THE EFFECT OF PHYSIOTHERAPY IN A GROUP ON THE MOTOR FUNCTION OF CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER.

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfillment of the requirements for the degree of Master of Science in Physiotherapy

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DECLARATION

I, Julie Brenner declare that this research report is of my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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ABSTRACT

Children with Developmental Coordination Disorder (DCD) are a heterogeneous group who have a marked impairment in the performance of functional motor skills. DCD affects 5-8 % of children in the mainstream educational system, with twice as many boys than girls being affected. DCD often co-occurs with other developmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD), Attention Deficit (ADD), severe learning disabilities and reading disabilities and is often associated with educational, social and emotional problems that often persist beyond adolescence. Current research has shown that children with DCD do not outgrow their motor problems and without intervention they do not improve (Zoia et al, 2006; Barnhart et al, 2003; Peters and Wright, 1999).

The aim of this study was to investigate the effect of an eight week group gross motor intervention programme on 26 children with Developmental Coordination Disorder (DCD) at Forest Town School, which is a special-needs school for children with learning disabilities. The intervention programme consisted of gross motor activities commonly used by the physiotherapists at the school for their DCD groups. The children attended a thirty-minute physiotherapy session a week, in groups of up to 6, for eight weeks.

The children's motor performance was assessed using the Bruininks-Oseretsky Test for Motor Proficiency (BOTMP) pre- intervention, post- intervention and then eight weeks after the intervention had ceased. The children were used as their own controls. The results of the statistical analysis revealed that the mean group gross motor and fine motor scores significantly improved after the intervention. It was found that the gross motor scores improved by a larger percentage than the fine motor, which may be because the intervention consisted purely of gross motor activities. The fine motor scores also significantly improved, implying that there was a transfer or generalisation of skills to the fine motor tasks. The improvement in the motor performance was found to be maintained eight weeks after the intervention was stopped.

It was concluded in the study that the eight week group physiotherapy programme at Forest Town School improved the motor skills of children with DCD and learning difficulties. Physiotherapy in a small group may therefore be a cost effective solution for the treatment of children with DCD in government-funded schools and hospitals that have a limited number of physiotherapists available to treat these children.

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ABBREVIATIONS

ABD- Atypical Brain Development

ADD -Attention Deficit

ADHD- Attention Deficit Hyperactivity Disorder

ADL- Activities of Daily Living

APA- American Psychiatric Association

BC-Battery Composite

BCPS- Battery Composite Point Score

BCSS- Battery Composite Standard Score

BCST- Battery Composite Stanine

BOTMP- The Bruininks- Oseretsky Test for Motor Proficiency

BOTMPSF- The Bruininks- Oseretsky Test for Motor Proficiency Short Form

CNS- Central Nervous System

CSS- Composite Standard Scores

DAMP- Deficits in Attention, Motor control and Perception)

DCD- Developmental Coordination Disorder

DSM-IV- Diagnostic and Statistical Manual of Mental Disorders IV

ELBW- Extremely-Low-Birth Weight

FM- Fine Motor

FMC- Fine Motor Composite

FMCPS- Fine Motor Composite Point Score

FMCSS- Fine Motor Composite Standard Score

FMCST- Fine Motor Composite Stanine

GM- Gross Motor

GMC- Gross Motor Composite

GMCPS- Gross Motor Composite Point Score

GMCSS- Gross Motor Composite Standard Score

GMCST- Gross Motor Composite Stanine

ICD-10- International Classification of Diseases 10

IQ- Intelligence Quotient

MABC- Movement Assessment Battery for Children

MBD- Minimal Brain Dysfunction

MND- Minor Neurological Dysfunction

NDT- Neurodevelopmental Therapy

NTT- Neuromuscular Task Training

PEDI- Pediatric Evaluation of Disability Inventory

PS- Point Scores

RD- Reading Disability

SD- Standard Deviation

SF-Short Form

SFST- Short Form Stanine

SI Therapy- Sensory Integration Therapy

SLI- Severe Language Impairment

ST- Stanine

TOMI- Test of Motor Impairment

CHAPTER 1

INTRODUCTION

Developmental Coordination Disorder (DCD) is the most recent internationally preferred term for a heterogeneous group of children who have insufficient motor skills to cope with the demands of daily living. Previously these children with motor difficulties were referred to either as clumsy, having minimal brain dysfunction, dyspraxic, low toned, or having perceptual, motor or attention deficits (Sugden and Chambers, 2003; Pless et al., 2000). DCD can be diagnosed in children who have a significant motor impairment that cannot be explained by the child's age, intellectual ability, or any other obvious medical or neuromuscular condition. The motor impairment negatively impacts on the child's academic achievement (mostly due to poor hand writing skills) and activities of daily living such as dressing, eating and riding a bicycle. When intellectual impairments are also present, the child's testable Intelligence Quotient (IQ) must be greater than 70 and the gross motor deficit must be greater than that expected for the child's mental age) in order for a diagnosis of DCD to be made (Zoia et al., 2006; Barnhart et al., 2003).

According to the American Psychiatric Association (APA) the prevalence of children with Developmental Coordination Disorder is 5-6% in the U.S.A. with a larger prevalence in boys than girls, with a ratio of at least 2:1 (Zoia et al., 2006; Sugden and Chambers, 2003 and O' Hare and Khalid, 2002). The prevalence was found to be 6- 8.5% in Britain and 5-19% in Australia (Dawson and Puckree, 2006). The prevalence in South Africa is unknown.

Children with DCD differ in the degree of their impairment, varying from mild to severe. Variety in the extent to which their daily tasks are affected also occurs i.e. from affecting nearly every task, to only specific activities (Missuina et al., 2003; Kaplan et al., 1998). Gross motor and postural functions and/or fine motor manipulative skills that need eye-hand coordination as well as other co-morbid conditions such as non-verbal learning disabilities, speech and language problems and attention deficit disorder, may also be

present. The full extent of the child's disabilities may not be apparent until they reach school-going age (Watemberg et al., 2007; Missuina et al., 2003; Macnab et al., 2001; Kaplan et al., 1998).

Although children with DCD are a varied group, there are some movement impairments which are common to the population. Many studies have described these children as having slow reaction and movement times, as well as relying on other senses, especially vision, to control movement. Selecting and planning the best motor response for a task is also difficult, and the same motor response is repetitively used for an activity even when its outcome is unsuccessful (Missuina et al., 2003).

Children with Developmental Coordination Disorder often have soft neurological signs such as hypotonia, persistence of primitive reflexes and poor strength and coordination. They may also have poor visual perception, spatial organization and sequencing skills, as well as joint laxity (Steyer, 2006; Missuina et al., 2003). This dysfunction interferes with their gross motor functioning and they often have unusual running patterns, fall easily, have poor balance reactions, are unable to imitate body positions and struggle to follow more complex motor commands. As a result, they tend to withdraw from sporting activities, which in turn leads to secondary sequelae such as poor muscle strength and power, and reduced opportunity to practice gross motor skills (Barnhart et al., 2003; Missuina et al., 2003).

Fine motor problems are commonly noticed when the child presents with handwriting or drawing difficulties. Legible handwriting is an important measure of academic success. It is a complex sensorimotor task and an essential life skill. Handwriting issues are the most common reason for referral to therapists. Children with DCD often have difficulty planning and executing other fine motor tasks such as gripping and dressing e.g. tying shoe laces, fastening buttons (Steyer, 2006; Barnhart et al., 2003; Missuina et al., 2003).

DCD also has social and behavioural consequences. Children may have decreased self-esteem which results in isolation from their peers and poor social participation. They may also present with poor concentration and distractibility which may result in behavioural

difficulties. Refusal to go to school or avoidance of challenging tasks may be further consequences (Barnhart et al., 2003; O'Hare et al., 2002).

In the past, parents were told that their children would outgrow DCD, however current research has shown that they do not improve without intervention (Barnhart et al., 2003). A number of studies have shown that motor skill intervention has a positive effect on the motor skills of children with DCD. In a study by Schoemaker et al (1994), children were found to have improved significantly after a three month treatment period using Bobath NDT principles and sensorimotor training. The children were treated twice a week on an individual basis. Pless et al (2000) reported that in a study by Revie and Larkin (1993), task specific training twice a week for 3 months produced a significant difference in the performance of the tasks taught during the three month intervention. In a study by Pless et al (2000), the effectiveness of an intervention consisting of a physical activity group conducted by a physical educator, once a week, for ten weeks was evaluated. The authors concluded that children with borderline motor disabilities benefited from the intervention, but children with definite motor problems did not. Watemberg et al (2007) concluded in their study that their four week, 8 session combined-therapy approach was effective in improving the motor skills of children with combined ADHD and DCD.

The identification and progress of children with DCD requires a comprehensive evaluation of the child's motor performance by a valid and reliable standardised test (Crawford et al., 2001). The Bruininks- Oseretsky Test for Motor Proficiency (BOTMP) is widely used by paediatric therapists as a standardised assessment tool as it measures skills that are important to paediatric practice (Wilson et al, 1995). The test can be used in children from the age of 4 ½ to 14 years of age who have mild motor problems. The complete test has 46 items that are divided into eight subtests which make up the Gross and Fine Motor Composite scores as well as the Battery Composite score. Bruininks (1978) reported test- retest reliability figures to range from .77 to .85 for Gross motor, .68 to .88 for Fine motor and .86 to .89 for Battery Composite scores. The intra- rater reliability was only tested for one subtest i.e. Visual-Motor Control and was reported to range from .77 to .97 for individual test items. According to Wilson et al (1995), the BOTMP is an appropriate evaluative tool for children with motor problems.

At Forest Town School for children with cerebral palsy and learning disabilities, physiotherapists must prioritise more severely affected children due to large caseloads. Children with developmental coordination disorder are treated in groups, once a week for six months or a minimum of 10 sessions. They are then placed on a waiting list for the next group rotation. A typical Gauteng Department of Education (G.D.E.) school year consists of four terms with approximately 10 weeks in each term. Each child in a group may therefore receive a maximum of 10 sessions of physiotherapy a term. However, other events such as class outings, sports days, absenteeism, exams etc may interrupt physiotherapy sessions. This means that realistically each child will only receive approximately 8 sessions of group physiotherapy a term. Physiotherapy in a group at Forest Town School is based on Bobath NDT principles and strength training. Activities to improve strength (especially in the shoulders and trunk), balance and coordination are used with the aim to improve motor skills. Most of the children in the groups have therefore had ongoing rotations in the physiotherapy groups with only a few entering their groups without having had physiotherapy intervention previously.

1.1 Aims of the Study

The present study was undertaken to evaluate the efficacy of the group motor skill intervention currently being offered at Forest Town School. The aim of the study was to establish the effect of physiotherapy in a group for one term, on the motor abilities of children with developmental coordination disorder with learning disabilities. The BOTMP was used to measure the children's motor skills pre and post treatment.

1.2 Objectives of the Study:

The first objective of the study was to measure the effect of eight weeks (one term) of gross motor intervention in a group on the motor performance of children with developmental coordination disorder at Forest Town School. The second objective was to establish which areas of motor performance the intervention had the most affect on.

1.3 The Significance of the Study

Children with DCD have been treated in groups at Forest Town School for many years. The effectiveness and outcomes of these groups have not been sufficiently evaluated. A successful, effective intervention in the current study was assumed if the mean group scores improved by one stanine i.e. at least 4 Bruininks- Oseretsky Composite Standard Score points. The outcome of the study will aid in determining whether the group treatment programme should be revised and changed or whether the group programme is effective for treating children with DCD and should be continued.

Children with DCD in South Africa who rely on therapists in government funded schools and in public hospitals for care seldom receive the specialised physiotherapy treatment that has been found to improve their functional outcomes. This is due to staffing constraints and the prioritising of children with more severe physical disabilities. The physiotherapists in these government institutions may find group physiotherapy a solution to address the therapy needs of children with DCD who constitute 5-8% of the school going population.

CHAPTER 2

LITERATURE REVIEW

The referenced articles in the literature review were located and found through searches on search engines such as PubMed as well as searches on popular journals, such as Developmental Medicine and Child Neurology, online archives for articles with keywords such as DCD. Keywords such as Developmental Coordination Disorder, physiotherapy, group therapy and motor performance were used in the searches. Some of the articles were located by reading through the reference lists of a previously reviewed article. The articles were located and accessed online through the University of the Witwatersrand E-journal portal. A hand search through the paediatric therapy journals archives at the Wits Medical School Library was also done. An ample amount of research was found in the literature on the sensorimotor, visual motor, gross motor and psychosocial problems linked to children who have been diagnosed with Developmental Coordination Disorder. There is however a scarcity of research evaluating the effect of physiotherapy in a group on the gross motor function of children with DCD.

