reason for using purposive sampling is to focus on particular characteristics of a population that are of interest, which will best enable the investigator to answer their research questions. The goal of purposive sampling is not to randomly select participants from a population with the intention of making generalisations to the wider population. It is rather to create a sample from a particular population to make generalisations to that particular population of interest. Purposive sampling relies on the judgement of the researcher when it comes to selecting the participants for the study. Purposive sampling was used in that only children attending this school where the principal researcher is employed and who met the inclusion criteria were eligible for participation in the study.

When any learner is admitted to the school, they undergo full assessment by an occupational therapist, physiotherapist, speech therapist, audiologist, psychologist as well as a remedial teacher. All therapists use standardized tests (Beery, CELF 4, SCAN 3: C, J/SAIS; one-minute Ballard test and Logue-Martins diagnostic test for phonics respectively) to evaluate the learners. The outcomes of these evaluations is to formulate an individual education plan (IEP) for each learner. The team discusses the findings and a multidisciplinary approach is formulated to target intervention for each learner's specific needs. The evaluations are distributed as follows: one copy for the parents, one copy for the main psychology file for the learner and a third copy is kept in the department from which is comes. The names of all learners identified with minimal motor dysfunction are thus available to the researcher. Learners that score a stanine of three or less on the BOT-MP (refer to 3.4.1) are classed as having minimal motor dysfunction. To be eligible, the participants had to score within four categories which are based on the BOT-MP norms. They are (1) a stanine of -1, (2) stanine of 1, (3) stanine of 2 and (4) a stanine of 3. This criterion also forms part of the policy governing which children are given physiotherapy.
With the help of a biostatistician[2], a power analysis determined that N=18 with a minimum of nine in each group is the minimum needed to detect differences between the two groups. As only one school was selected for participation into this

2 Moleen Zunza, University of Stellenbosch Biostatistics Department

study it was deemed appropriate to include all the learners who provided the necessary consent and the resultant final sample was N=37.

Inclusion Criteria

To be included in the study, participants had to:

- score a stanine of three or below on the BOT-MP test
- be of average intellectual ability, as determined by assessment of the school psychologist
- be between the ages four years five months and 14 years five months. The BOT-MP is only standardized from four years five months up to 14 years five months

Exclusion Criteria

Participants were excluded if:

- they presented with any other associated mental or physical conditions which could affect their movement abilities
- they received any additional physiotherapy or occupational therapy privately

3.3. Procedure

The first step taken was to ask permission from the principal and governing body of the school to conduct the study. After permission had been granted, approval from the Department of Education and the Stellenbosch University (SU) Human Research Ethics Committee (HREC) was sought. Following approval from Stellenbosch University (SU) Human Research Ethics Committee (HREC) (S15/11/268) (Addendum F) and the DoE (Addendum B), the process of sampling began. The researcher has access to the physiotherapy files of all the learners in the school. Every learner has a file whether they receive physiotherapy or not. The file contains relevant medical history and the original Bruininks-Oseretsky test sheets and scores, unless the learners is physically disabled. The physically disabled learners, even if they are ambulant, are not tested with this test as it is standardized for typically developing children. The researcher sat in a quiet office and went through these files. The first criteria was that the learners were of between four and fourteen years old. Secondly the learners had to have scored a stanine of three or below on the BOT-MP test. The medical history was then checked as learners with any underlying neurological conditions were not eligible. Once the eligible learners were identified, the learners were invited to participate. An Information leaflet and informed consent (IC) document (Addendum A) was sent home with eligible participants. Those whose parents provided written informed consent (Addendum B) and for children above seven years of age – who provided written assent (Addendum C) where included in the study [N=37].

The school's database/learner folders contain information including a pre-admission Chronological Development Questionnaire. This questionnaire was formulated by the school's multidisciplinary team to obtain biographical and medical information. It is completed by all parents as part of the admissions package to the school. These folders were retrieved and information regarding the birth history, diagnoses made by medical professionals and name and dosage of any medication used by the child was recorded onto a data collection sheet to be used for correlational analysis later.

The participant's height and weight was recorded using a standardised protocol (Salie et al., 2009) with the school nursing sister's equipment (Safeway home scale and the SECA height measuring tool) and also recorded on the data collection sheet (Addendum C). Their height and weight was measured without shoes on. Although the scale was not calibrated, it did compare with a second scale used in the therapy department.

Testing was conducted during school hours by a research assistant[3] who was kept blinded as to the group allocation. For the motor proficiency testing, the physiotherapy gymnasium was set out by the researcher strictly adhering to the specifications as set out in the BOT-MP manual (Bruininks, 1978). The testing was done on a one-to-one basis so that the research assistant was focussed on the performance of only one learner at a time. For the testing of visual-motor integration ability, this was done by the school Occupational Therapist (OT) who was also blinded as to which group participants were in. The testing by the Occupational Therapist (OT) was done on an individual, one-to-one format so that each child was

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given maximal opportunity to do their best. This applies to both pre and post testing. The testing was done in the Occupational Therapy department.

The intervention was carried out during therapy periods to ensure that no extra time was spent out of the classroom in accordance with the DoE's stipulation. Withdrawal of OT and usual physiotherapy for the duration of the study was raised as an ethical concern. However due to the high intake of learners at the beginning of every year, OT rarely commences in the first term due to the large load of testing, scoring and report writing. It was therefore considered acceptable to withhold OT for term one in 2016. In cases however where the learner's therapy is related to Alternative Augmentative Therapy (AAC) and Sensory Integration (SI) the therapy was allowed to continue. The above occurred in consultation with the parents concerned.

The experimental group followed the intervention programme, three times per week, for the duration of eight weeks during the first term 2016 while the control group had no therapy during the same time period.

3.4 Outcome measures (OMs)

The following standardised OMs were used to test motor skills and visual integration in the current study:

3.4.1 Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP)

The BOT-MP was used to determine the participant's level of motor function (Bruininks, 1978). The complete test comprises fine motor and gross motor skills and provides norms for typically developing children (TDC). Gross motor skills are normed for ages four years five months up until 14years five months (Deitz et al., 2007). The BOT-MP is the most common measure used to assess children for minimal motor deficits or DCD in North America (Crawford et al., 2001) (Larkin & Rose, 2005). In Canada in 2005 ten schools were randomly selected as a part of a larger study, to validate the BOT-MP and the M-ABC in field-based settings. Three hundred and forty grade four learners underwent testing using the BOT-MP and the M-ABC. The researchers recommend that each assessment measured different dimensions of motor ability but that under field-based conditions the M-ABC may be less useful, when compared to the BOTMP, when applied by non-clinicians (Spironello et al., 2009).

For the current study, the test was performed by a research assistant who has extensive training in paediatric neurology and has attended courses in administering the test. The BOT-MP gross motor composite section was used to test running speed and agility, balance, bilateral coordination and muscle strength in detail to obtain to a gross motor composite percentile rank. The BOT-MP Short Form tests elements of gross motor composite skills, as well as upper limb coordination, response speed, visual-motor control and upper limb speed and dexterity. This then translates to a global motor proficiency percentile rank.

3.4.2 Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI)

The VMI (Beery & Beery, 2006) was administered by the school Occupational Therapist to establish levels of visual-motor integration at pre- and post-intervention.

The Beery test assesses the ability of children ages four to 18 years to reproduce a developmental sequence of 24 geometric forms. This test was developed to identify possible areas of difficulties that children may have in specific areas of visual-motor integration (VMI). VMI is defined as the degree to which visual-perception and finger-hand movements are co-ordinated (Pienaar, Barhorst & Twisk, 2014). The VMI test has been widely validated and is reported to be a culturally-unbiased test (Beery & Beery, 2006; Pienaar et al., 2014). The reason for its extensive use is due to its well-documented and vast psychometric properties (Lim et al., 2014; Beery & Beery, 2006). Beery and Beery (2006) have reported that the inter-rater reliability ranged from 0.92 to 0.98 and test-retest correlation is 0.92 for a two-week interval.

3.5 Intervention

Subjects in the experimental group (EG) participated in an exercise programme which the researcher had devised based on clinical experience and from evidence sourced from the literature. The programme was specifically aimed to improve balance, muscle strength, bilateral coordination, cardiovascular fitness as well as postural control and core stability.

Care was taken to ensure that activities in the programme were not too alike to those that were tested with the BOT-MP but would improve the execution of activities requiring similar skills. The children were grouped according to their age and grades to avoid class work becoming too disrupted.

3.5.1 Group composition and duration

Learners in the EG participated in an eight-week training programme three times per week, during school hours. Each session lasted 30 minutes. Groups were comprised of three to four learners from the same grade.

Pless and Carlsson (2000) conducted a meta-analysis on the effects of motor skill intervention on children with DCD. The authors recommended that intervention for DCD be conducted in a group setting or in a home programme, with intervention frequency of at least three to five times per week. In a South African study, Peens et al. (2007) found that a group programme twice a week, for a period of eight weeks, yielded significant ($p>0.01$) improvement in the motor skills of children aged seven to nine years who had been diagnosed with DCD. In addition to this, a school term is usually approximately 10 weeks each, thus eight weeks was considered to be an appropriate period to implement the programme, leaving the first and last weeks available for the pre and post testing. Based upon these factors, it was decided to implement the exercise programme three times a week for eight weeks.

3.5.2 Programme (exercise) composition (Addendum E)

The exercises and activities included in the programme were devised and modified by the primary researcher and the physiotherapists at the school. The literature was consulted and more than 40 combined years of work experience informed the programme composition. The children were also asked to give input regarding the exercises in terms of being challenging and also which were enjoyable. This inclusive approach to devising an intervention is supported by the evidence triad as proposed by Sackett et al (1996) in which best practice emerges from expert opinion, best available published evidence and the patient needs and preferences.

As described in 2.3 (p.13) Interventions for children with minimal motor dysfunction, the programme targeted the most important fundamental gross motor and fine motor skills and the basic motor abilities that are believed to be prerequisite for other skills. The modalities used in the programme ranged from strength training (Ferguson et al., 2014; McKay & Henschke, 2012), balance-targeted interventions (Fong et al, 2016) and aerobic exercise (Schott et al, 2007) to whole body vibration (WBV) (Cardinale & Wakeling, 2005; Saquetto et al., 2015).

The exercises included were broken down into seven categories (Addendum E). At least three categories of exercises were executed for 10 minutes each per session, i.e. (1), (5) and (2) in session One, (3), (6) and (4) in session Two, and (5) and (7) in session Three etc. All the session's end in five minutes of cool down activities which include deep breathing and stretches. Pictures of some of the activities can be found in Addendum I. The exercises are broken down as such:

1. Cardio-vascular:
    - Treadmill
    - Exercise bicycle
    - "Air walker"

2. Strengthening:
    - E.g. Push-ups
    - Sit-ups (including those with trunk rotation)
    - Weight-training (with dumbbells and kettle bells)
    - Plyometric exercises
    - Exercises performed on the vibration machine

3. Balance:
    - 'Jelly tennis' (single leg standing, other leg on medium physioball; child given a racket and must maintain balance while hitting back tennis balls).
    - Obstacle course: the child must navigate various surfaces while maintaining balance.

4. Bilateral coordination
    - 'roller jumping'
    - Jumping in place with arm and opposite leg synchronized.

5. Combination exercises
    - Hanging from wall bars while bending knees up.
    - Backward weight bearing through arms on roller while maintaining a bridge and stomping feet.
    - Skateboard: child must propel themselves forwards then backwards while lying prone on skateboard using only their arms. They must simultaneously maintain hip extension i.e. feet don't touch the ground.

6. Upper limb co-ordination
   - Throwing a bean bag into the air and counting the claps before catching bean bag.
   - Bean bag catching and throwing.

7. Visual-motor control
   - Drawing a line through a crooked path with preferred hand.
   - Drawing a line through a curved path with preferred hand.

3.5.3 Equipment

Hula hoops, beanbags, tennis balls, therapy balls, soccer balls, rollers, vibration machinery, balance beam, exercise mats, treadmills, stationary bicycles and various other apparatus was used during the training sessions. Challenging, but enjoyable motor activities were chosen to enhance the learner's willingness to practice, and the activities included a large amount of repetition. Experiencing success motivated the learner to try new challenges and give of their best. The learners actively participated in the circuit-style programme and were competitively motivated and encouraged by the other group members. As recommended by Pless et al. (2000), when children are learning motor skills, they need to actually want to learn the task and understand what to learn in order to achieve successful outcomes.

3.5.4 Level of risk

All sessions were conducted under the supervision of the principal researcher. The sessions were all done in the physiotherapy gym and adjacent carpeted passage. The gym walls are covered in mirrors. Equipment was positioned to enable exercises to be executed by all the participants in a circuit format. A school nurse on the premises was easily accessible in case of an emergency.

3.6 Statistical analysis and treatment of the data

The scores from the BOT-MP were converted to standard scores by using Table 23 for the corresponding age group in the BOT-MP Test manual. Table 24 (page 129) and Table 25 (page 130) are used to calculate the overall percentile rank and stanine of the learner for gross motor proficiency. Table 27 (pages 132 and 133) is used to calculate the BOT-MP-Short Form percentile rank and stanine for global motor proficiency. The data was stored on the researcher's laptop in the form of an Excel spreadsheet. The laptop is password protected and the data was backed up on a USB stick and locked in a cupboard in the researcher's office. The data was entered into the Excel spreadsheet using only the assigned number given to each participant. This was done to ensure complete privacy of information, even from the biostatician. The excel spreadsheet contained the pre-test and post-test data.
The Data was analysed using the STATA software with the assistance of a biostatistician at the University of Stellenbosch. A one-way ANOVA was done to test the effect of randomization, which indicated that experimental and control groups did not differ at baseline and therefore did not influence any further analysis (refer to 4.1).
Pre-study: Using data from the BOT-MP, a power analysis was used to calculate the minimum sample size required so that one can be reasonably likely to detect an effect of a given size. It was determined that N=18 with a minimum of 9 learners in each group is necessary to detect significant differences between the two groups.

It was however decided to include all the learners who complied with the inclusion criteria given this was a purposively selected sample; and from an ethical perspective to exclude some learners may be viewed as unjust.

Post-study: For statistical analysis, significance level was set at 0, 05.
Subgroup analysis was also done to compare pre-test classification of BOT-MP scores impact on outcome.

The Mann- Whitney test was carried out to accommodate for the imbalance in baseline scores between the two groups. The test is used to compare continuous outcome between the two groups.

The difference in scores between the control and experimental groups in the gross motor composite sub tests was analysed using two-sample t tests with equal variances.

3.7 Ethical Considerations

The following ethical considerations were addressed:

1. Permission was requested from Eastern Cape Education Department to conduct the study in the school. (Addendum B)
2. Confidentiality was assured to all participants. All personal information would be used solely by the researcher and should there be any publications, the participant's identity would not be disclosed. (Addendum A)
3. Permission was sought from the Human Research Ethics Committee at the University of Stellenbosch before the research was undertaken. (S15/11/268)
4. Participation was entirely on a voluntary basis and refusal or discontinuation was allowed without affecting standard treatment.
5. Informed consent forms were drafted using the University of Stellenbosch's template. All relevant information was included in language that is readily understood, i.e. no medical terms/jargon was used. The consent forms were then sent to the head of the psychology section at the school. The reason for this was to moderate for any ethical concerns or risks to the learners. Once the psychology section had approved the consent forms they were sent home with the learners in a sealed envelope to ensure privacy (Addendum A). The consent forms also included a paragraph where the parents were told that they could raise any concerns regarding the project directly to the head of psychology should they not wish to discuss them with the researcher. The parents/guardians completed the forms and returned them to the physiotherapy department.
6. Once the parents/guardians had consented to participation in the project, informed assent from all the learners was obtained (Addendum D). All the learners, in the presence of a witness, were taken through the process and what would be expected of them. They were given the opportunity to ask questions and raise any concerns.
7. Consent to use any photographs taken during testing or participation in any presentations or publications was also obtained from parents and participants.

8. The researcher then asked permission from the principal of the school to use the Physiotherapy department's Bruininks-Oseretsky Test of Motor Proficiency (BOT-MP) assessment tool. This was granted as only learners from the school were included in the study and all testing would occur on school premises during school hours.
9. The results would be made available to Cape Recife High School, and to the parents upon request.
10. A registered nurse was available at the school in the event of any accidents or injuries that may have occurred during or as a result of the exercise programme.
11. The control group received the same programme of intervention that the experimental group had been given once post-intervention testing was completed. The outcome of the CG was not included in the analysis of this study due to time constraints to allow for timeous completion of the master's degree.

3.8 Piloting the intervention

The intervention was not formally piloted. However, during the term before the intervention took place, elements of the programme were practiced in the gym. The number of stations used for the circuit format was rehearsed with learners to test for the ability to supervise the learners. The learners were also asked to give feedback regarding the activities presented to them. They were asked to rate the activities in terms of level of difficulty and which they enjoyed the most. This feedback was taken into consideration when the activity list was planned. These planning sessions included the other physiotherapists working at the school so that their input and experience could also be incorporated into the programme.

Chapter 4: Results

This chapter will begin with a description of participant demographics. Thereafter, the effect of the group exercise programme on gross motor composite scores, running speed and agility, balance, bilateral coordination and muscle strength will be reported on. The global scores, as tested with the BOT-MP SHORT FORM and Beery test, are also reported. The results of the correlational analysis between outcome and selected demographic variables are also reported.

4.1 Description of the sample

A total of 40 children were identified for possible participation in the current study. From this cohort of children, three parents did not consent to their child participating in the study. The total sample comprised of 4(11%) of children with autistic spectrum disorder (ASD), 15(40%) presented with a specific learning disorder (SLD) and the majority 18(49%) had SLD and ADHD (Table 3).

The two groups did not differ significantly from one another for gender, diagnoses or medication use. There was however a significant difference between the EG and CG for height and weight (Table 3). The learners in the control group were on average taller and heavier than the treatment group, most likely due to age differences (Table 5).

Table 3 Demographic data measured on subjects in the control and intervention groups in the study

Characteristic	**Control group (CG)**	**Experimental group (EG)**	**Diff btw groups p-value**
Gender (male: female)	13 : 5	10 : 9	0.22
Diagnoses: ASD SLD SLD+ADHD	3 8 7	1 7 11	0.37
Height (m)	154.1 ± SD 10.3	141.2± SD 17.8	**0.01**
Weight (kg)	59.8 ± SD 17.2	39.6 ± SD 17.2	**0.001**
Use of ADD/ ADHD medication No Yes	44.4% 55.6%	42.1% 57.9%	0.89

ASD: Autistic spectrum disorder; SLD: Specific learning disorder; ADD: Attention deficit disorder; ADHD: Attention deficit and hyperactivity disorder

At baseline there were no significant differences in the gross motor skills scores in terms of diagnosis (Table 4).

Table 4 Spread of diagnoses according to stanine levels as determined by the BOT-MP

Diagnosis	Stanine 1 (Percentile rank-1 - 3)	Stanine 2 (Percentile rank 4-10)	Stanine 3 (Percentile rank 12- 21)
ASD	4	0	0
SLD	10	2	3
SLD+ADHD	11	4	3
Difference between stanine groupings amongst diagnosis categories p-value			0.62

There were significant differences found regarding distribution of age of participants between the two groups ($p= 0.03$) (Table 5).