2.1 Developmental Coordination Disorder

For the past century, poor motor coordination in children has been acknowledged as a developmental problem. Terms such as clumsy, awkward, developmental apraxia, perceptual motor difficulties, mild motor problems, low toned, minimal brain dysfunction, minimal cerebral palsy or sensory integrative dysfunction have been used to describe children with this developmental problem (Barnhart et al. 2003; Missiuna et al., 2003; Sugden and Chambers, 2003; Dewey and Wilson, 2001). In 1994, an International Consensus Meeting on Children and Clumsiness was held in London, Ontario, in Canada with the aim to reach an international consensus on the definition and a name for this disability. At this meeting it was agreed upon that the Diagnostic and Statistical Manual

of Mental Disorders IV (DSM-IV) term Developmental Coordination Disorder (DCD) should be used (Dewey and Wilson, 2001).

2.1.1 Definition

The DSM-IV has specific criteria to assist in describing DCD. According to the criteria, a diagnosis of DCD can be given to children who: 1) have a marked impairment of motor skills or motor coordination; 2) these motor problems significantly impact on the child's academic performance or activities of daily living (ADL); 3) have no other medical or neurological explanation that would exclude this diagnosis. That is, the child must not have any disturbance in muscle tone (ataxia or spasticity), sensory loss, or involuntary movements; and 4) the motor delay is in excess of that expected for the child's intellectual ability. If mental retardation is present, the child must have an IQ of above 70 and the motor impairment must be greater than that anticipated for the IQ. A child diagnosed with DCD may not meet the criteria for a diagnosis of Pervasive Developmental Disorder (PDD) (Magalhães et al., 2006; Barnhart et al., 2003; Dewey and Wilson, 2001). The International Classification of Diseases 10 (ICD-10) classifies Developmental Coordination Disorder as a "Specific developmental disorder of motor function" (Dewey and Wilson, 2001).

2.1.2 Prevalence

The prevalence of DCD is estimated to be between 5-8% of school-going children, with twice as many boys being diagnosed than girls. A higher incidence of DCD may occur in children who have a history of pre-natal or peri-natal difficulties (Davis et al., 2007; Barnhart et al., 2003; Dewey and Wilson, 2001). In their study to ascertain the occurrence of DCD in children who were born at extremely-low-birth weights (ELBW; less than 1000g) or very preterm (less than 28 weeks), Davis et al. (2007) found that these children had significantly inferior motor skills compared to children with normal birth-weights. They also found that the strongest risk factor for DCD for these children was their sex i.e.

ELBW/very preterm males were especially at risk. Davis et al. (2007) further established that ELBW/very preterm children had poorer cognitive functioning (lower IQ's), delayed academic progress (especially in mathematics), and more behavioural problems when compared to ELBW/very preterm children without DCD at the age of eight years. They concluded that minor motor impairment had adaptive functioning implications, and because motor problems and DCD could be identified in the preschool period, it could help with early identification of children at risk for learning and behavioral difficulties (Davis et al., 2007).

2.1.3 Aetiology

Due to the heterogeneity of DCD, identifying its cause has been complex. A number of theories have hypothesized that the aetiology of DCD is part of the continuum of cerebral palsy; is secondary to pre-, peri- or neonatal damage; or is secondary to neuronal damage at the cellular level in neurotransmitter or receptor systems. Relating the observed motor impairments and difficulties in DCD to the primary impairment or neuropathology with standard and non-standard tests, is difficult (Barnhart et al., 2003). Current theories propose that difficulties found in children with DCD result from abnormalities in neurotransmitter or receptor systems rather than from specific brain areas or neuronal groups (Barnhart et al., 2003).

2.1.4 Development of Motor Control

A number of theoretical models exist to explain the function of the central nervous system (CNS) in motor development. The impairments of motor control in children with DCD can be explained using these models. Many years ago Neural-Maturationist Theories, such as the out-dated primitive reflex model as theorized by Peiper in the 1960's, were widely accepted (Barnhart et al., 2003; Hadders-Algra, 2000). It postulated that as development occurred, the higher centres of the brain exerted increasing motor control over the lower reflex centres. It was based on a theory of a hierarchy of motor

control in which the higher centres of the brain were able to carry out a motor plan without feedback from lower centres of the CNS. They also believed that basic motor skills such as standing and walking were not learned by experience, but were a result of cerebral maturation (Barnhart et al., 2003; Hadders-Algra, 2000).

More current theories propose complex interaction between the different levels of the CNS. In the Dynamic Systems model proposed by Kugler et al. and Schöner et al. in the 1980's, sensory feedback is analysed by the CNS and a suitable motor plan is selected depending on current experience, internal and external environmental factors, and memory of similar movements (Barnhart et al., 2003; Hadders-Algra, 2000).

The Neuronal Group Selection Theory includes aspects of both these models. This model proposes that functional neuronal groups occur at all levels of the CNS and are determined by evolution. Their functional integrity depends on the afferent information acquired by movement and experience. These genetically determined neuronal groups (interconnected neurons) in the cortical and sub-cortical structures serve as an early repertoire for movement or receipt of specific sensory information (Barnhart et al., 2003; Hadders-Algra, 2000).

This model has two phases: the first is the primary variability phase which consists of erratic movements that don't need sensory information for its initiation or guidance. These self generated general movements (GM's), present in the human foetus and newborn infant up to about 4 months of post-term age, give rise to afferent (kinaesthetic and visual) inputs that reinforce specific synaptic connections in each group. Cortical synaptogenesis is abundant in this phase and all goal directed movements start at this stage during infancy (Hadders-Algra, 2000). An intermediate period in which effective patterns are chosen is followed by the secondary or adaptive variability phase. The creation of secondary cortical repertoires, are associated with extensive synaptic rearrangement, which is the result of synapse formation and elimination. It is facilitated by progressively shorter processing times which can be attributed partially to ongoing myelination (Hadders-Algra, 2000). Sensory and motor factors interact in this phase to create the intercellular synapses that produce specific and complex muscle contractions

which constitute coordinated, goal directed movements. Each repetition of a functional movement reinforces the reciprocal connections between neuronal groups coordinating movements in various other parts of the body. As the more efficient movement patterns are practiced, the appropriate synaptic circuits are reinforced and established (Barnhart et al., 2003).

The ability to select adaptive variations, generate the most efficient movement pattern, attend to sensory feedback (visual, kinaesthetic and proprioceptive) to choose the most efficient strategy to apply in a particular situation and the idea of variable application of strategies and use of feedback corresponds to the stages of acquisition of skilled movement. The first cognitive stage of learning consists of variability as the child gets the general idea of the movement and chooses the most efficient motor pattern to use. In this phase the child needs to attend to and assimilate past experience with feedback from the environment (Missiuna et al., 2003). In the second associative stage, the child learns to carry out skilled accurate movements and respond to sensory feedback as they detect and correct errors. In the third phase the movement is automated and less conscious attention of the feedback is required to perform the movement (Missiuna et al., 2003).

2.1.5 Effects of DCD on Motor Function

Dysfunction in children with developmental coordination disorder impacts on 3 different areas of their lives: gross motor and fine motor function, as well as psychosocial function

2.1.5.1 Gross Motor Function

Like that found in the early stages of motor learning, children with DCD lack adaptability and flexibility in their movement and demonstrate inaccurate motor behaviour that lacks fluency. They demonstrate slow reaction and movement times (Missiuna et al., 2003). They tend to work more slowly, or sacrifice speed for accuracy (Dewey and Wilson, 2001). Children with DCD rely on vision more than any other sensory input to control

movement, well past the age that typically developing children would rely on vision (Missiuna et al., 2003; Dewey and Wilson, 2001). In a study by Deconinck et al. (2006) on the effect of vision on walking in children with DCD, it was found that in normal lighting, children with developmental coordination disorder and typically developing children had similar gait patterns, except for a slightly longer support phase in children with DCD. In the dark however, the DCD group had decreased step frequency and step length resulting in slower walking velocity. They also found a larger medio-lateral excursion of the centre of mass, indicating a longer support phase. They concluded that children with DCD depended more on visual feedback than typically developing children for the maintenance of balance and velocity control in walking (Deconinck et al., 2006).

Other studies have found children with DCD to have: deficits in the timing of actions; difficulty in maintaining their postural stability; weak integration of the components needed in dynamic motor control i.e. proprioceptive, kinaesthetic and visual (Dewey and Wilson, 2001). Some researchers have suggested that children with DCD do not have anticipatory control strategies, but rely on feedback, especially visual, to control movement. Anticipatory motor control involves preparatory movements that occur before and during the task, as well as those to support that movement. It is a state of readiness seen in pre-movement organisation (or "postural biasing") and is a prerequisite for coordinated, efficient movement (Missiuna et al., 2003). Children with coordination problems have also been described as repeatedly doing the same task the same way, regardless of their success with the task. It was proposed that this occurred because children with DCD do not effectively use the feedback from their previous experience of the task. They have difficulty understanding the demands of the task and its components and they may attend to incorrect cues and not more relevant aspects of the feedback (Missiuna et al., 2003).

Children with DCD often use "fixing" of their joints during activities. Fixing is defined as stabilizing one joint or part of the body so that another part can be moved with better control (Missiuna et al., 2003). This leads to the stiff, awkward and clumsy appearance of movement seen in children with DCD. It also increases the time taken to adapt to changes in their movement environment. They are more likely to be become fatigued and to be

inconsistent when performing a task when they use fixing strategies (Missiuna et al., 2003).

In children with DCD; besides the poor ability to attend to sensory feedback during the performance of the movement, and the lack of control to alter the degrees of freedom of joints (fixing) to permit more efficient, flexible and adaptive movements; another rate-limiting factor may be the manner in which they activate their muscles during activities that require co-activation (Missiuna et al., 2003). Children with DCD use different neuromuscular strategies to their age-matched peers. Compared to typically developing children, in unilateral reaching tasks children with DCD have a delayed onset of antagonist muscle activity and a longer duration of agonist activity. In asymmetrical bilateral reaching, children with DCD use variable strategies changing the onset of one or both agonist and antagonist muscle groups, whereas their peers change only the duration of antagonist muscle activation (Missiuna et al., 2003). Raynor (2001) found that children with DCD produced lower levels of maximal strength and power compared to their age-matched typically developing peers. She also found an increased level of co-activation in knee flexion/extension tasks and less effective methods of muscle organisation, especially when their balance was challenged (Raynor, 2001). These inefficient patterns of muscle activation are believed to contribute to slower and more variable movement times.

Children with DCD have also been shown to have poor eye-hand co-ordination, in that they have difficulty linking sequential shifts of gaze and hand needed to carry out everyday tasks. They also have inter-limb co-ordination problems. Inter-limb co-ordination is important for many activities of daily living such as running, intercepting objects while moving, and locomotor transitions. Children with DCD often find these activities difficult (Zoia et al., 2006). Co-ordination problems in children with DCD can result from a combination of one or more impairments in proprioception, motor programming, timing, or sequencing of muscle activity (Barnhart et al., 2003).

Children who have DCD are a heterogeneous group and may differ in the degree of involvement, from mild to severe, and in the degree to which the condition impacts upon their daily activities (Missiuna et al., 2003; Macnab et al., 2001). It may only affect

specific tasks or nearly every activity. Gross motor and postural functions, or only fine motor manipulative skills needing eye-hand coordination may be involved (Missiuna et al., 2003). Many children have features of poor cerebellar function reflected in difficulties in posture, balance and control of fast accurate movements (O'Hare and Khalid, 2002). Although DCD theoretically is present from birth, the age of apparent onset may differ. The full extent of their difficulties may not be obvious until they reach school going age where the child is required to perform skills that require adaptation in speed, timing, force or distance (Missiuna et al., 2003).