Table 5 Spread of age groups between control and experimental groups

Age groups	Control group (CG)	Experimental group (EG)
5-7 years old	0	5
8-10 years old	6	8
11-14 years old	12	6
Difference between age groupings amongst CG and EG p-value		**0.03**

4.2 Effect of the intervention on total gross motor scores as measured by the BOT-MP

The experimental group improved significantly more than the control group with $p<0.01$ (Table 6) for total scores on the BOT-MP. Both groups improved their scores from pre to post intervention however the change recorded in the CG was not significant.

Table 6 Effect of the intervention on gross motor skills as determined by the BOT-MP

Score variable	EG	CG	Diff btw EG & CG (p-value)
pre-test BOMTP gross motor composite score: median percentile rank (interquartal range)	3 (1 – 16)	1 (-1 – 3)	**0.004**
post-test BOMTP gross motor composite score: median percentile rank (interquartal range)	31 (16 – 58)	8 (1 – 18)	
Within group effect (p-value)	**0.001**	0.25	

4.3 Effect of the intervention on global motor proficiency scores as measured by the BOT-MP Short Form

The BOT-MP Short Form includes subtests which measure running speed and agility, balance, bilateral coordination, muscle strength, upper limb coordination, response speed, visual-motor control and upper limb speed and dexterity. In both the EG and CG scores showed improvement with significant differences scored from pre- to post testing (Table 7). The difference between the two groups however was not significant suggesting that the intervention was no better than no intervention (p= 0.14) (Table 7).

Table 7 Results of the BOTMP-SHORT FORM test

Score variable	**EG**	**CG**	**Diff btw EG & CG (p-value)**
pre-test BOMTP Short Form score: median percentile rank (interquartal range)	14 (3 – 27)	3 (1 – 6)	0.14
post-test BOMTP gross motor composite score: median percentile rank (interquartal range)	34 (14 – 46)	14 (2 –24)	
Within group effect (p-value)	**0.008**	**0.02**	

4.4 Effect of the intervention on gross motor composite scores: sub test analysis

4.4.1 Effect of the intervention on running speed & agility and balance

The scores for both group where higher at the post-test analysis for running speed and agility (Figure 2), however the change from pre to post within each group was not significant and there was no difference found between the two groups (p= 0.19).

The same effect was seen in balance scores. There was no significant improvement within each group nor was a difference found between the two groups for this variable (p= 0.86) (Figure 2).

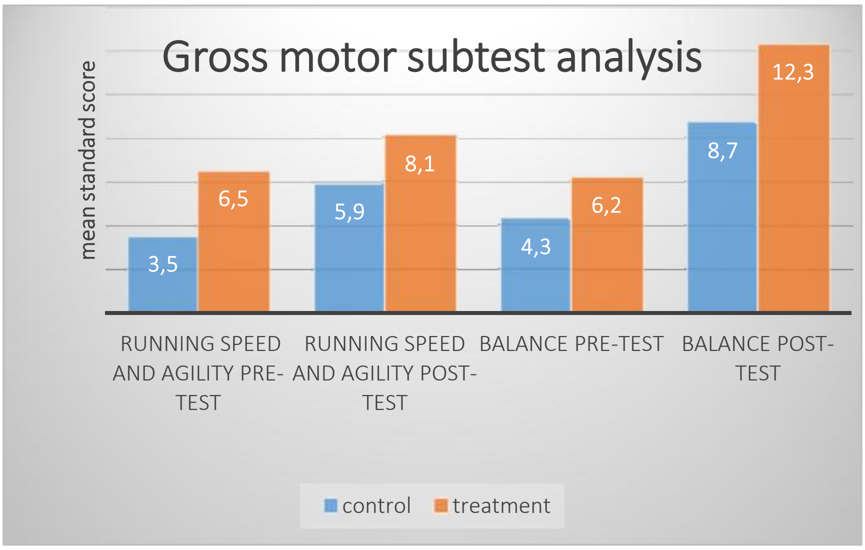

Figure 2 Effect of the intervention on running speed & agility and balance

4.4.2 Effect of the intervention on bilateral coordination and muscle strength

Similar effect was noted at post-test analysis for scores related to bilateral coordination (Figure 3), however the change with was not significant. Similarly, no difference was noted between the two groups (p= 0.86). A significant difference for muscle strength scores between the EG and CG (p=0.001) was found, suggesting that the intervention can improve muscle strength in this population.

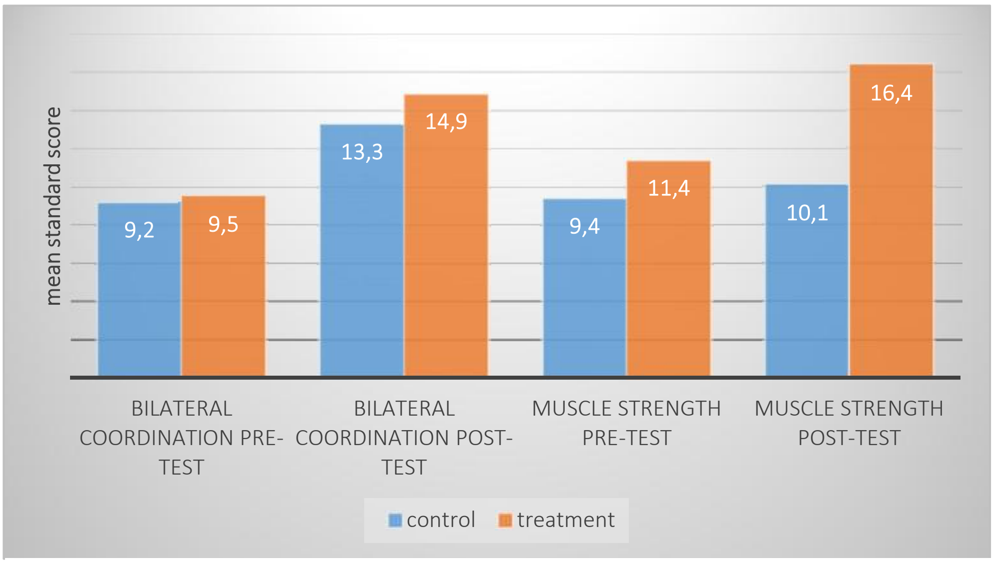

Figure 3 Effect of intervention on bilateral coordination and muscle strength.

4.5 Effect of the intervention on stanine levels

There were eleven learners that tested as a stanine 1 (percentile rank -1 to 3), two learners as stanine 2 (percentile rank 4 to 10) and six as a stanine 3 (percentile rank 12 to 21) at baseline. Following intervention these scores increased and although the sub groups are too small to extrapolate statistical significance, the clinical effect is evident (figure 4).

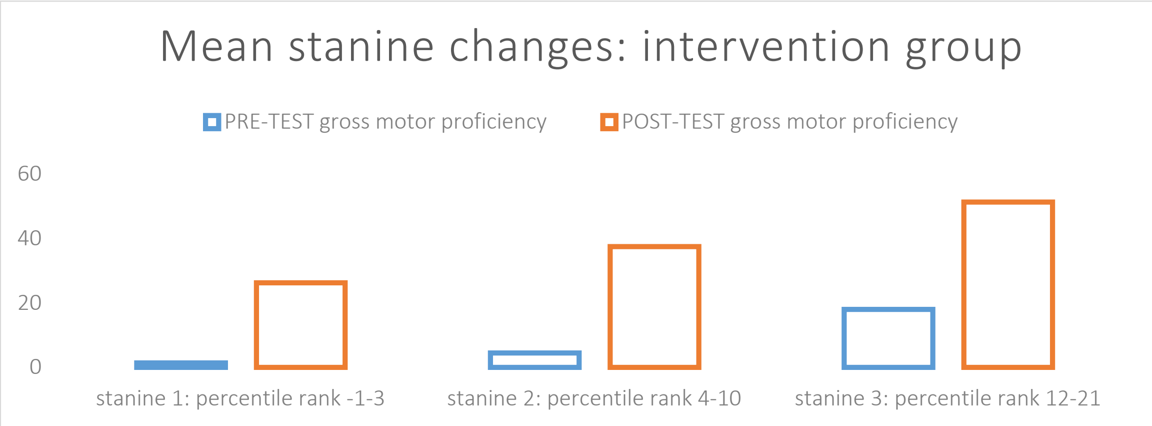

Figure 4 Mean stanine changes in intervention group

4.6 Effect of intervention on Visual Integration (Beery Test scores)

For this variable no significant differences were found from pre to post intervention within group and similarly no differences were found between the EG and CG (Table 8).

Table 8 Effect on the intervention on VMI as determined by the Beery Test

Score variable	**EG**	**CG**	**Difference between EG & CG (p-value)**
Beery score: median percentile rank **pre-test**	27	34.89	0.45
Beery score: median percentile rank **post-test**	36.21	38.78	
Within group effect (p-value)	0.31	0.79	

4.7 Relationships between age, diagnosis, medication use and performance in gross motor function scores

4.7.1 Age and effect of gross motor function

The various age groupings in the current study responded differently to the intervention. Figure 5 shows the mean gross motor percentile ranks in the five to seven-year-old group (5 participants), eight to ten-year-old group (8 participants) and eleven to fourteen year old group (6 participants). Although the sub groups are too small to extrapolate statistical significance, the clinical effect seems evident.