Many children with DCD display neurological soft signs such as hypotonia, persistent primitive reflexes, and immature balance reactions. These along with sensorimotor dysfunction, muscle activation abnormalities which affect strength and power, as well as other associated conditions such as Joint Hypermobility Syndrome (in a study by Kirby and Davies (2006), thirty seven percent of the children displayed symptoms of Joint Hypermobility Syndrome) may hinder gross motor development. These children may demonstrate awkward running patterns, fall frequently, drop items, have difficulty imitating body positions and following 2 to 3-step motor commands, and have poor co-ordination, strength and power capabilities for activities such as jumping, hopping and running (Barnhart et al., 2003; Raynor, 2001). In a study by O' Hare and Khalid (2002) to evaluate the association between abnormal cerebellar function in children with DCD and reading difficulties, they found that three activities included in the parental questionnaire on gross motor skills distinguished the children with DCD from typically developing children. They were: catching a ball, jumping on a moving playground roundabout and writing. Because of their poor motor performance, children with DCD avoid physical activity which may lead to a further reduction in their strength and endurance as well as have an impact on their social interaction and development (Barnhart et al., 2003; Missiuna et al., 2003).

2.1.5.2 Fine Motor Function and Activities of Daily Living (ADLs)

Handwriting and drawing difficulties are often the first sign of fine motor problems in children with DCD. Their pencil grasp patterns are immature and they seem to exert excessive pressure in their written work, seemingly related to poor distal control of movement (Dewey and Wilson, 2001). In a study by Rodger et al. (2003) on the motor and functional skills of children with DCD, they found that 31% of the children used immature pencil grasp and scissor prehension patterns. They also found that the children with DCD scored averagely in the social and mobility measures of the Pediatric Evaluation of Disability Inventory (PEDI). They did however score below the average range in the self care function. Activities such as putting toothpaste on the toothbrush, brushing tangled hair, nose care and tying shoe laces were especially difficult (Rodger et al., 2003). A qualitative study by Summers et al. (2008) confirmed that in children who have DCD, their motor difficulties impact significantly on their ability to perform self-maintenance activities, relative to their typically developing peers. Problems such as: slowness in carrying out the activity, problems with spatial orientation (buttons in the wrong holes, clothes back to front, socks upside down, shoes on the wrong feet), dressing (poor balance in standing so they have to sit down to put on pants, putting both legs in the same pants hole), controlling the flow of tooth paste from the tube and coordinating the brushing of their teeth, drying their body or hair after a bath, coordinating the use of utensils when eating, were all reported by the parents in the focus groups (Summers et al., 2008). Teachers report that these motor problems affect the child's abilities in physical education classes, writing, handling equipment in science classes, arts and crafts, as well as being able to move around the class without bumping into objects or other children (Dewey and Wilson, 2001).

2.1.6 Psychosocial Function

Children with DCD judge themselves to be less competent socially, and more introverted and anxious compared to their typically developing peers. In a study by Green, Baird and Sugden (2006) on the psychopathology of children with DCD, they found that 85% of the

47 children (mean age 8 years, 1 month) in their study with DCD had significant problems on at least one of the subscales of the Strengths and Difficulties Questionnaire (SDQ), which consists of 25 questions concerning the emotional and behavioural attributes of the child. Their parents reported a significant impact of these symptoms on their daily life. The study could not correlate age, gender or degree of motor impairment to the emotional and behavioural problems. However, they did find that in 7- and 8- year olds, inattention/hyperactivity was reported more often and that girls had more peer problems than boys (Green et al., 2006) Teenagers with DCD are well aware of their physical difficulties and this has a significant impact on their social and emotional well being (Dewey and Wilson, 2001). They may act out in class more often than other children, may become the class clown or find other less socially desirable means to gain attention. Adolescents with DCD have been found to have fewer friends, more anxiety and lower self worth than their peers or younger children with DCD (Barnhart et al. 2003).

2.1.7 Subtypes and Co-morbidity

Understanding the different subtypes and co-morbidities a child with DCD may have is important, as it may increase our knowledge of the specific problems a child may experience, and improve the diagnosis and treatment of children with this disorder (Visser, 2003).

There are many inconsistencies in the literature on the description of DCD. These may be due to the existence of discreet subtypes (Macnab et al., 2001). The distinctions which give rise to more defining subtypes are often made on either the extent of the motor problems or whether the fine motor difficulties are greater than the gross motor problems, or the complexity of the motor skills (perceptual motor problems) (Green, Chambers and Sugden, 2008). Macnab and colleagues (2001) found 5 different subtype profiles: 1) children with better gross motor than fine motor skills (but still below average); 2) poor kinaesthetic ability and balance (normal visuo-motor and visuo-perception skills); 3) poor kinaesthetic and visual skills (greatest overall involvement); 4) poor visual and dexterity,

but good on kinaesthetic tasks; and 5) good in visual–perceptual skills, but poor in running speed and agility compared to DCD peers. In a review of the literature, Green et al. (2008) found that Hoare (1994) established similar subtypes to Macnab et al. (2001). They included patterns of perceptuo-motor dysfunction including: 1) poor dynamic balance and kinaesthetic acuity; 2) visual perception competency with poor kinaesthetic acuity; 3) visual-motor deficits; 4) poor static balance and visual perceptual/visual motor functions; and 5) poor static and dynamic balance. Green et al. (2008) found similar clusters in their study. They were: 1) weak kinaesthesis; 2) poor static balance; 3) weak static and dynamic balance; 4) poor manual dexterity and perceptual skills; and 5) poor in all items. In their study, the 43 children with DCD were randomly divided into groups that each underwent one 6 month period of treatment over a period of 2 years, with reassessments after each 6 month period. They found that children in clusters 4 and 5 had the highest degree of motor impairment; clusters 2, 4 and 5 made little or no progress without treatment, and children in cluster 2 actually got worse prior to treatment; children in cluster 1, 2 and 4 responded well to treatment, making a categorical change in their motor difficulty; proportionally fewer children in clusters 3 and 5 changed category with more children in cluster 5 continuing to have difficulties at the end of the study. Green et al. (2008) proposed that visual perceptual problems may have a poorer outcome with or without treatment and/or associated co-morbid conditions. Analyses in their study showed that significantly more children with a co-morbid diagnosis did not make progress during the study; however a third of them did make good progress. Seventy six percent of the children with definite and severe motor problems had improved their category by the end of the study. They found that children with severe motor problems have a greater range of difficulties at a more profound level, but these children can also improve. They concluded that progress in motor skills after intervention was not related to initial severity or subtype (Green et al., 2008).

Research has shown that various developmental problems tend to occur together i.e. ADD (Attention Deficit), ADHD (Attention Deficit Hyperactivity Disorder), Reading Disability (RD) and SLI (Severe Language Impairment). Children with DCD differ too in the extent to which they exhibit co-occurring conditions (Kaplan et al., 2006; Missiuna et al., 2003; Visser, 2003; Macnab et al., 2001; Kaplan et al., 1998). In a study by Kaplan et

al. (1998) on 115 children referred for learning or attention problems, they found that co-morbidity was 'the rule rather than the exception'. Of the 115 children, they classified 53 cases as "pure" and met the criteria for either DCD, ADHD or RD, and 62 were co-morbid cases. Of the 62 co-morbid cases, 39 children met the criteria for 2 problems and 23 met the criteria for all 3 developmental problems (Kaplan et al., 1998). In a study by Watemberg et al. (2007) on physiotherapy intervention in children with DCD/ADHD found that 55% of the 96 children with ADHD also had co-occurring DCD. This was in agreement with other studies reporting a co-occurrence of 50%. Watemberg et al.'s (2007) study showed that DCD co-occurred more frequently in children with inattentive ADHD. They also found that children with ADHD/DCD had a higher incidence of specific learning disabilities and phonological deficits than children with only ADHD.

Kaplan et al. (2006) presented a series of investigations they had conducted on school-aged children and analysed the data to investigate the relationship between DCD, ADHD and RD. The three sets of analyses concluded that: co-occurrence of more than one disorder was more common than not for children with DCD; poorer performance on tests of memory and visual-motor skills, more prevalent behavioural problems and more impairment in everyday functioning were associated with a higher number of co-existing disorders in children with ADHD; and that there was a linear relationship between the severity of DCD and impairments in the cognitive and psychosocial skills that were assessed (Kaplan et al., 2006).

Researchers investigating the issues of co-morbidity are now questioning whether children with these co-occurring problems exhibit two or more separate disorders, or a number of symptoms associated with a single underlying condition. A number of theories based on the concept that developmental disorders are related to anomalous brain development of some kind have come to light in the past (Kaplan et al., 2006). Terms as such as Minimal Brain Dysfunction (MBD) were popular many years ago but fell out of favour because the word 'damage' was inappropriate for developmental disorders, and too many heterogeneous conditions were grouped into one diagnosis. In the 1980's the term Minor Neurological Dysfunction (MND) was used and focused more narrowly on the association between neurological 'soft signs' and motor dysfunction. According to the

MND concept ‘soft signs’ could indicate a nervous system that was wired abnormally and was vulnerable to exogenous influences such as disease, uninformed rearing practices and poor psychosocial conditions (Kaplan et al., 2006). The concept of DAMP (deficits in attention, motor control and perception) represents a specific disorder and therefore differs from MBD and MND. It implies that the problems in perception, motor control and attention are three dimensional in nature. They suggest that children with severe DAMP fall into the lowest portion of the normal distribution with regards to their perception, motor and attention skills. They are also are more likely to display co-occurring problems in cognition. A generalized causal factor is therefore suggested for symptoms of DAMP (Kaplan et al., 2006; Visser, 2003)

The concept of Atypical Brain Development (ABD) introduced by Kaplan et al. (1998) refers to developmental variation in the brain and represents a single underlying disorder. The concept suggests that variable brain structure and functioning result in individual differences in behaviour, and that ultimately, individual differences are the result of a complex interaction between genes and environment. The use of ‘atypical’ implies that the brain functioning is not limited to dysfunction or damage but may result in exceptionally high skills as well as impairments. They imply that ABD is a diffuse dysfunction of the brain, rather than localized, and that there are no discreet developmental disorders (Kaplan et al., 2006; Visser, 2003; Kaplan et al., 1998).

2.1.8 DCD in Adolescence and Adulthood

Previously parents were told that their child would outgrow their ‘clumsiness’. However, current research into the prognosis of DCD has found that children do not outgrow their motor problems, and without intervention they will not improve (Barnhart et al., 2003).

Cantell and colleagues (2003) conducted a study to assess the outcomes of early motor delay in a group of 17-18 year old Finnish adolescents who were originally evaluated at age 5 and then at 15. Sixty five adolescents took part in the study; 22 with significant motor problems; 23 with minor motor problems (intermediate group); and 20 controls.

The aim of the study was to reassess the results they found when they were 15 years of age and to assess whether the variables used previously could still discriminate between the DCD (significant motor problems), intermediate and control groups at age 17. They found that the DCD group performed worse than the control group on all perceptual motor tasks, and that the intermediate group performed at a level between the DCD and control groups. It was harder to distinguish between the control and intermediate group at 17 compared to age 15. The IQ results together with the vocational choices in the adolescents with persistent DCD indicate a low school achievement and motivation history. They chose vocation training rather than a long high school career. They were also reported to be immature for their age by their parents. The study concluded that two patterns of perceptual motor outcome emerged among adolescents with an early diagnosis of motor problems: persistence and resolution. Children with more definite motor problems in the DCD group were still distinguishable from their peers at age 17, where as the intermediate group with a similar early diagnosis had shown only minor perceptual motor problems, performing close to the level of the control group (Cantell et al., 2003).

To investigate the effects of DCD in adulthood, Cousins and Smyth (2003) recruited 19 adults aged between 18 and 65, with age and gender matched controls. Participants were given tests of manual dexterity, handwriting, construction, obstacle avoidance, static balance, dynamic balance, dual task performance, ball skills, movement time, reaction time and sequencing. They found that the adults with DCD performed more poorly in all the tasks compared to the controls, and that slowness and variability of movement was characteristic. The DCD adults seemed to trade speed for accuracy. Many of the DCD adults also had significant problems with sequencing and dual task performance. Interestingly, the investigators performed a discriminative function analysis of 6 measures which accurately classified participants as car drivers or non-drivers due to poor motor skills. Cousins and Smyth (2003) concluded that adults with DCD do retain their motor difficulties which can exclude them from important activities of daily living and restrict their social and employment opportunities.

Evidence therefore shows that at least half the children with DCD may resolve their motor problems by adolescence. However, the other 50% of children with significant

motor impairments have persistent motor problems throughout their adult life, which may impact on their activities of daily living as well as their social and employment outcomes. It is therefore important to employ effective intervention programs early in childhood as well as vocational counselling for adolescents to avoid the carry over of negative perceptual motor experiences to academic and social outcomes (Cantell et al., 2003).

2.2 Therapeutic Intervention

2.2.1 Intervention Approaches

Intervention strategies in the treatment of children with developmental coordination disorder are diverse, and their efficacy is controversial. Approaches to intervention have been based on competing motor development and motor skill acquisition theories, and are divided into two categories: 1) process or deficit-orientated approaches; and 2) approaches that teach specific functional skills such as task specific interventions and cognitive-motor approaches (Sugden, 2007; Mandich et al., 2001).

Process or deficit–orientated therapies such as Sensory Integration Therapy and Perceptual Motor Training are traditional intervention approaches which aim at remediating underlying processing deficits and facilitating neuromaturational development. Intervention targets neural structures such as the cerebellum, or sensory processes such as vision or proprioception, based on the assumption that there is a direct link between underlying processes and functional performance (Sugden, 2007; Mandich et al., 2001).

The second category of functional skills approaches utilizes cognitive-motor and task-specific interventions. Task specific interventions focus on teaching the task to be learned that is causing the child difficulties (Sugden and Chambers, 2003). These interventions are based on the assumption that performance is the result of learning, and learning is most effective when teaching the target task. The task to be learned may be broken into

components, or steps, which are taught separately, and then put together in order for the task to be completed as a whole. The transfer and generalization of skills to other activities must be taught specifically, by grouping similar tasks together (Niemeijer et al., 2007; Mandich et al., 2001). Cognitive motor interventions emphasize the planning and execution of movement and the use of cognitive skills in problem solving thus facilitating task acquisition (Sugden, 2007; Barnhart et al., 2003).

In a systematic review by Mandich et al. (2001) of the various types of treatment approaches used to intervene in children with developmental coordination disorder, the conclusion was made that there was a lack of evidence to endorse any one type of approach. The overwhelming conclusion from the literature is that most interventions appear to work but no specific approach is superior (Peters and Wright, 1999). Other reviews have found that the functional skill-specific intervention studies have had a larger treatment effect size than SI Therapy studies (Sugden, 2007; Barnhart et al., 2003). These reviews indicated that therapists often use a combination of approaches and rely on their clinical judgment to determine the best approach for each individual child, depending on the child's specific needs (Sugden, 2007; Mandich et al., 2001).

2.2.2 Physiotherapy Intervention

The underlying principle for physiotherapy intervention in developmental coordination disorder, is based on the theory that muscle strengthening, improved trunk control and repeated training with progression in difficulty, improve motor control and performance, and the skill to cope with different motor activities. There is a lack of studies to be found in literature on the role of physiotherapy in the treatment of developmental coordination disorder (Watemberg et al., 2007). There are even fewer articles on the effectiveness of physiotherapy in a group.

2.2.2.1 Individual Therapy

The most comprehensive study on the effects of physiotherapy for children with developmental coordination disorder was published by Schoemaker et al. (1994). In their study, eighteen "clumsy" children who met their selection criteria participated in the study. These children were in the lowest 5 percent for their age related norms on the Test of Motor Impairment (TOMI) were considered to be in need of intervention. The mean age of the children was 7 years and 4 months. Children who attended special schools or had received previous treatment for movement problems, were excluded. The children in the study group first underwent a 3 month period of no therapy after their initial assessment. They were then individually examined on the TOMI (Test of Motor Impairment) and MABC (Movement Assessment Battery for Children- a general motor co-ordination test) before undergoing a three month period of physiotherapy. The intervention was conducted for each child on an individual basis by the same physiotherapist, twice a week for 45 minutes, over a period of 3 months. The physiotherapy treatment consisted of a combination of Sensorimotor Integration and Bobath (NDT) therapy. The children were reassessed post intervention and then again following a further three months (with no intervention), thus acting as their own control (Schoemaker et al., 1994).

A control group of 18 children, matched to the age and sex of the children in the study group, was also used for comparison. This group scored within the normal range on the TOMI and MABC (Schoemaker et al., 1994).

Schoemaker et al. (1994) showed a significant improvement in the study group's TOMI scores after the 3 month intervention period, as opposed to no significant improvement in the control group's scores. They also found that the effect of the therapy was maintained for 3 months after the intervention. They concluded that the effects of treatment were transferred to skills, as the exercises in the programme were different to the tasks in the test items (Schoemaker et al., 1994).

Schoemaker et al.'s (1994) study was methodologically sound and they used valid and reliable measurement instruments. The effects of normal development were eliminated by having a 3 month period of no therapy prior to the intervention for the study group in which no change in their gross motor performance was recorded. A period of 3 months with no intervention after the therapy programme, followed by a re-assessment, substantiated the fact that treatment effects were maintained after therapy. The conclusions of the study were that their physiotherapy programme had been effective for clumsy children because all eighteen of the children in the study group improved their motor skills.

A South African pilot study by Stevens (2002), measured the efficacy of postural exercises (using the NDT approach) on fine motor function in 15 children with minor motor difficulties. Two groups of children were compared over a 3 month treatment period, using the BOTMP. Group A only received individual physiotherapy which lasted for 45 minutes once a week and Group B received individual physiotherapy and a home exercise programme. Both groups showed improvement in their fine motor function, with group B showing a greater improvement. However, the difference between the mean group fine motor improvement between group A and B was not statistically significant ($p=0.06$). A greater number of children in Group B compared to Group A reached their desired chronological fine motor age, which was significant ($p=0.04$). Stevens (2002) study had a small sample size ($n=15$) with only 7 children in group A and 8 in group B, thus making it difficult to generalise the results to the general population. The BOTMP fine motor scores were used to evaluate the fine motor function. As this test does not evaluate the quality of the movement or ADL functional activities, the impact of the improvement on their every day life and functioning was not determined.

Sugden and Chambers (2006) investigated the effect of a 16 week intervention carried out by teachers and parents on 26 children with DCD. They monitored the children's motor performance, educational performance and self-concept over a 4 year period. They found that after intervention 14 of the 26 children had shown improvement and stability in all areas, eight of which no longer displayed symptoms of DCD. Eight of the 26 children had profiles of variability in that they moved in and out of the DCD classification (they

improved after intervention but slipped back into a DCD classification when intervention ceased), and 4 children showed no improvement. They concluded that for over half the children in their study intervention was effective and permanent in nature. There was however a group of children for whom it was short lived and only effective for the duration of the intervention, and in a small group of children, intervention had no effect (Sugden and Chambers, 2006).

2.2.2.2 Group Therapy

While Schoemaker et al. (1994), Stevens (2002) and Sugden and Chambers (2006) treated the children individually; other studies have assessed the effectiveness of group physiotherapy for children with DCD. Pless et al. (2000) is one such study. In their study, 17 five-to-six year old children with DCD were treated in small groups of 6 to 8 children with a motor skill intervention programme conducted by a physical educator. The intervention was based on the practice of functional skills (ball skills, balance, skipping etc), with time to aid skill retention. The children attended the group once a week, for 10 weeks. The children's motor skills were evaluated on the MABC (Movement Assessment Battery for Children) which is a norm referenced test for motor performance. An MABC score on or below the 5th percentile indicates definite motor difficulties, and a score between the 5^{th} and 15^{th} percentile indicates borderline motor difficulties. Both children with definite and borderline motor problems were included in the study. MABC scores were established before intervention and 6 months post intervention. The children with DCD in the control group did not receive motor skill intervention, only the usual physical therapy evaluation and consultative services available to all the children with DCD (Pless et al., 2000).

Pless et al. (2000) found no significant difference in the within-subjects or the between-subject scores on the MABC. They did however find that significantly more children with initial borderline motor problems (according to the MABC) changed their category to no motor difficulties. They concluded that motor skill intervention may have positive effects in children with DCD who have borderline motor problems. Children with definite motor

difficulties did not benefit from this programme, but may instead need more specific, individual therapy.

Another study that explored the use of physiotherapy in a group was Watemberg et al. (2007). The aim of their study was to determine the effect of physical therapy on children with combined DCD and ADHD (Attention Deficit and Hyperactivity Disorder). Twenty eight children participated in their study and were divided into two groups. The intervention group had 14 children in it who received 4 weeks of intensive physical therapy in a group, twice a week, with each session lasting one hour. Each group consisted of 4 to 5 children. Instructions on a daily, half-hour home therapy programme was given to each child and their parents. The control group matched the intervention group for age, sex and MABC scores and consisted of 14 children with DCD and ADHD who received no intervention (Watemberg et al., 2007).

The eight-session intervention programme that took place over a 4 week period, consisted of a cognitive, task specific approach with attention to the performance of skills, and emphasis on self control in carrying out the activities. Watemberg et al.'s (2007) results showed a significant improvement in the intervention group, in that post intervention, 7 of the 14 children (50%) treated showed normal MABC scores (i.e. above the 15 percentile). Five children improved their scores to the 5-15% and only 2 showed no improvement (they were siblings). The control group had no improvement in their MABC scores. Watemberg et al.'s (2007) study therefore endorses physiotherapy in groups for the treatment of children with DCD with ADHD.

In a study by Peters and Wright (1999), the effectiveness of an interdisciplinary physical activity programme on the motor skills, respiratory functioning and self perceived competence of children with developmental coordination disorder was evaluated. Fourteen children attended group classes at a community centre once a week for 10 weeks. The classes lasted for one hour each and the same instructor conducted all of them. The intervention consisted of a programme co-designed by a physiotherapist and a teacher. It included activities to motivate and build confidence; improve motor skills (postural control, motor power, rhythm and timing of movement); emphasize sensory

input (body sensation and spatial awareness) and improve organizational skills (visualization and planning movement). Pre- intervention, the MABC scores of 10 children showed that they had definite motor difficulties, 2 had borderline motor difficulties and 2 were only just in the normal range. After the intervention, 4 children still had definite motor difficulties, 4 had borderline motor difficulties and 6 scored within the normal range. The results therefore showed that 12 of the 14 subjects showed a significant improvement in their MABC scores after attending the programme (Peters and Wright, 1999). As there was no control group in Peters and Wright (1999)'s study, it weakens the generalisability of the results.

Peters and Wright (1999)'s results were similar to Watemberg et al.'s (2007), as they found their subjects MABC scores also improved and changed motor difficulty categories. Peters and Wright (1999) and Watemberg et al.'s (2007) results, conflict with Pless et al.'s (2000) conclusions that only children with borderline motor difficulties benefited from their programme. It does however give encouraging indications of the value of a combined therapy approach in a group, for the treatment of children with DCD.

Although literature on the value of group physiotherapy and gross motor skill intervention for children with developmental coordination disorder is scarce, these various studies endorse their effectiveness (Watemberg et al., 2007; Pless et al., 2000; Peters and Wright, 1999). Other studies exploring the effects of dyad or group training in subjects without neurological impairments have also shown the usefulness thereof. McNevin et al. (2000) reviewed studies on the factors that affect the learning of motor skills. One of these factors included dyad or group training. The reviewers concluded that training in groups may be beneficial as participants may learn from observing someone else perform the task, allowing them to process information that would not be possible whilst performing a complex activity that requires high attention. Group training also adds a competitive aspect to motivate the learner to set goals at a higher level of difficulty and often more cost and time effective than individual treatment (McNevin et al., 2000).

2.2.2.3 Types of Therapy

In the current study, the physiotherapy programme was based on a combination of therapy approaches including Neurodevelopmental Therapy (Bobath), strength training and task- specific training. The previous studies have utilised task-specific training, NDT, SI therapy and general motor programmes. However the importance of strength training is yet to be discussed. Raynor (2001), in her investigation into the strength, power and coactivation in children with developmental coordination disorder, showed that they produced lower levels of maximal strength and power during knee extension and flexion activities when compared to age-matched, normally coordinated peers. They also had increased levels of muscle coactivation. The effect of muscular strength and power on everyday activities, especially weight-bearing propulsive activities like jumping, hopping and running is evident and therefore children with DCD have difficulties with these fundamental motor skills. Raynor (2001) surmised that increased muscle coactivation may be a significant contributor to the decreased strength and power in children with DCD. It may also be linked to the lack of movement experience and the programming problems often associated with DCD.

A case report by Kaufman and Schilling (2007) on a strength training program they carried out on a 5-year-old boy with developmental coordination disorder, described the treatment and improvement of a 5 year old boy's gross motor function, strength and proprioceptive awareness after a 12 week programme of strength training, twice a week for 30 minute sessions. They found that after the intervention his Bruininks- Oseretsky Test for Motor Proficiency (BOTMP) scores had only minimally improved, however, his muscle strength, function and confidence had greatly improved. They concluded that muscle and neural adaptation could have occurred in the 12 week period of strength training, and that neuromotor learning may have occurred from the repetition, which improved his proprioceptive awareness as he lifted against resistance. As this was a single case study with no control, caution should be used about generalizing the results to other children with DCD, as it is a heterogeneous condition.