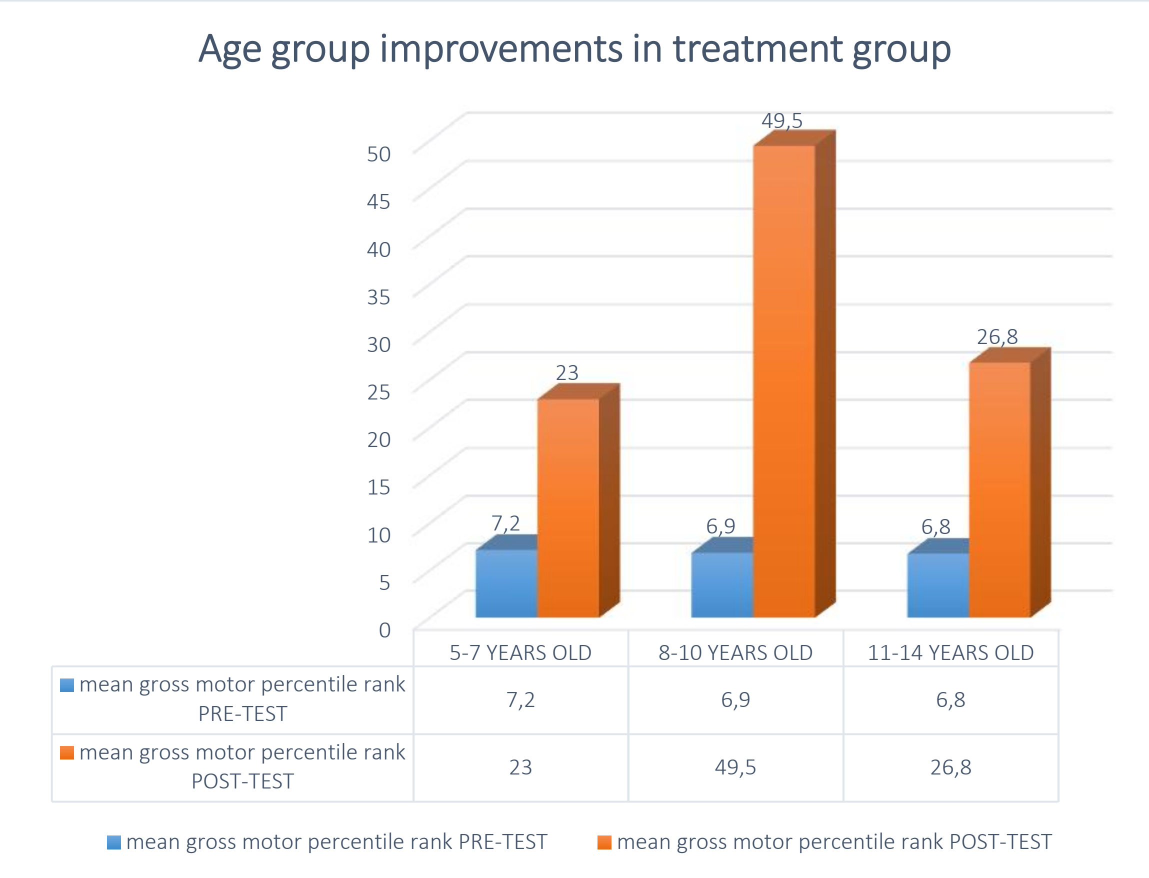

Figure 5 The effect of intervention on gross motor function (BOT-MP) for different age groupings

4.7.2 Diagnosis and effect on gross motor function

The various diagnosis groupings also responded differently to the intervention. Figure 6 shows the mean gross motor percentile ranks in the Autistic spectrum disorder group (1 participant), Specific learning disability group (7 participants) and

Specific learning disability and Attention deficit hyperactivity disorder group (11 participants). Although the sub groups are too small to extrapolate statistical significance, the clinical effect is clear. Children with a diagnosis of combined SLD and ADHD evidently made the most improvement.

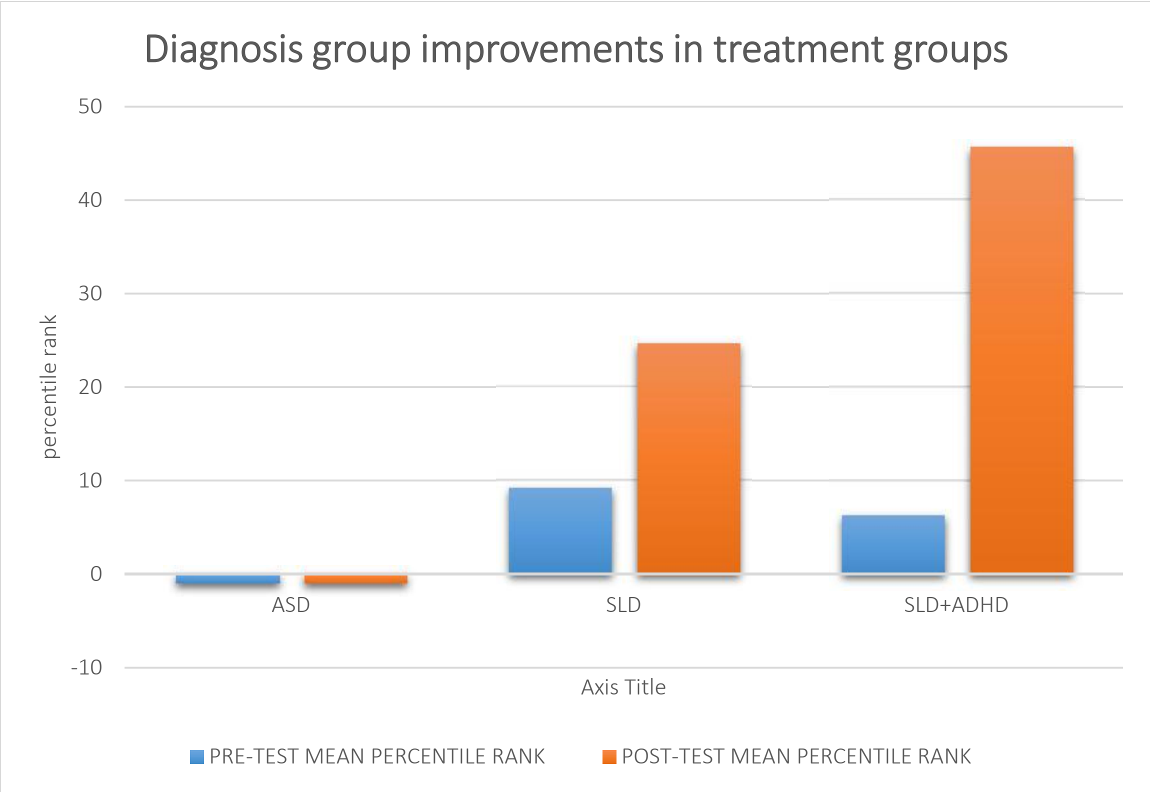

Figure 6 The effect of intervention on gross motor function (BOT-MP) for different diagnosis groupings

4.7.3 Medication use and effect on gross motor function

Figure 7 shows the mean gross motor percentile ranks pre and post-intervention for the groups using concentration/attention medication (11 participants) and the group not using medication (8 participants). Although medication is not indicated for every child with a Specific learning disability, ASD and/or Attention deficit hyperactivity disorder, it is often prescribed. It was an interesting to note that although the two groups had a fairly similar pre-test mean percentile rank, the levels of improvement differ greatly.

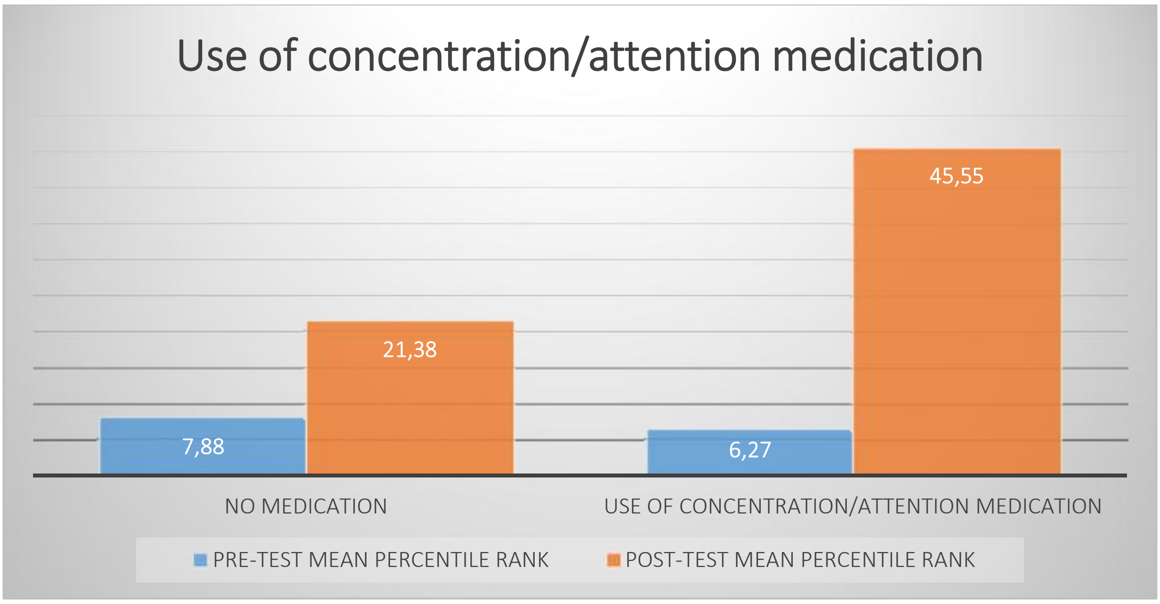

Figure 7 The effect of intervention on gross motor function (BOT-MP) for groups using attention/concentration medication

SUMMARY

From this study it can be concluded that a physiotherapy group exercise programme three times a week for a period of eight weeks can improve general gross motor skills of children aged five to fourteen years old presenting with minimal motor dysfunction. According to the subscale scores of the BOT-MP inferring muscle strength, the results of the current study also suggest that general muscle strength improved following participation in this group based intervention. The results of the study also show a trend towards the intervention affecting balance; bilateral coordination; and running speed and agility. The current intervention however was unable to show any effect on VMI skills within this sample.