The current study was devised to investigate the value of the physiotherapy programme within one school term for children with DCD and learning difficulties at Forest Town School. A school term typically consists of 10 weeks. The children with DCD receive one physiotherapy session a week for 30 minutes, in a group of up to 6 children. The programme was based on Bobath Therapy principles, strength training and task specific training. As other school events and occurrences such as class outings, sports events or absenteeism come into play, realistically each child only attends 8 physiotherapy sessions a term. Thus the study was conducted over an eight week period. The type of therapy, duration and number of children in a group in the current study are therefore comparable to other studies that have been done.

2.3 The Bruininks Oseretsky Test of Motor Proficiency (BOTMP)

The identification of Developmental Coordination Disorder requires a comprehensive assessment that includes a valid and reliable evaluation of the child's motor abilities. This includes measurement by a standardized test, as well as a judgment-based clinical observation of the child's interaction with his/her environment, and the quality of their movement (Crawford et al., 2001). The Bruininks –Oseretsky Test of Motor Proficiency (BOTMP) is one of the most widely used paediatric tests of gross and fine motor skills (Yoon et al., 2006; Crawford et al., 2001; Wilson et al., 1995). It is used to assess children aged 4½ to 14½years who demonstrate motor deficits which are not due to obvious neurological disorders. The BOTMP was developed to assist in assessing a child's motor skills, to develop and evaluate motor training programmes and to assess serious motor dysfunctions and developmental disabilities (Wilson et al., 1995; Bruininks, 1978). It can therefore be used as a descriptive and evaluative measure.

The BOTMP is an individually administered norm-referenced test of a child's gross and fine motor function. Bruininks (1978) collected normative scores of 765 children in the U.S.A. for standardisation purposes. The data included standards for every age and percentile rank. The complete test has 46 items to assess gross and fine motor functions,

divided into 8 subtests, including Running Speed and Agility, Balance, Bilateral Coordination, Strength, Upper Limb Coordination, Response Speed, Visual Motor Control, and Upper Limb Speed and Dexterity. The eight subtests make up the Gross and Fine Motor Composite scores as well as the Battery Composite score. Bruininks (1978) reported test- retest reliability figures to range from .77 to .85 for Gross motor, .68 to .88 for Fine motor and .86 to .89 for Battery Composite scores. The inter-rater reliability was only tested for one subtest i.e. Visual-Motor Control and was reported to range from .77 to .97 for individual test items. The intra-rater reliability was never tested but was assumed to be greater than the inter-rater reliability (Bruininks, 1978). Bruininks (1978) developed norm scores for the BOTMP by transforming item raw scores (e.g. time taken to complete the item, or number of errors) into scaled scores called point scores. The point scores were normalised to get subtest standard scores with a mean of 15 and standard deviation (SD) of 5 for each age group. Gross and fine motor composite standard scores are calculated by adding the subtest standard scores. These scores were transformed to normalised standard scores that have the same relative meaning for each age group. These normalised composite scores have a mean of 50 and a SD of 10. From these scores percentile ranks, stanines and age equivalent scores were calculated. The test adjusts for 6 month age differences. Bruininks (1978) defined impairment as a BOTMP composite score of 42 or below. He also stated that it was valid to re-administer the BOTMP within 3 to 4 weeks. No articles were available on studies evaluating the suitability of the BOTMP for assessing South African children.

Wilson et al. (1995) in their evaluation of the BOTMP as an assessment tool concluded that it was a valid test for measuring the changes in motor function. They felt that re-administration of the test may substantiate a clinician's impression that the child has improved. If the progress was slow, normative scores (subtest standard scores and composite scores) may not reflect the change, as normative scores were compiled from children without motor problems. They felt that these scores would only reveal progress if the rate of change is faster than normal development, or if the child did not change age groups between tests. Wilson et al. (1995) concluded that it may be more beneficial to measure progress by using the subtest point scores, thereby comparing the child's performance to his/her previous performance, rather than a normative sample and that

subject standard scores be used for diagnostic purposes. Yoon et al. (2006), in a review of three tests of motor proficiency recommended that the BOTMP be used as a measure of the change in motor development over time rather than a diagnostic tool.

The BOTMP yields three estimates of motor proficiency i.e. a Gross Motor Composite, a Fine Motor Composite and a Battery Composite. The Gross Motor Composite is an index of the ability to use the large muscles effectively; the Fine Motor Composite is an index of the ability to effectively use the small muscles of the lower arm and hand; and the Battery Composite is an index of general motor proficiency (Bruininks, 1978). It was recommended that the Complete Battery be administered. However, Bruininks (1978) claimed that subtests 1-4 and subtests 6-8 could be used alone for an index of gross and fine motor proficiency, respectively. In a study by MacCobb et al. (2005) investigating the relationship between neonatal and infancy measures and the BOTMP administered at 9 years of age, suggested that it was not justified to divide the BOTMP into gross motor (GM) and fine motor (FM) scores as some of the GM subtests were statistically correlated to some of the FM subtests (e.g. running speed with upper limb coordination and balance and dexterity). They concluded that there was a lack of construct validity to distinguish between the gross/fine motor components of the BOTMP. The inclusion of fine motor section in the test has been questioned by other researchers as well, because the BOTMP has a predominance of gross motor items (Crawford et al., 2001). MacCobb et al. (2005) also questioned the validity of the battery composite score. They ascertained that if a child scored moderately across the board, they could not be distinguished from another child who scored well in some areas and poorly in others. The clinical implication of this could be the under-identification of children with DCD.

Factors such as attention, memory or visual-motor demands may also impact on the motor performance of children (Dewey et al., 2001). During the administration of the BOTMP, much verbal prompting and correction is allowed. This may be favourable for children with attention problems whereas the other popular standardised test for motor proficiency, the Movement-ABC (MABC), has a stricter scoring scale with no prompting and more detailed instructions. It is therefore more difficult for children with inattention (Yoon et al., 2006; Crawford et al., 2001). Reports on the consistency between the

BOTMP and the MABC vary from fair to good (Dewey et al., 2001; Kaplan et al., 1998) to poor (Crawford et al., 2001). The results of these investigations suggest that the different tests identify different kinds of difficulties.

Bruininks (1978) designed a Short Form of the BOTMP (BOTMPSF) for situations that require a screening of the general motor proficiency. The items were selected from the Battery Composite for the BOTMPSF based on: the size of the correlation between the item and its subtest and total test scores; the range of ages the item supplied significant information about motor proficiency; the amount of time needed to arrange equipment and administer the item; and the ease of scoring (Bruininks, 1978). The short form standard scores, stanines and percentile rank are comparable to those of the Battery Composite score. The standard scores also have a mean of 50 and SD of 10 for each age group (the same as the Battery Composite scores). The short and long form standard score correlations ranged from between 0.83 to 0.94 depending on the age group (Yoon et al., 2006). Kaplan et al. (1998) found good correlation between the BOTMP Battery Composite and BOTMPSF scores, fair to good agreement between the BOTMPSF and Gross Motor Composite scores, but poor agreement between the Fine Motor Composite and BOTMPSF scores. It may then be useful to use BOTMPSF scores to screen children for motor difficulties.

At Forest Town School, children with mild motor difficulties are assessed with the Short Form of the BOTMP to diagnose those with DCD, and to determine whether physiotherapy is indicated. Those children who achieved a stanine of 4 or less, along with a physiotherapist's clinical assessment that the child needed physiotherapy intervention in their initial assessment when they were admitted to the school, were included in the study. As standardised tests do not evaluate the quality of the movement, they are limited in their ability to identify DCD. Therefore, the use of standardised as well as informal and clinical judgment should be used to identify children with DCD (Crawford et al., 2001).

The Bruininks- Oseretsky Test for Motor Proficiency is a well known, commonly used standardised tool for the identification of children with motor skill difficulties, and in the

measurement of change in motor skill abilities in children with DCD (Yoon et al., 2006; Crawford et al., 2001; Wilson et al., 1995 and Bruininks, 1978). It was chosen as the evaluation tool in the current study because: the subjects in the study were originally tested with it and had a short form score which was used for the inclusion criteria for the study (comparisons of the scores may be valuable); the investigator had previous experience in administering the short form and no experience on the MABC (which is also very commonly used in DCD studies); the test adjusts for 6 month age differences, as well as it being valid to re-administer within 3 to 4 weeks, and it is therefore a valid instrument to measure any change in the motor skills of children after an 8 week group physiotherapy programme; it allows for verbal prompting and correction during the test items, therefore enabling children with attention and learning problems to perform at their best and more consistently (many of the subjects in the study have these problems); the BOTMP has standardised norms for children between the age of 4½ and 14½ years (which would include all the subjects in the current study whose ages range between 7 and 13), whereas the MABC has an age range of 4 to 12 years; the MABC has 4 age bands for children between 4 and 12 years of age with 8 test items in each band which may present ceiling effects especially in children over 12 years.

Therefore, even though no studies were found validating the BOTMP for use in South African children, the fact that it is widely used in clinical settings and studies internationally as well as at Forest Town School, the results of the current study could be used to compare to the results of other international studies. The Bruininks- Oseretsky Test for Motor Proficiency was therefore the most suitable assessment tool for the current study.

2.4 Conclusion

Developmental Coordination Disorder is a chronic and usually permanent condition found in children and which often persists into adulthood. It interferes with the child's academic achievement, social development as well as activities of daily life. Various intervention strategies have shown to be effective in improving motor skills, ADL skills

and psychosocial outcomes. Individual as well as group therapy studies have been successful in improving the motor skills of children with DCD.

The current study was devised to investigate the value of the physiotherapy programme within one school term for children with DCD and learning difficulties at Forest Town School. A school term typically consists of 10 weeks. The children with DCD receive one physiotherapy session a week for 30 minutes, in a group of up to 6 children. The programme was based on Bobath Therapy principles, strength training and task specific training, all of which have been shown to be effective in treating the motor problems of children with DCD. As other school events and occurrences such as class outings, sports events or absenteeism come into play, realistically each child only attends 8 physiotherapy sessions a term. Thus the study was conducted over an eight week period. The type of therapy, duration and number of children in a group in the current study are therefore comparable to other studies that have been reviewed.

CHAPTER 3

METHODOLOGY

3.1 Population

The subjects in the study were learners attending Forest Town School in Johannesburg, South Africa. Forest Town School is a government school for children with learning and physical challenges.

3.2 Sample Selection

Forest Town School is a special needs school that caters for the needs of children with cerebral palsy, other neuro-muscular conditions, physical disabilities as well as learning disabled children that may have co-existing conditions such as DCD, ADHD or language problems. The learners in the study were recruited from the current list of children receiving group physiotherapy for developmental coordination disorder, or those on the waiting list for the next cycle of therapy groups. A sample size of twenty six children was used in the study, male (n=18) and female (n=8) i.e. a ratio of approximately 2:1 boys to girls, which is consistent with prevalence figures published by APA and other studies on DCD (Zoia et al., 2006; Sugden and Chambers, 2003 and O' Hare and Khalid, 2002). Of the twenty six children in the study, twenty four of the original BOTMP short form scores were available to the author from the Physiotherapy Department. The other two subjects had their physiotherapy assessments available in which the physiotherapist identified that the child needed gross motor intervention. The original BOTMP short form assessments and clinical observations were carried out by various physiotherapists who had worked in the Physiotherapy Department between 2002 and 2007.

3.3 Inclusion Criteria

- Children from the age of 7 to 13 years with minimal motor limitations.
- Children who had been screened with the Bruininks- Oseretsky Test for Motor Proficiency Short Form and had scored a stanine of 4 or less; and/or had been identified by a physiotherapist after clinically observing them, as needing physiotherapy intervention.

3.4 Exclusion Criteria

- Children who receive private therapy outside of school therapy.
- Children with medical problems which may affect their motor performance e.g. uncontrolled epilepsy.
- Children with congenital or clinically apparent neurological abnormalities.
- Children with an IQ less than 70.

3.5 Assessment Tool

The Bruininks- Oseretsky Test of Motor Proficiency (BOTMP) was used to measure the pre and post intervention motor scores of the children who met the inclusion criteria. The BOTMP has been recognized as a dependable assessment tool for evaluating motor proficiency in children and is one of the most commonly used tests in the study of children with motor and learning difficulties (Yoon et al., 2006). The test is individually administered to assess gross and fine motor functioning in children aged 4.5 to 14.5 years. It consists of 8 subtests, including, Running Speed and Agility, Balance, Bilateral Coordination, Strength, Upper Limb Coordination, Response Speed, Visual-Motor Control and Upper Limb Speed and Dexterity. The eight subtests make up the Gross and Fine Motor Composite scores as well as the Battery Composite score.

According to Bruininks (1978) a GMC, FMC, BC or SF composite score of below 43, or a stanine of below 4 is indicative of impairment. The children in the current study were included based on, either, a physiotherapist's clinical evaluation and opinion that the child needed gross motor intervention or a previous BOTMP short form assessment stanine score of 4 or less. The children in the current study that had scores at baseline within population norms i.e. a stanine of 4 or more, or a composite standard score above 42 were still included, as the BOTMP does not evaluate the quality of movement, such as fixing of joints, slowness of movement and poor motor planning that is often found in children with DCD and impedes their motor skills (Missuina et al., 2003; Dewey and Wilson, 2001).

For the purpose of this study the composite standard scores, point scores and stanines of the Gross Motor Composite, Fine Motor Composite and the Battery Composite were compared pre and post intervention and after the period of no intervention (eight weeks after the end of the intervention).

3.6 Procedure

Information letters were sent to the principal of the school and to the Gauteng Department of Education explaining the aims of the study and written permission to conduct the study was obtained.

The guardians of the subjects who met the inclusion criteria at Forest Town School were given information letters explaining the aims of the study. Written parental consent and learner assent to take part in the study, an information questionnaire, as well as permission to access their child's records was obtained (Appendices 1, 2, 3, 4 & 5). Subjects were assigned a number so as to keep them anonymous.

Two therapists not involved in the intervention (the author and a research assistant) assessed the children with the Bruininks- Oseretsky Test for Motor Proficiency the week before the intervention started. Inter-rater reliability was tested by each assessor scoring

the same four subjects. The point score results were used to determine the correlation between the assessors' scores. A Pearson correlation coefficient of 0.99 was found i.e. almost a perfect correlation. As the BOTMP is a standardised test that is widely used internationally, the intra-rater reliability is well-established (Yoon et al., 2006; Crawford et al., 2001; Wilson et al., 1995). Furthermore, the BOTMP manual assumes that the intra-rater reliability would be greater than the inter-rater reliability and hence the researcher in the current study made the same assumption and did not find it necessary to test as the inter-rater reliability was almost a perfect correlation (Bruininks, 1978).

An eight week gross motor intervention programme was carried out. The programme consisted of one physiotherapy session a week for half an hour, for eight consecutive weeks. Each group had a maximum of six children in it. The physiotherapy session consisted of a standardised programme of exercises that were compiled by the author from the exercises that are commonly used by the physiotherapists at Forest Town School to treat children with developmental coordination disorder (Appendix 7). Three physiotherapists at Forest Town School, other than those who assessed the children, were trained to carry out the intervention programme.

The children were retested with the BOTMP the week after the intervention programme was completed. After a further eight weeks of no intervention, BOTMP scores were again taken by the same two assessors. This was to eliminate the possibility that any improvement found after the intervention was due to normal development (or there would be an equal improvement in the scores), and to see whether treatment effects were maintained in the short term. The standard and point scores of the eight subtests, Gross Motor composite, Fine Motor composite and Battery composite of the three sets of data were analysed.

3.7 Statistical Analysis

Differences in the stanines, composite standard scores and point scores of 26 children, following an eight week gross motor intervention programme, were assessed in this

study. The children were treated in groups of up to six. A quasi- experimental time series design was used.

For each outcome measure i.e. Battery Composite, Gross Motor Composite, Fine Motor Composite, and Short Form of the BOTMP, data summary employed descriptive statistics i.e. mean, standard deviation, confidence intervals for onset, endpoint and changes in the standard scores.

The statistical significance of the change at the end of the intervention was assessed using the Students paired t-test. The long term effect of the intervention was assessed 8 weeks after the end of the intervention. If the underlying distribution of the data was not normal (Gaussian), the Wilcoxon's matched pairs signed ranks test would have been used. Testing was done at the 0.05 level of significance.

A successful intervention was assumed when the group improve by one stanine i.e. at least 4 Bruininks- Oseretsky Composite Standard Score points. The standard deviation was assumed to be 6 points (maximum change/ 6= 36/6=6 i.e. the total range is assumed equal to 6 standard deviations). A sample size of 26 children will have 90% power to detect a change of one stanine i.e. 4 standard score points. Testing was done at the 0.05 level of significance.

3.8 Ethical Clearance

An ethical clearance certificate was obtained from the Medical Human Research Ethics Committee of the University of the Witwatersrand. The protocol number is M070414. (See Appendix 6)

CHAPTER 4

RESULTS

In this chapter the results of the study will be presented.

4.1 Demographic Data

Twenty six subjects with DCD participated in the study, of which 8 were girls and 18 were boys. There was a ratio of 2.25:1 boys to girls which concurs with the internationally reported ratio of at least 2:1 (Zoia et al., 2006; Barnhart et al. 2003; Sugden and Chambers, 2003). All the children attended a special needs school and therefore had co-morbid learning problems. The mean age of the children at the baseline assessment (first assessment) was 10.59 years (i.e. 10 years and 7 months) with a standard deviation (SD) of 1.9 years (i.e. 1 year and 11 months) and age range of 7.33 (7 years and 4 months) to 13.5 years (13 years and 6 months).

The parent information questionnaire revealed that of the 26 children in the study: 3 were born prematurely, 1 was born post term, 3 had to have oxygen therapy and 5 were put into an incubator post-natally. The medical histories included 1 child that was currently on medication (Lamictin) for epilepsy (petit mal), 2 other children had had seizures at the age of 3 and 5 years respectively, but not since and therefore neither was on medication. Eleven children were on Ritalin and one was on Strattera for ADD/ADHD, 2 were asthmatic and on medication, and one was on Cilift (an antidepressant medication). Twenty four of the 26 children had previously had physiotherapy whether in a group at the school or individual private therapy. Only 2 children had not had physiotherapy before. See Figure 4.1 for medical history of the children.

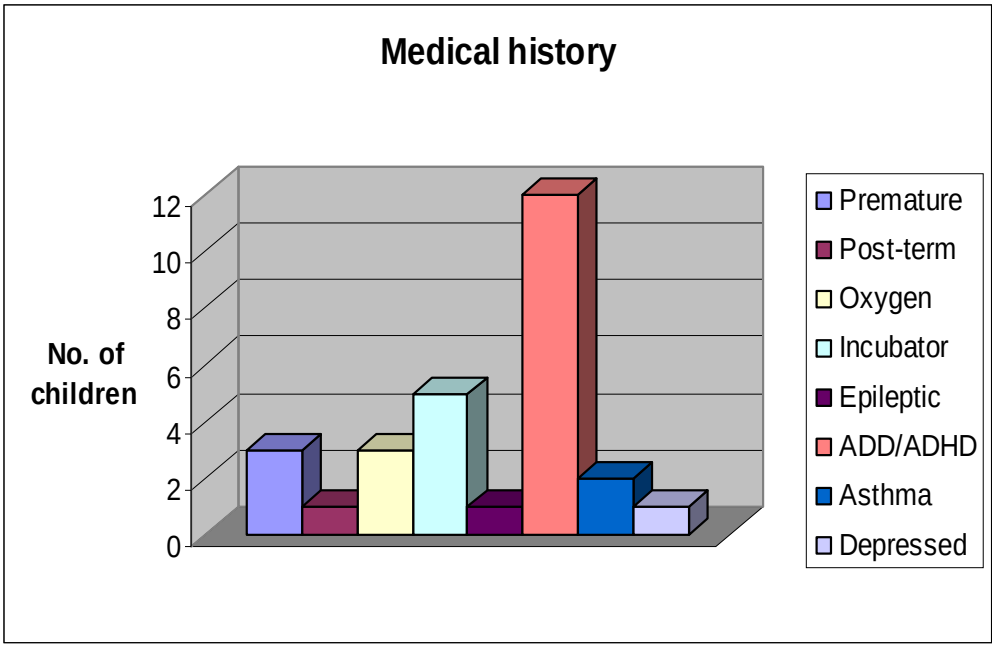

Figure 4.2: Medical History

4.2 Statistical Analysis

The group mean Point Scores (PS), Composite Standard Scores (CSS) and Stanines (ST) for Gross Motor (GM), Fine Motor (FM), Battery Composite (BC) and Short Form (SF) were compared to each other for the 3 assessment series (pre-treatment, post- treatment and final assessment after 8 weeks rest post treatment). The mean group scores with their standard deviations are presented in Table 4.1. The statistical significance of the change at the end of the intervention was assessed using the Students paired t-test. The long term effect of the intervention was assessed 8 weeks after the end of the intervention. Testing was done at the 0.05 level of significance.

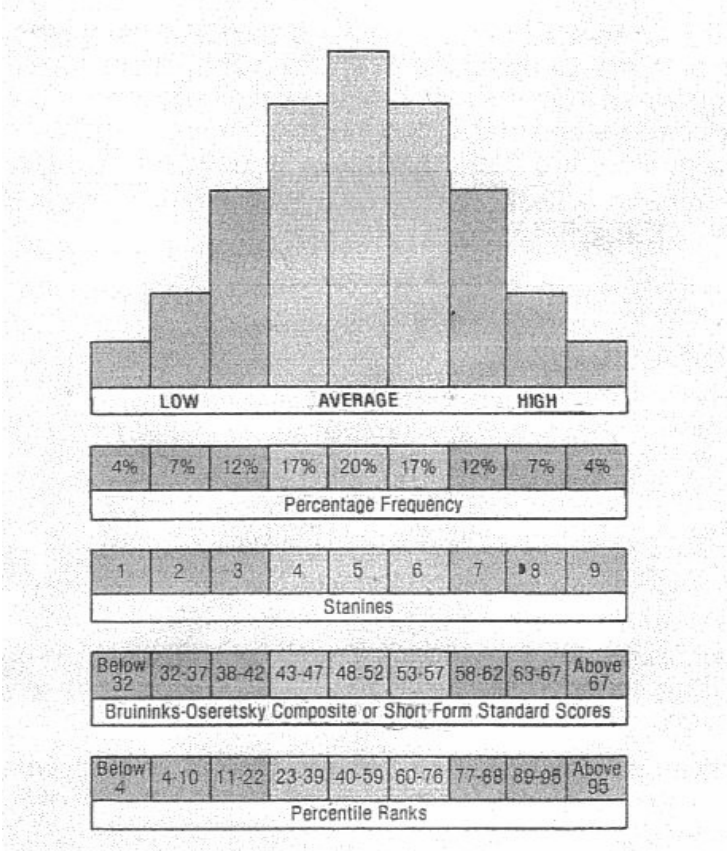

Figure 4.2: Relationship of composite or Short Form standard scores to stanines (taken from the Bruininks- Oseretsky Test for Motor Proficiency Examiner's Manual pp. 137).

Table 4.1 Group Mean GMC, FMC, BC and point, standard and stanine scores.

Scores	***Assessment 1***	***Assessment 2***	***Assessment 3***
GMC:Point Score	52.15 (±11.12)	58.35 (±9.88)	56.62 (±9.62)
: CSS	32.54 (±8.59)	37.35 (±10.34)	36.5 (±11.38)
: Stanine	1.89 (±1.24)	2.85 (±1.78)	2.69 (±1.76)
FMC :Point Score	55.81 (±12.2)	59.58 (±13.22)	61.92 (±11.39)
: CSS	33.38 (±9.54)	36.65 (±11.49)	37.15 (±10.31)
:Stanine	2.19 (±1.39)	2.65 (±1.87)	2.77 (±1.7)
BC :Point Score	124.19 (±23.17)	134.46 (±2.96)	136.54 (±20.05)
:CSS	30.92 (±8.89)	35.15 (±11.55)	35.89 (±11.11)
: Stanine	1.85 (±1.22)	2.46 (±1.88)	2.62 (±1.7)
SF : Point Score	43.88 (±10.47)	49.61 (±.47)	49.65 (±8.54)
:SS	31.19 (±8.23)	35.65 (±10.85)	35.92 (±10.49)
: Stanine	1.8 (±1.27)	2.54 (±1.77)	2.58 (±1.65)

Mean group scores with SD in brackets

4.2.1 Point Scores

The BOTMP consists of 8 subtests with a number of test items in each subtest. The raw scores for each item in the subtest are summed together to attain a subtest point score. Subtests 1 to 4 are grouped together to form the gross motor composite (GMC) and subtests 6 to 8 to form the fine motor composite (FMC). Subtest 5, the Upper Limb Coordination subtest is not included in GMC or FMC. The battery composite (BC) is the sum of the GMC, FMC and upper limb coordination subtest point scores. The point scores are not standardized for each age group and therefore have to be converted to standard scores. The point scores can therefore be used only as a measure of comparison between the child's own previous scores or between the mean group point scores. The

comparison between point scores may pick up a smaller change in motor performance than standard scores which are norm referenced and may not reflect an improvement especially if the child changes age band.