Chapter 5: Discussion

INTRODUCTION

The current study aimed to determine the effect of a group-based exercise intervention on motor performance and visual integration skills in children who presented with minimal motor dysfunction. These children attend a special school where the researcher was employed. This chapter discusses the findings of the current study and compares them to those reported in similar studies. Given the study was conducted within the constraints of a Master's thesis with limited funds and time, there are limitations which were taken into account when the study was developed; and when data was analysed and interpreted. These are discussed below. Recommendations for future research in this field as well as the implications for practice of physiotherapy at special schools are made.

The current study hypothesised that the gross motor and visual motor integration skills (VMI) of the experimental group would improve following exposure to an 8-week group-based exercise intervention.
Significant improvement was noted in the gross motor skills, however no statistically significant improvement was found in VMI skills at post intervention testing.

This study is also novel in that it included the older child/adolescent. The evidence for group intervention for children with minimal motor dysfunction to date is mostly reported for children ten years and younger. This study demonstrated that learners older than ten can also benefit from group-based intervention. To better understand why some learners did better than others, the relationship between demographic variables (age, gender, diagnoses and medication use) and motor outcome following participation was also explored.

This chapter will first discuss the generalizability of the findings of the current study to the greater population of children with minimal motor dysfunction. This is followed by discussion regarding the effect of the intervention on gross motor and visual-motor integration skills. The exercise programme, its design and feasibility within the school setting will also be discussed. Recommendations for future research and the implications for clinical practice will follow.

The current study outlined three specific aims that were investigated thoroughly. These three aims referred to: the gross motor skills of learners presenting with minimal motor dysfunction and their response to an eight-week intervention programme; the effect of a gross motor intervention on VMI skills of the sample and the relationship between outcome and demographic variables. After referring to the data collected and comparing results of the current study with other research some conclusions can now be discussed. Recommendations will be presented for future studies on this topic, and the limitations of the current study will be outlined.

5.1 Generalizability

The participants in the current study presented with the common characteristics described in the literature for DCD (APA, 2000). All of the children had average and similar cognitive ability and had no other neurological disorders. Only learners who were unable to perform activities usually acquired at their age, which were interfering with their activities of daily living, participated in the current study. There were nearly twice as many boys than girls in the sample (refer to table 3) which correlates with many DCD prevalence figures reported for populations worldwide including information from studies conducted in developing/ low resourced countries (Ferguson et al., 2014; Zwicker et al., 2013; Salie et al., 2009; Hillier, 2007).

As the evidence for group interventions in older children and adolescents is sparse, the age range of participants in this study is larger than what has been reported in previous studies. Pless et al (2000) investigated effect in children aged five to six years old and Peens et al.'s (2007) sample comprised of children seven to nine-year-old. Salie et al.'s study (2009) looked at learners that were six to ten years old. The results for older learners finds its significance particularly in the field of school-based physiotherapy. Learners are not always referred to Education Support Services in the foundation phase from the mainstream schools. This translates to learners being referred to LSEN schools from the intermediate and even senior phases. As a result, older children were also invited to participate in the current study compared to those typically enrolled in these studies (Peens et al., 2007; Salie et al., 2009). This was done to validate the policy in our school which does not prescribe an age limit to physiotherapy.

One of the goals of the current study was to explore the effect on the older child for whom currently therapy is not readily available or offered. Despite the gross motor function scores in learners in the age grouping of eight to ten years having the largest change following participation in the intervention, the improvements seen in the older age group of 11 to 14 was also evident. This group showed the second largest change in scores. Although the current study was unable to show that this change in scores from pre to post intervention differed significantly between age groups (because the current sample size was to small) - their improved scores are similar to the improvements in gross motor skills reported in other studies which targeted the younger age group (Peens et al., 2007; Salie et al., 2009). These findings warrant further exploration into the effect of the intervention on older children with minimal motor dysfunction.

Most of the sample presented with comorbid conditions such as ASD, SLD and ADHD (refer to table 3). The literature on this group of children describes the substantial overlap with attention deficit hyperactivity disorder (ADHD), specific learning disorder (SLD) and autistic spectrum disorders (ASD). Studies examining the demographics of this population of children report that 30-50% of children diagnosed with ADHD have DCD as a co-morbid condition (Fliers et al., 2010; Smits-Engelsman et al., 2012). The profile of the total sample is in line with these findings as 50% of the learners had a diagnosis of ADHD (refer to table 3). This adds to the ability to generalise these results to the larger population of learners with DCD/ minimal motor dysfunction.

The analysis looking at the use of concentration/attention medication yielded very interesting results. Systemic reviews into intervention efficacy for children with DCD have described the impact of concentration/attention medication, for example Methylphenidate (Smits-Engelsman et al., 2013). More than half the children in the intervention group had been prescribed, and were taking, concentration/attention medication. The post-test improvements in the group using medication was considerably more than the group not using, despite similar starting scores.

Although the EG and CG did not differ significantly from one another in terms of the co-morbid diagnoses as well as the use of attention and concentration medication at baseline, differences where noted between the EG and CG when analysing these possible confounders. The results however should be interpreted with caution as the sample size for these analyses was not powered high enough. Although the difference noted in response to the intervention between these age groups need to be interpreted carefully as the subgroups were too small to show whether this was significant or not. Preliminary evidence suggests though that the results did show that children with a diagnosis of combined SLD and ADHD seemingly made the most improvement

Similarly, the learners in the control group were on average taller and heavier than the treatment group. This was most likely due to age group differences. Despite the age discrepancy between the two groups, the EG and CG did not differ in terms of gross motor function at the start of the study. As the BOT-MP is standardized for age bands (Bruininks & Bruininks, 2005) this was not deemed to affect the outcome of the study.

The socio-economic status of the children was not specifically noted in the demographic profile. However, as the school is a state-owned LSEN school, the school fees are according to a sliding scale of income. Thus children from all socio-economic groups have access to the school. The children are also placed by the district Education Support Services Centre and the school may not admit learners directly. The learners are transported to school by the school's transport system which sends buses to all areas, suburbs and townships around Port Elizabeth. The school also has a hostel which accommodates learners from outside Port Elizabeth such as farms, small towns and other cities that do not have a school such as Cape Recife High School in their area.

5.2 Overall gross motor skills improvement

Several studies support group therapy for improving motor functioning in pre-schoolers up to 11 years old (Bardid et al., 2013; Peens et al., 2007; Peters & Wright, 1999; Salie et al., 2009). Bardid et al. (2013) more recently demonstrated that pre-school children with motor problems improved following a ten week bi-weekly 60 minute group session exercise programme run by teachers. Peters and Wright (1999) carried out a motor skill intervention in learners seven to eight years old. The intervention was led by a physiotherapist and a teacher. The intervention was prescribed as once weekly for ten weeks and were all an hour long. The intervention showed significantly improved motor scores (Peters & Wright, 1999). Salie et al. (2009) investigated the effects of a group exercise programme, run by a physiotherapist, in learners aged six to ten years old. The programme ran over eight weeks, three sessions per week of 30-45 minutes each. The study also concluded that a group-based exercise intervention programme is effective for improving motor proficiency in children with motor dysfunction**.** Another intervention devised by a biokineticist targeted learners seven to nine years old. The learners received bi-weekly 30 minute sessions for a period of eight weeks. The motor intervention group greatly improved their scores (Peens et al., 2007).

A teacher-led programme is described in Zask et al. (2012) who undertook to assess four year old children from 31 (18 intervention; 13 control) pre-schools in New South Wales, Australia in 2006. The children were then exposed to a gross motor programme. The programme consisted of two terms of ten sessions with each session repeated twice per week. The programme also reported positive outcomes (Zask et al., 2012).

The evidence for group therapy has been well-established. Besides the physical benefits to the learners, the psycho-social ramifications for the participating learners has been well described as a positive side effect of the programmes (Peters & Wright, 1999).

Current study

From this study it can be concluded that a physiotherapy group exercise programme three times a week for a period of eight weeks can improve general gross motor skills of children aged five to fourteen years old presenting with minimal motor dysfunction. According to the subscale scores of the BOT-MP inferring muscle strength, the results of the current study also suggest that general muscle strength improved following participation in this group based intervention. The results of the study also show a trend towards the intervention affecting balance; bilateral coordination; and running speed and agility.

5.3 Exercise programme

Learners in the EG participated in an eight-week training programme three times per week, during school hours. Each session lasted 30 minutes. Groups were comprised of three to four learners from the same grade. Grouping the learners together according to classes worked well. The teachers preferred to have three to four learners be removed from the class at a time, as opposed to one by one. In this way the teacher continued with activities that the learners could afford to miss, such as art, and teach when the whole class was present.

The exercise programme was a self-developed programme devised from evidence from the literature as well as in consultation with the other physiotherapists working in the school. However, this cannot be considered wide expert consultation. The programme was also largely informed by the resources and equipment available to the researcher. Due to time constraints and the limitations imposed on the requirements for a masters study a more rigorous process such as a Delphi study which would have included a wide range of expert therapists, was not possible.

Another possible limitation was the lack of a formal pilot study. Results from piloting every element of the intervention may have led to better sub-test improvements for all categories of the gross motor composite (running speed and agility, balance, bilateral coordination and muscle strength) as well as the global motor proficiency sub-tests as tested by the BOT-MP gross motor composite and short form respectively.

Spending time in the occupational therapy section of the school observing the testing of visual-motor integration may have led to the inclusion of activities geared towards the underlying motor skills required. The omission of this highlights the importance of inter-disciplinary teamwork for improved outcomes for the learners.

Intensity and repetitions of the activities presented were modified for each age group. However, more capitalising on the older learners, particularly the boys', stage of development could have been beneficial and more 'interesting' for the learners. For example, weights and strength training did hold a strong appeal for the older participants as they become more self-conscious in the pubescent years. Both the older boys and girls enjoyed the abdominal strengthening activities in the pursuit of the ‘six pack’ as well as the vibrating plate. Although the study did show that physiotherapy can make a change in the motor proficiency of the older child, special attention to the type of activities presented to them is recommended.