Table 4.2: Paired t-test results of the GMC, FMC, Upper limb coordination and BC point scores.

Point Scores	Assessment 1/ 2	Assessment 1/3	Assessment 2/3
GMC	p = 0.0002 *	p = 0.0145 *	p =0.2618
FMC	p = 0.0192 *	p =0.0001 *	p =0.0546
ULCoord	p = 0.207	p = 0.0023 *	p =0.07
BC	p =0.0003 *	p =0.0000 *	p = 0.4097

**Significant at p< 0.05*

A dependent t-test was used to compare the difference between the group point score data (presented in Table 4.2) for pre- and post intervention (Assessment 1/2), pre- and end point (Assessment 1/3) and post intervention and end point (Assessment 2/3). All the results for Assessment 1/2 and Assessment 1/3 were significant at $p < 0.05$ (see Table 4.2). These significant results imply that the intervention programme improved the gross motor, fine motor as well as overall motor performance of the study group. There was also significant change between the pre- intervention and final/end point results (Assessment 1/3). It may therefore be assumed that a significant improvement was maintained for at least 8 weeks after the intervention programme had ceased. The t-test results for the difference between the post-intervention and end point intervention i.e. Assessment 2/3, for GMC, FMC and BC point scores were not significant at $p < 0.05$ (see table 4.2). This therefore confirms that for 8 weeks after the intervention the treatment effects were maintained as there was no significant change in the point scores. It also eliminates the chance that spontaneous development might be responsible for the improvement in motor performance over an 8 week period. The only significant improvement in the upper limb coordination subtest point scores was between the baseline and final scores i.e. Assessment 1/3. This may imply that for this subtest the score only improved with practice and familiarity with the activity. It also only has one

item whereas the other subtests have a number of test items in each, thus making it more difficult to significantly improve the score.

Figure 4.3 depicts the improvement in the point scores for each assessment series. The FMCPS and BCPS improved with each assessment. However, the GMCPS improved between the baseline to second assessments, but decreased slightly at the final assessment compared to the second assessment. The upper limb co-ordination point scores increased only slightly at each assessment.

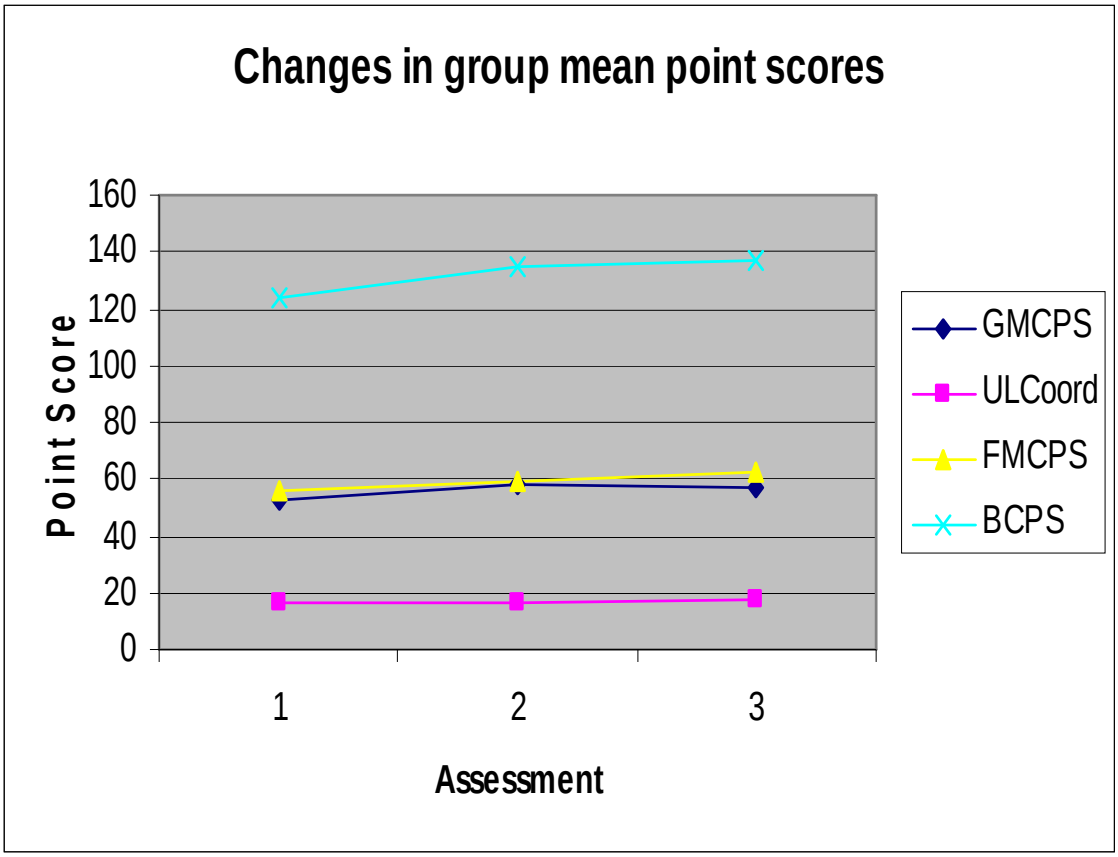

Figure 4.3: Group mean point scores for each assessment series

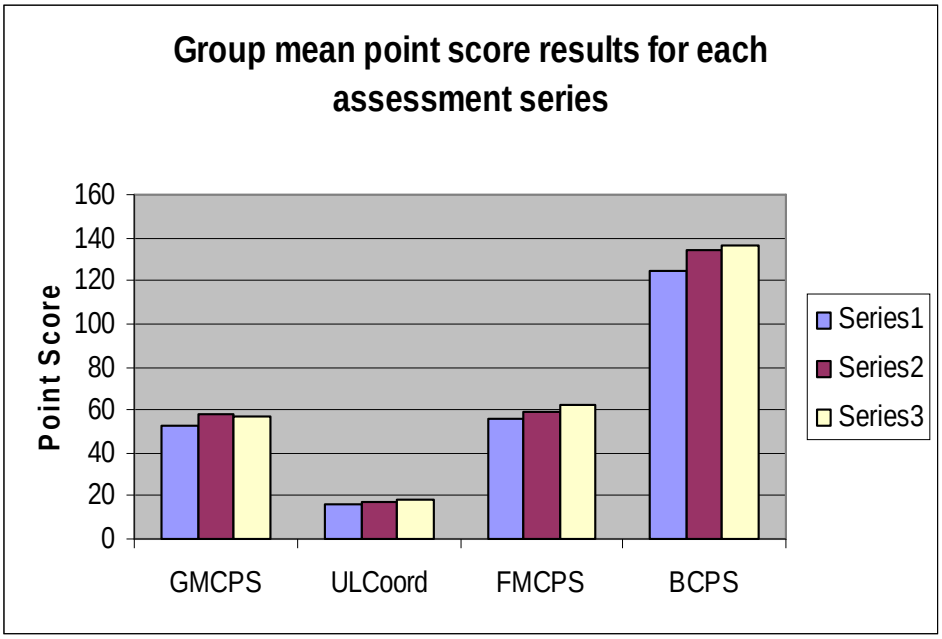

Figure 4.4: Comparison between the point scores for each assessment

Figure 4.4 compares the mean group GMC, FMC, upper limb coordination and BC point scores for each assessment series. All the mean group point scores increased from the first to the second assessment, and from the second to third assessments, except the GMC. This may be due to the fact that the intervention programme consisted of only gross motor activities and therefore there was a slight decline in the point scores after a period of no intervention. The FMC and UL coordination score continued to improve post intervention (although not significantly). This may be due to carry over from the treatment into fine motor activities.

4.2.2 Composite Standard Scores

The point scores of the BOTMP for each subtest are converted to standard scores for each age group. These norm referenced standard scores range from 1 to 36 and provide the same meaning for each subtest in each age group, and therefore may be compared to each other. The sum of the specific subtest standard scores, provide the GMC, FMC and BC composite standard scores (CSS). The normalised composite standard scores have a mean

of 50 with a standard deviation of 10. The system of composite standard scores was derived to achieve comparability within a single age group and between successive age groups i.e. a score of 50 denotes the same level of performance on all composite scores, regardless of the subject's age. The Short Form (SF) composite is comparable to the BC standard scores (Bruininks, 1978). A successful intervention in the current study was assumed when the composite standard score improved by 4 points i.e. one stanine (see Figure 4.2).

Figure 4.5 illustrates the change in the composite standard scores from the first to the third assessment. All the composite scores improved between the first and second assessments (probably due to the intervention programme) and stabilised between the second and third assessments.

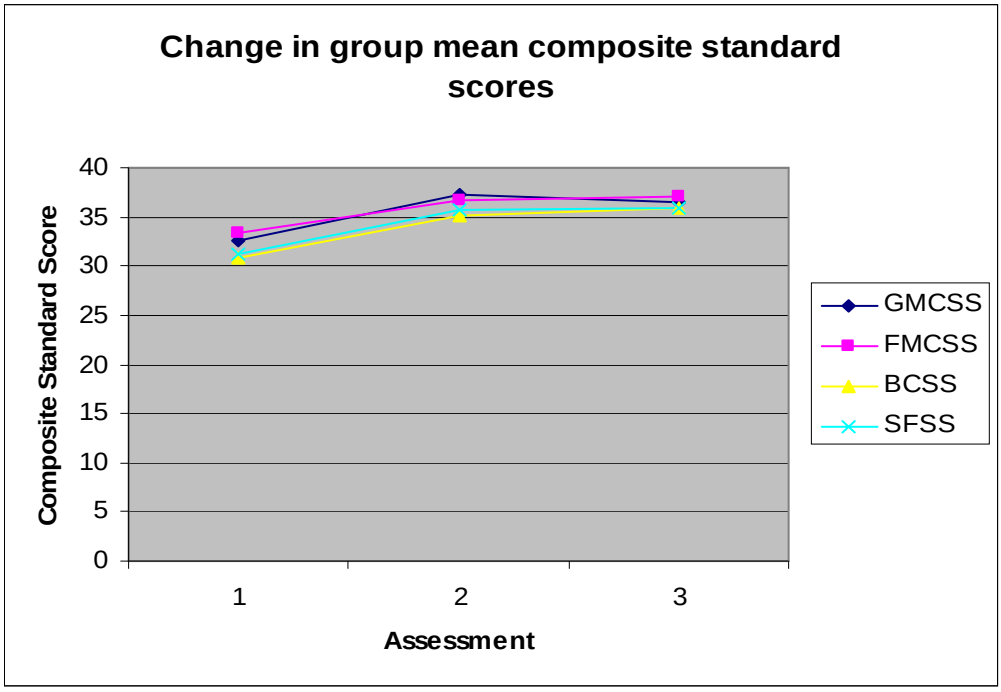

Figure 4.5: Change in the composite standard scores for GMC, FMC, BC and SF.

A dependent t-test on the composite standard scores data (Table 4.4), revealed significant results ($p < 0.05$) for all the assessment 1/2 and assessment 1/3 results. It therefore supports the theory that the physiotherapy intervention programme improved the motor

performance of children with DCD and that the treatment effect was still evident 8 weeks post intervention. The t-test results for the assessment 2/3 were not significant ($p > 0.05$), thus eliminating the question of whether normal development may improve the motor performance in children with DCD over a period of 8 weeks, and supporting the theory that the intervention programme may have been responsible for the improvement in the motor performance after the programme. Table 4.3 shows the t-test p-values for the various composite scores.