Conducting the programme over an eight-week period can be recommended was sufficient time to make a change in the gross motor skills of the learners, and is in line with the recommendations from the literature.
Children with DCD often present with co-morbidities (Blank, 2012; Kooistra et al., 2005; McLeod et al., 2014; Fliers et al., 2010) and these diagnoses were represented in the study. McNab et al. (2001) also identified five different subtype profiles of DCD which are well described in the literature (Table 1). The participants in the study were not divided into the subtypes as described by Nab et al (2001). This may have had an influence on the degree of improvement after the exercise programme but sub groups were too small for analysis. The appeal for more studies examining the subtypes and their response to intervention has been repeated many times in the literature (McNab et al., 2001; Visser, 2003). This was not done for this study as there is no description or prevalence data referring to the rates in South African children.

The use of circuit-style format to present the programme can be recommended. The circuits comprised of different combinations of exercises/activities for every session. This is very important when treating these learners who mostly have ADHD as a co-morbid condition. This approach managed to hold their attention and interest for longer and using circuits meant that activities changed every 8 to 10 minutes and kept the learners alert and enthusiastic. For practical implementation, this type of intervention is better delivered in this format for situations where there is only one therapist. The circuits are designed so that while half of the group are engaged in activities with lower level need for supervision, the therapist is able to focus their attention onto the learners busy with higher level supervision exercises/activities. This approach is safe and ensures that the leaners do the exercises properly and safely.

5. 4 Limitations

This study does present with several limitations.

5.4.1 Retention of effect

Only immediate effects were investigated in the current study due to time constraints. However evidence of retention or ongoing improvement is necessary to motivate for the continuation of such a program within our setting and for recommendation to implement in other schools for LSEN. The learners in the current study were followed up but that data has not yet been processed and did not form part of the objectives for the current study/thesis.

5.4.2 Sampling

The purposive sampling utilised in the current study did not allow for assessment of all children in the district which may have allowed for a more representative sample of the broader population of children with minimal motor dysfunction. However given the available prevalence figures and from personal experience, the sample was deemed representative of all school aged children within the South African setting.

5.4.3 Control group

It was noted that the post-intervention scores for the control group had also marginally improved. The reasons for this were the introduction of practical Life Orientation (LO) periods as per the CAPS curriculum. The school also offers various sporting activities to the learners. These include swimming, soccer, tennis and cricket. Although no learner is forced to take part in sport, the LO periods are mandatory as part of the curriculum. Although occupational therapy was withheld from the learners in the study, they were exposed to the Life Orientation practical classes as well as class-based remedial tuition. This may account for the improvement in the control groups global motor proficiency scores. Although this may not seem ideal for the purposes of this study, it is in keeping with the mainstream curriculum and thus representative of the population. It is pleasing that the curriculum has included physical activity programmes which are clearly making a difference to the learners, even when physiotherapy and occupational therapy is not available.

5.4.4 Programme design

The programme was self-designed and as previously referred to, a better understanding of Occupational Therapy’s contribution to children with minimal motor dysfunction would have resulted in the inclusion of exercises more appropriate for affecting VMI skills. It is clear from the literature that improved VMI can improve motor performance and is associated with self-care as well as education-related activities such as hand writing, reading and mathematics (Pienaar, Barhorst, & Twisk, 2014; Lim et al., 2014) and should have been included.

Chapter 6: Conclusion and Recommendations

The results of this study support the hypothesis that a targeted eight-week group exercise programme can improve the gross motor skills of children with DCD as measured by the BOT-MP. Statistically significant improvement was noted in the intervention group at post intervention testing as compared to the control group. The improvement was noted in the total BOT-MP percentile rank scores (p= 0.004) and the muscle strength subtest standard scores (p= 0.001). The results for the Beery test score for the intervention group did indicate a trend for improvement. However, although this may be clinically significant, the results of this test were not statistically significant. A larger study is recommended to determine sustainability in other contexts as well as to examine what type of activities could affect visual-motor integration skills.

Recommendations for clinical practice

The learners thoroughly enjoyed the programme and most were disappointed when the eight week programme completed. Although time management in a school context can be challenging, the positive outcomes can potentially be seen after 8 weeks. In this light, it is possible to plan a timetable so that all children could be allocated to complete the programme at least once for the school year. The use of a circuit format in settings where there is only one therapist can be recommended. This style ensured both the safety of the learners and allowed the therapist to be hands-on during more complicated/high supervision level activities.
Another recommendation that became evident was a need for better inter-disciplinary teamwork. The learners would have been better served had the programme also had input from the occupational therapists working in the school. Inter or even multi-disciplinary endeavours are not only possibly more effective, but they may provide a solution in situations where resources such as therapists and time in the busy school day are in short supply.

An additional spin-off from doing this research within the school setting, is that the physiotherapists working at the school have now written into the school policy that re-assessment of learners that have received therapy and have clinically made good progress is mandatory. This is to uphold standards of best-evidence practice which promote evidence-based criteria for discharge from physiotherapy.

Recommendations for further research

The results of this study do support the hypothesis that the older learner can benefit from group-based physiotherapy. However, larger samples need to be used so that statistical significance can be established.

The existence of subtypes within this population has been established. Further studies could perhaps include the learners in a sample being identified into a subtype and extrapolating the response to intervention within each subtype.

Follow-up studies to explore the retention of improved motor skills following intervention is also required.

When developing a self-compiled programme a more rigorous process such as a Delphi study should be conducted which would include a wide range of expert therapists.

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ADDENDUM A

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT:

'The effects of an eight week grouped exercise programme on gross motor proficiency of children with minimal motor dysfunction.'

PRINCIPAL INVESTIGATOR: Mrs Jackie Kolesky

ADDRESS: Cape Recife High School, Port Elizabeth

CONTACT NUMBER: 041-5832147

Your child is being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask Mrs Kolesky any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied and that you clearly understand what this research entails and how your child could be involved. The participation is **entirely voluntary** and you are free to decline to participate. If you decline to participate, this will not affect your child negatively in any way whatsoever. You are also free to withdraw your child from the study at any point, even if you do initially agree to take part.

This study has been approved by the **Health Research Ethics Committee at Stellenbosch University** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki; South African Guidelines for Good Clinical Practice; and the Medical Research Council (MRC) Ethical Guidelines for Research. The study has also been approved by the Eastern Cape Department of Education.

What will your responsibilities be?

- You have no responsibilities. The study will be conducted at school during school hours.
- There are no costs involved.

PROCEDURES:

What will the study involve?

- An evaluation of your child's motor skills will be done at the end of the fourth term 2015 / beginning first term 2016. This will be done by Mrs Kolesky and Mrs Steyn at school during school hours.
- Once the sample has been identified, the learners will be allocated randomly to an intervention or control group.

- The intervention period will be the first term next year. The learners that were allocated to the control group will receive the physiotherapy from the second term.
- At the end of the first term all the learners will be re-evaluated.
- Learners in the study will not receive occupational therapy in the first term of 2016. This is to avoid skewed data as there is some overlap between the two therapies. Where occupational therapy is indicated, it will continue in the second term.
- Your child's occupational therapy tests scores will be made available to Mrs Kolesky. This information will also be kept in strictest confidence. One of the aims of the study is to demonstrate that an improvement in gross motor skills can have a positive impact on classroom functioning.
- There are no costs involved, all sessions will be carried out during school hours and all information will be kept in strict confidence.

Will your child benefit from taking part in this research?

- The purpose of the study is to determine the effects of an eight week grouped exercise class programme on gross motor proficiency of children with below average motor skills. There is good evidence to support that this programme does improve gross motor skills.

Are there in risks involved in your taking part in this research?

- The researcher is testing the efficacy of the standard physiotherapy treatment provided at the school. The risk factors in the study are thus the same as those for standard treatment.
- If you have any questions about your child's rights as a subject or participant in this research you are welcome to contact the Chair of the University of Stellenbosch Human Ethics Committee.

Who will have access to your medical records?

- All personal information will be used solely by Mrs Kolesky and should there be any publications, the participant's identities will not be disclosed.

Is there anything else that you should know or do?

- You can contact the Health Research Ethics Committee of the University of Stellenbosch at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by your study physiotherapist, Mrs Kolesky.
- You will receive a copy of this information and consent form for your own records.

Declaration by parent of participant

By signing below, I .... agree to allow my child to take part in a research study entitled *'The effects of an eight week grouped exercise programme on gross motor proficiency of children with minimal motor dysfunction.'*

I declare that:

- I have read or had this information and consent form read to me and it is written in a language with which I am fluent and comfortable.
- I have had an opportunity to ask questions and all my questions have been adequately answered.
- I understand that participating in this study is **voluntary** and that I have not been pressurised to allow my child to participate.
- My child may choose to leave the study at any time and will not be penalised or prejudiced in any way if choosing to do so.
- My child may be asked to leave the study before it has finished, if Mrs Kolesky feels it is in my child's best interests, or if my child does not follow the study plan, as agreed to.
- I agree to have photos taken of my child during the research programme. I will be given an opportunity to approve the photos before they can be used for presentational purposes only. Such photos will be altered in such a way that facial details will not be recognisable.

Signed at (*place*) .... on (*date*) .... 2015.

.... **Signature of participant**

.... **Signature of parent**

Declaration by researcher

I *(name)* .... declare that:

- I explained the information in this document to ....
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .... on (*date*) .... 2015.

.... **Signature of researcher**

.... **Signature of witness**

CAPE RECIFE HIGH SCHOOL

Circular No. 73 /2015

21 October 2015

Dear Parent/Guardian

PARTICIPATION IN RESEARCH PROJECT: ***The effects of an eight week grouped exercise class programme on gross motor proficiency of children with minimal motor dysfunction.***

It is the policy of the school to assist researchers with their projects to increase the body of evidence for the interventions used at our school. Mrs Jackie Kolesky, a physiotherapist at our school, is currently a Masters student at the University of Stellenbosch. Her study aims to prove that the physiotherapy intervention used at our school is significantly effective in the learners with minimal motor dysfunction.

Your child has been identified by our physiotherapists as a possible candidate for the study.

The project will involve the following participation:

1. An evaluation of motoric proficiency at the end of the fourth term 2015 / beginning first term 2016. This will be done by the physiotherapists at the school during school hours.
2. Once the sample has been identified, the learners will randomly be allocated to an intervention or a control group.
3. The intervention period will be the first term 2016. The learners that were allocated to the control group WILL receive physiotherapy from the second term.
4. At the end of the first term all the learners will be re-evaluated.
5. Learners who require occupational therapy, will not receive therapy for the first term 2016. It will resume, where indicated, in the second term.

Participation in the study is on a voluntary basis. All information will be kept in the strictest confidence and no outside physiotherapists or research assistants are involved. Permission for the study has been obtained from the Department of Education.

Enclosed please find Addendum A, an informed consent form, for your completion.

Your co-operation is greatly appreciated as we seek to validate our intervention strategies.

Kind regards

JACQUES HUGO
PRINCIPAL

REPLY SLIP

Circular No. 73/2015

(The reply slip must be returned to Mrs Kolesky by 13 November 2015)

PARTICIPATION IN RESEARCH PROJECT: ***The effects of an eight week grouped exercise class programme on gross motor proficiency of children with minimal motor dysfunction.***

Mr / Mrs...parent/ guardian of..(Grade..............) hereby acknowledge the receipt of Circular No........../2015.

Mr / Mrs.. indemnify the Education Department and Cape Recife High School against any eventuality which may occur while my child is participating in the voluntary programme of Mrs Kolesky.

SIGNED BY PARENT/ GUARDIAN:..

DATE:.............................

ADDENDUM B

Province of the

EASTERN CAPE

DEPARTMENT OF EDUCATION

Education Support Programmes * 46 Park Drive * Port Elizabeth * 6001 * REPUBLIC OF SOUTH AFRICA *
Tel: +27 (041) 508-8314 Fax (041) 508-8307 Fax email 0865546063
email: andile.nogaga@edu.ecprov.gov.za Cell: 0824155048/0832442105
Enquiries: A.S. NOGAGA

26/05/2015

Jackie Kolesky

Cape Recife High School

Admiralty Way

Summerstrand

Dear Ms Kolesky

PERMISSION TO UNDERTAKE A MASTERS THESIS: THE EFFECTS OF AN EIGHT WEEK GROUP EXERCISE CLASS PROGRAMME ON THE GROSS MOTOR PROFICIENCY OF CHILDREN AGED FOUR TO FOURTEEN WITH MINIMAL MOTOR DEFICITS

1. Thank you for your application to conduct research.
2. Your application to conduct the above-mentioned research at Cape Recife school under the jurisdiction of the Port Elizabeth District in the Eastern Cape Department of Basic Education (ECDBE) is hereby approved on condition that:
   a. There will be no financial implications for the Department;
   b. Institution and respondents must not be identifiable in any way from the results of the investigation;
   c. You will make all the arrangements concerning four research;
   d. The research may not be conducted during official contact time , as educators' programmes should not be interrupted;
   e. The research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;
   f. Your research will be limited to the school(s) or institution(s) for which approval has been granted;

g. You comply with all the requirements as contemplated in the Terms and Conditions to conduct Research in the ECDBE document.

h. You comply with your ethical undertaking (commitment form)

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in terms and conditions to conduct research in the ECDBE.

4. The Department wishes you well in your undertaking.

Yours Sincerely

N.E LUKWE

ACTING DISTRICT DIRECTOR: PORT ELIZABETH

Addendum C

Data collection sheet

Subject:T(treatmentgroup)/N(controlgroup)

Identitycode:...Gender:.................................
weight:...m1..............m2.........................height:m1..............m2........

Diagnosis: SLD/ ASD/ SLD+ADHD

Birth: premature/full term (from 37 weeks) c-section /NVD

Medication: attention and concentration:YES/ NO.......................................

Age at pre-test BOTMP (1A)...

Age at post-test BOTMP (1B)..

Age at pre-test Beery (2A)..

Age at post-test Beery (2B)...

TEST	*PRE-TEST*	*POST-TEST*
GROSS MOTOR COMPOSITE- BOTMP *PERCENTILE RANK*		
GROSS MOTOR SUBTEST: ***-Running speed and agility*** *STANDARD SCORE*		
-Balance *STANDARD SCORE*		
-Bilateral Coordination *STANDARD SCORE*		
-Strength *STANDARD SCORE*		
BOTMP-SHORT FORM*(includes gross and fine motor sections and upper limb coordination)* *PERCENTILE RANK*		
BEERY VMI *PERCENTILE RANK*		

STELLENBOSCH UNIVERSITY

FACULTY OF HEALTH SCIENCES

PARTICIPANT INFORMATION LEAFLET AND ASSENT FORM

TITLE OF THE RESEARCH PROJECT:
'The effects of an eight week grouped exercise programme on gross motor proficiency of children with minimal motor dysfunction.'

RESEARCHER'S NAME: Jackie Kolesky

ADDRESS: 58B 5th Avenue, Walmer, Port Elizabeth

CONTACT NUMBER: 041-5832147

What is RESEARCH?
Research is something we do to find new knowledge about the way things (and people) work. We use research projects or studies to help us find out more about disease or illness. Research also helps us to find better ways of helping, or treating children who need help.

What is this research project all about?
Mrs Kolesky wants to show other physiotherapists and teachers that the physiotherapy sessions that children at our school receive, makes them stronger and improves their physical skills.

Why have I been invited to take part in this research project?
Mrs Kolesky believes that she can help to show how physiotherapy can help you. She also wants to improve your skills with her exercise programme.

Who is doing the research?
Mrs Kolesky will be doing the exercises with you. Mrs Steyn will be testing your skills before and after the programme. No strangers will be involved.

What will happen to me in this study?
You will come to the gym three times per week during school time. We will do a 30 minute exercise programme during that period. If you are not part of group one, you will get your turn during term 2.

Can anything bad happen to me?
There are no dangerous or painful exercises in the programme at all. All care will be taken to ensure your safety.

Can anything good happen to me?
Yes, we are hoping to make you feel stronger and improve your abilities on the playground and in the classroom.

Will anyone know I am in the study?
No one except Mrs Steyn and Mrs Kolesky will know the names of the children in the project. The information we collect and send to the University of Stellenbosch will not have your name on. No one else in the school will know you are part of the project.

Who can I talk to about the study?
You can speak to Ms Dreyer at any point if you have any problems relating to the programme.

What if I do not want to do this?
Even if your parents have agreed for you to take part, at any time that you do not want to take part anymore, you can just tell Mrs Kolesky. You will not be in any kind of trouble and no-one will be cross with you. If anything in the programme bothers you, you can ask Mrs Kolesky to explain it to you.

Do you understand this research study and are you willing to take part in it?

YES NO

Has Mrs Kolesky answered all your questions?

YES NO

Do you understand that you can pull out of the study at any time?

YES NO

_______________________ _______________________

Signature of Child Date

Addendum E				
SESSION 1:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(1)cardio-vascular* *treadmill walking (6km/hr.; no incline) 5 minutes *'air walker' 2 minutes	*(5)combination exercises* *Hanging by arms at wall-bars (20 knee to chest lifts) *Skateboard (propel forwards with arms 30m, backwards 30m) 8 minutes	*(8) plyometric exercises* *Jump squats(3 sets of 5 repetitions) *Walking lunges(3 sets of 5 repetitions) 5 minutes	*(2) strengthening* core stability: ***Abdominal crunches** (2 sets of 30 repetitions) Supine, knees bent ***Sit-ups with rotation** (2 sets of 30 repetitions) Supine, knees bent 5 minutes
SESSION 2:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(3) Balance* *obstacle course compromised of gym beams of varying widths. Learner must navigate the course while maintaining balance (approx.10 m course) (repeat x3) *'Jelly tennis' (single leg standing, other leg on medium physioball; child given a racket and must maintain balance while hitting back tennis balls). Learner must hit 20 balls in order to swop to other leg.(repeat on each side 3x in total) 8 minutes	*(6) Upper limb coordination* * Throwing a bean bag into the air and counting the claps before catching bean bag.(repeat for 20 throws) *Bean bag catching and throwing. Therapist throws bean bag to learner, from 3m away, with right hand while simultaneously learners throws beanbag to therapist with left hand. Swop hands after 20 caught throws. (repeat twice per hand) 8 minutes	*(9) whole body vibration* *squats performed on the vibrating plate(20 repetitions; repeat x3)(settings of 20Hz and amplitude 3mm) 5 minutes	*(4)bilateral coordination* *'roller jumping':60cm in diameter solid roller wedged into position. Learner stands on one side of roller, puts outstretched arms onto roller and jumps to bring both legs to other side of roller in one movement. Continue for 2 minutes. 2 minutes

SESSION 3:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(5)combination exercises* * Backward weight bearing through arms on roller while maintaining a bridge and stomping feet. Learners continues to stomp for 30 seconds then slowly lowers onto mat. Rest for 5 counts then repeat. Continue for 3 minutes * Skateboard (propel forwards with arms 30m, backwards 30m) * Hanging by arms at wall-bars (20 knee to chest lifts) 10 minutes in total	*(1)cardio-vascular* * Exercise bicycle: horizontal bicycle with supported seat. Tension control 0-8(maximum resistance) Progress each learner through the tension settings. Beginning at 1 for first session and increase to the next setting as learner can manage. 5 minutes	*(6) Upper limb coordination* * Throwing a bean bag into a target from 3m away.(repeat for 20 throws) 2 minutes	*(7) visual-motor control* * Drawing a line through a crooked path with preferred hand. 2 attempts *Drawing a line through a curved path with preferred hand. 2 attempts 8 minutes
SESSION 4:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(1)cardio-vascular* *treadmill walking (6km/hr.; setting 1 incline) 5 minutes *'air walker' 2 minutes	*(5)combination exercises* *Hanging by arms at wall-bars (20 knee to chest lifts) *Skateboard (propel forwards with arms 30m, backwards 30m) 6 minutes	*(8) plyometric exercises* *Jump squats(3 sets of 5 repetitions) *Walking lunges(3 sets of 5 repetitions) *squats(3 sets of 5 repetitions) 6 minutes	*(2) strengthening* *Weight training: arms. Triceps, biceps and deltoid groups. In seated position. Begin with 1kg weights and progress as appropriate (2 sets of 15 repetitions for each of the 3 groups) 6 minutes

SESSION 5:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(3) Balance* *obstacle course compromised of gym beams of varying widths. Learner must navigate the course while maintaining balance(approx. 10 m course) (repeat x3) *'Jelly tennis' (single leg standing, other leg on medium physioball; child given a racket and must maintain balance while hitting back tennis balls). Learner must hit 20 balls in order to swop to other leg.(repeat on each side 3x in total)8 minutes	*(6) Upper limb coordination* * Throwing a bean bag into the air and counting the claps before catching bean bag.(repeat for 20 throws) *Bean bag catching and throwing. Therapist throws bean bag to learner, from 3m away, with right hand while simultaneously learners throws beanbag to therapist with left hand. Swop hands after 20 caught throws. (repeat twice per hand) 8 minutes	*(9) whole body vibration* *push-ups performed on the vibrating plate (both hands on plate) (boys under 8 years and girls: knee push-ups: boys older than 8 full push-ups) (20 repetitions; repeat x3)(settings of 20Hz and amplitude 3mm) 5 minutes	*(4)bilateral coordination* * Jumping in place with arm and opposite leg synchronized. Continue for 2 minutes *'roller jumping':60cm in diameter solid roller wedged into position. Learner stands on one side of roller, puts outstretched arms onto roller and jumps to bring both legs to other side of roller in one movement. Continue for 2 minutes. 4 minutes
SESSION 6:				
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 5 minutes	*(5)combination exercises* * Backward weight bearing through arms on roller while maintaining a bridge and stomping feet. Learners continues to stomp for 30 seconds then slowly lowers onto mat. Rest for 5 counts then repeat. Continue for 3 minutes * Skateboard (propel forwards with arms 30m, backwards 30m)8 minutes in total	*(1)cardio-vascular* * Exercise bicycle: horizontal bicycle with supported seat. Tension control 0-8(maximum resistance) Progress each learner through the tension settings. Beginning at 1 for first session and increase to the next setting as learner can manage. 5 minutes	*(2) strengthening* *core stability: **Abdominal crunches** (2 sets of 30repetitions) Supine, knees bent **Sit-ups with rotation** (2 sets of 30 repetitions) Supine, knees bent**Abdominal cycles**(2 sets of 30 repetitions) Supine, supported head maintained in flexion with legs air cycling 8 minutes	*(6) Upper limb coordination* * Throwing a bean bag into the air and counting the claps before catching bean bag.(repeat for 20 throws) 2 minutes

SESSION 7:					
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(1)cardio-vascular* *treadmill walking (6km/hr.; setting 2 incline) 5 minutes *'air walker' 2 minutes	*(5)combination exercises* *Hanging by arms at wall-bars (20 knee to chest lifts) *Skateboard (propel forwards with arms 30m, backwards 30m) 6 minutes	*(8) plyometric exercises* *Jump squats(3 sets of 5 repetitions) *Walking lunges(3 sets of 5 repetitions) *squats(3 sets of 5 repetitions) 6 minutes	*(2) strengthening* *Weight training: arms. Triceps, biceps and deltoid groups. In seated position. Begin with 1kg weights and progress as appropriate (2 sets of 15 repetitions for each of the 3 groups) 6 minutes	
SESSION 8:					
Warm-up * running on the spot (varying paces) * star jumps *stride jumps 2 minutes *Cool down* *stretches and deep breathing exercises 3 minutes	*(3) Balance* *obstacle course compromised of gym beams of varying widths. Learner must navigate the course while maintaining balance(approx. 10 m course) (repeat x3) *'Jelly tennis' (single leg standing, other leg on medium physioball; child given a racket and must maintain balance while hitting back tennis balls). Learner must hit 20 balls in order to swop to other leg.(repeat on each side 3x in total)8 minutes	*(6) Upper limb coordination* * Throwing a bean bag into the air and counting the claps before catching bean bag.(repeat for 20 throws) *Bean bag catching and throwing. Therapist throws bean bag to learner, from 3m away, with right hand while simultaneously learners throws beanbag to therapist with left hand. Swop hands after 20 caught throws. (repeat twice per hand) 8 minutes	*(9) whole body vibration* *lunges performed on the vibrating plate (one leg on plate, lunge forward into knee flexion) (20 repetitions; repeat x3)(settings of 20Hz and amplitude 3mm) 5 minutes	*(4)bilateral coordination* * Jumping in place with arm and opposite leg synchronized. Continue for 2 minutes *'roller jumping':60cm in diameter solid roller wedged into position. Learner stands on one side of roller, puts outstretched arms onto roller and jumps to bring both legs to other side of roller in one movement. Continue for 2 minutes. 4 minutes	

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Approval Notice

Response to Modifications- (New Application)

09-Feb-2016
Kolesky, Jacqueline JM

Ethics Reference #: S15/11/268

Title: **The effects of an eight week grouped exercise programme on gross motor proficiency of children with minimal motor dysfunction.**

Dear Miss Jacqueline Kolesky,

The **Response to Modifications - *(New Application)*** received on **14-Jan-2016**, was reviewed by members of **Health Research Ethics Committee 1** via Expedited review procedures on **09-Feb-2016** and was approved.
Please note the following information about your approved research protocol:

Protocol Approval Period: **09-Feb-2016 -08-Feb-2017**

Please remember to use your **protocol number** (**S15/11/268**) on any documents or correspondence with the HREC concerning your research protocol.

Please note that the HREC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review:
Please note a template of the progress report is obtainable on www.sun.ac.za/rds and should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.
Translation of the consent document to the language applicable to the study participants should be submitted.

Federal Wide Assurance Number: 00001372
Institutional Review Board (IRB) Number: IRB0005239

The Health Research Ethics Committee complies with the SA National Health Act No.61 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 Part 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility permission must still be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Contact persons are Ms Claudette Abrahams at Western Cape Department of Health (healthres@pgwc.gov.za Tel: +27 21 483 9907) and Dr Helene Visser at City Health (Helene.Visser@capetown.gov.za Tel:

+27 21 400 3981). Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

We wish you the best as you conduct your research.
For standard HREC forms and documents please visit: www.sun.ac.za/rds

If you have any questions or need further assistance, please contact the HREC office at 0219389657.

Included Documents:

Cover letter
Checklist
CV M Unger
20160121 MOD Protocol Synopsis
Exercises
Assent form
20160121 MOD Declaration M Steyn
20160121 MOD Cover letter
20160121 MOD CV M Steyn
20160121 MOD PICF
20160121 MOD Exercise schedule
Protocol
Declaration J Kolesky
CV J Kolesky
EC Dept of Education approval
Data collection sheet
Data collect sheet (2)
20160121 MOD Permission letter EC DOE
20160121 MOD Data Collection Sheet
Consent form
20160121 MOD Application & PI Declaration
Declaration M Unger
Protocol Synopsis
Application form_signature page
20160121 MOD Protocol

Sincerely,

Franklin Weber
HREC Coordinator
Health Research Ethics Committee 1

Investigator Responsibilities

Protection of Human Research Participants

Some of the responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the HREC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research.

2. Participant Enrolment. You may not recruit or enrol participants prior to the HREC approval date or after the expiration date of HREC approval. All recruitment materials for any form of media must be approved by the HREC prior to their use. If you need to recruit more participants than was noted in your HREC approval letter, you must submit an amendment requesting an increase in the number of participants.

3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the HREC-approved consent documents, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least fifteen (15) years.

4. Continuing Review. The HREC must review and approve all HREC-approved research protocols at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the HREC approval of the research expires, **it is your responsibility to submit the continuing review report in a timely fashion to ensure a lapse in HREC approval does not occur.** If HREC approval of your research lapses, you must stop new participant enrolment, and contact the HREC office immediately.

5. Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, number of participants, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the HREC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written HREC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the HREC should be immediately informed of this necessity.

6. Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research-related injuries, occurring at this institution or at other performance sites must be reported to the HREC within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the HRECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch Universtiy Health Research Ethics Committee Standard Operating Procedures www.sun025.sun.ac.za/portal/page/portal/Health_Sciences/English/Centres%20and%20Institutions/Research_Development_Support/Ethics/Application_package All reportable events should be submitted to the HREC using the Serious Adverse Event Report Form.

7. Research Record Keeping. You must keep the following research-related records, at a minimum, in a secure location for a minimum of fifteen years: the HREC approved research protocol and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the HREC

8. Reports to the MCC and Sponsor. When you submit the required annual report to the MCC or you submit required reports to your sponsor, you must provide a copy of that report to the HREC. You may submit the report at the time of continuing HREC review.

9. Provision of Emergency Medical Care. When a physician provides emergency medical care to a participant without prior HREC review and approval, to the extent permitted by law, such activities will not be recognised as research nor will the data obtained by any such activities should it be used in support of research.

10. Final reports. When you have completed (no further participant enrolment, interactions, interventions or data analysis) or stopped work on your research, you must submit a Final Report to the HREC.

11. On-Site Evaluations, MCC Inspections, or Audits. If you are notified that your research will be reviewed or audited by the MCC, the sponsor, any other external agency or any internal group, you must inform the HREC immediately of the impending audit/evaluation.