Table 4.3: Paired t-test p values for mean composite standard score results

CSS	Assessment 1/ 2	Assessment 1/3	Assessment 2/3
GMC	p = 0.0051 *	p = 0.012 *	p =0.6537
FMC	p = 0.0406 *	p = 0.0105 *	p = 0.740
BC	p = 0.01 *	p =0.0002 *	p =0.7022
SF	p= 0.0078*	p= 0.007 *	p= 0.865

**Significant at p< 0.05*

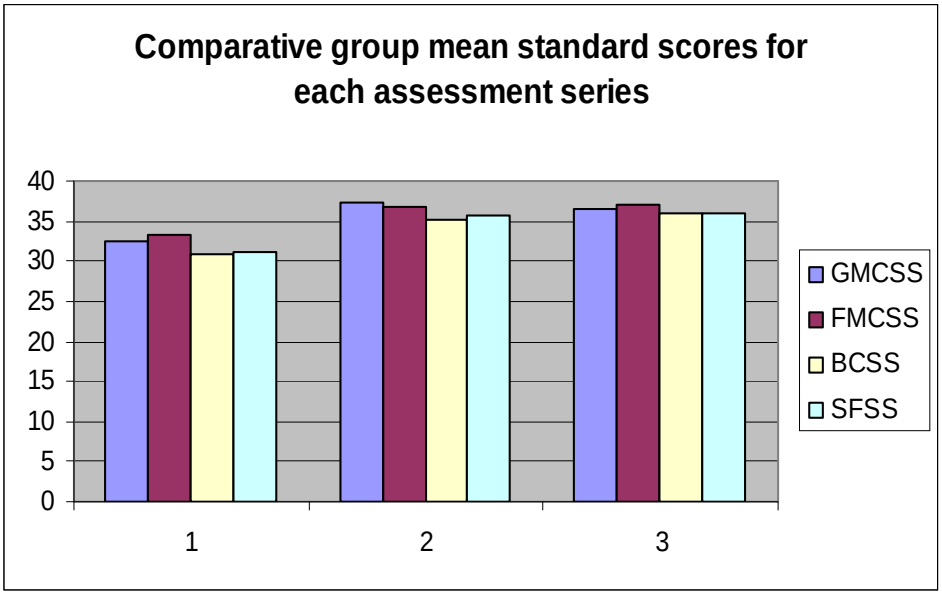

Figure 4.6: Comparison between the mean group composite standard scores for each assessment

Figure 4.6 shows the comparison between GMC, FMC, BC and SF composite scores for the different assessments. These scores may be compared to each other. The GMCSS was lower than the FMCSS at baseline (i.e. the group fine motor performance exceeded the gross motor performance). However, after intervention (assessment 2) the GMCSS was better than the FMCSS with a 14.8% increase in the GMCSS baseline score compared to a 9.8 % increase in the FMCSS baseline score. The BCSS and SFSS scores are also very closely linked and are all within 0.5 composite standard points of each other. Therefore the use of the Short Form to screen or assess children would be valid as the scores are closely correlated to the BC scores.

According to the Bruininks (1978), a composite standard score of 42 or less is indicative of impairment (see Figure 4.2). At baseline (assessment 1), assessment 2 and assessment 3 the mean group composite scores for GMC, FMC, BC and SF were all below 42 and therefore in the impairment range. However, individually a child may score within normal range i.e. above 42 for either GMC or FMC and therefore achieve a normal BC standard score as the BC is dependent on GMC and FMC. Therefore if only looking at the BC standard score then an impairment score on the GMC or FMC may be missed. Table 4.4 presents the number of children changing impairment category in their gross motor, fine motor and battery composite scores.

At baseline only 3 children had a GMCSS above 42 (i.e. in the normal range with no impairment); 4 had a FMCSS above 42; and 3 had a BC above 42. Of these only 2 children had all three i.e. GMC, FMC and BC standard scores above 42. At the second assessment (post intervention), 10 children had a GMCSS above 42; 8 had a FMCSS above 42 and 7 had a general BC above 42 (i.e. in the normal range). Of these, 4 children had all three scores in the normal range. Thus, after intervention, 7 children changed their gross motor performance from impaired to within normal range, 4 changed their fine motor performance from impaired to normal and 4 improved their overall motor performance from impaired to within normal population standards. At 8 weeks post intervention at the final assessment, there were still 10 children in the group who maintained their gross motor skills with scores above 42, 11 (an extra 3 from assessment 2) achieved normal scores for fine motor performance and 7 had battery composite

general scores within a normal motor performance range. Of the 7 with BC scores in the normal range, only 6 had GMC, FMC and BC scores above 42 (the other one still had a FMC score below 42). Thus the effects of treatment were maintained for 8 weeks post intervention and therefore possibly even in the long term. Further motor skill intervention may no longer be indicated for at least 6 of the 26 children in the study group (i.e. 23 % of the group).

Table 4.4: No. of children at each assessment with CSS> 42.

Assessment	GMC	FMC	BC
Baseline (Assessment 1)	3	4	3
Post intervention (Assessment 2)	10	8	7
Final (Assessment 3)	10	11	7

4.2.3 Stanines

Stanines are standard scores that range from a low of 1 to a high of 9. A stanine of 5 indicates the average performance within a given reference group. They are similar to composite standard scores as they define a scale of approximately equal units (except for stanine 1 and 9). Children who score a stanine of 4 are below average but still with in the normal range. A stanine of 3 and below is in the impairment range. Stanines are sometimes preferred to other types of standard scores when it is advantageous to minimize the possibility of over interpreting the differences between the score of individual subjects (Bruininks, 1978). In the current study a successful intervention was assumed if the group improved by one stanine.

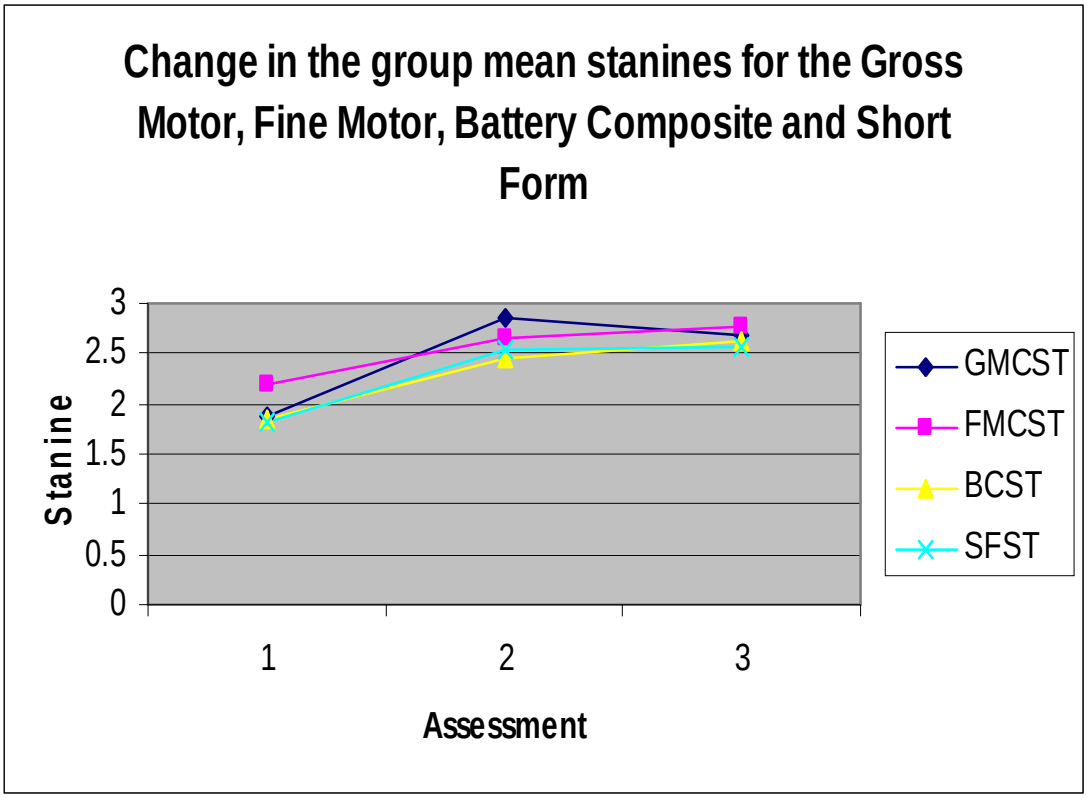

Figure 4.7: Stanine scores for the three different assessment series

Figure 4.7 and 4.8 illustrate that the GMC, FMC, BC and SF mean group stanine scores increased from baseline (assessment 1) to post intervention (assessment 2). The GMC mean group stanine improved from 1.89 at baseline to 2.85 post intervention. This resulted in a 50.8 % increase in the mean GMC stanine score. The FMC mean group stanine score increased from 2.19 to 2.65 which is only a 21 % increase. The BCST score increased from 1.85 to 2.46 post intervention. This was a 33% increase. The GMCST as with the GMC standard scores were lower than the FMC scores at baseline, but improved to a higher score post intervention. This once again shows that the gross motor skill intervention caused a greater effect on the gross motor scores than the fine motor scores. However, the gross motor intervention did also improve the fine motor performance, possibly from the carry over of the improved gross motor skill performance to fine motor skills.

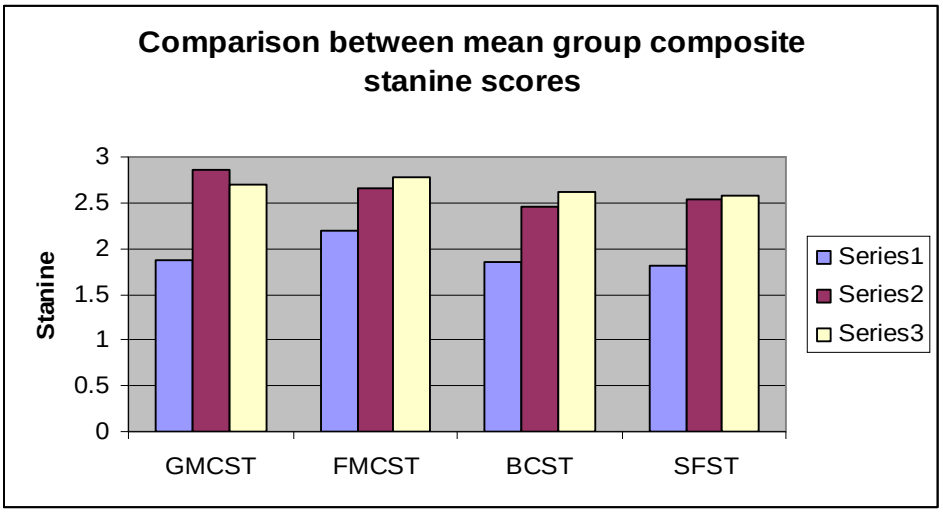

Figure 4.8: Difference between the GMC, FMC, BC and SF stanines at the various assessments

Statistical analysis with a paired t-test was used to investigate the significance of the change in the GMC, FMC, BC and SF mean group stanines (Table 4.1). Testing was done at a 0.05 level of significance.

Table 4.5: T-test p values for composite stanine scores

Stanine	Assessment 1/ 2	Assessment 1/3	Assessment 2/3
GMC	p = 0.0015 *	p = 0.0021 *	p = 0.621
FMC	p = 0.0966	p =0.0405 *	p =0.6313
BC	p = 0.0361 *	p= 0.0016 *	p =0.627
SF	p=0.076 *	p= 0.0027 *	p=0.87

* Significant at p< 0.05

The results of the t-test analysis revealed that all the p-values for the assessment 1/2 and assessment 1/3 were significant (see Table 4.5). These results once again confirm what the point score and composite standard score results showed, i.e. that the gross motor and general motor performance of the group improved significantly after the intervention programme. It also confirms that a significant improvement was maintained for at least 8

weeks after the intervention had ceased. The p-value for the FMC assessment 1/2 was not significant (p= 0.0966) thus indicating the increase in the FMCST post intervention had not significantly improved compared to the baseline score. This result differs from the FMCPS and FMCSS results and may be because stanine units are larger than standard score units and may therefore not be as sensitive to a smaller change. Therefore CSS and PS statistical analysis was also employed to be able to detect a smaller change which may be significant. The FMCST assessment 1/3 p-value was significant (p=0.0405), however the FMC assessment 2/3 was not (p= 0.63), implying that fine motor performance improved even after the intervention had ceased, and by the end of the study had reached a level of significance. Assessment 2/3 values for p were all greater than 0.05 and therefore the results were not significant, implying that the stanine scores did not change significantly for 8 weeks after the intervention and that treatment effects were maintained.

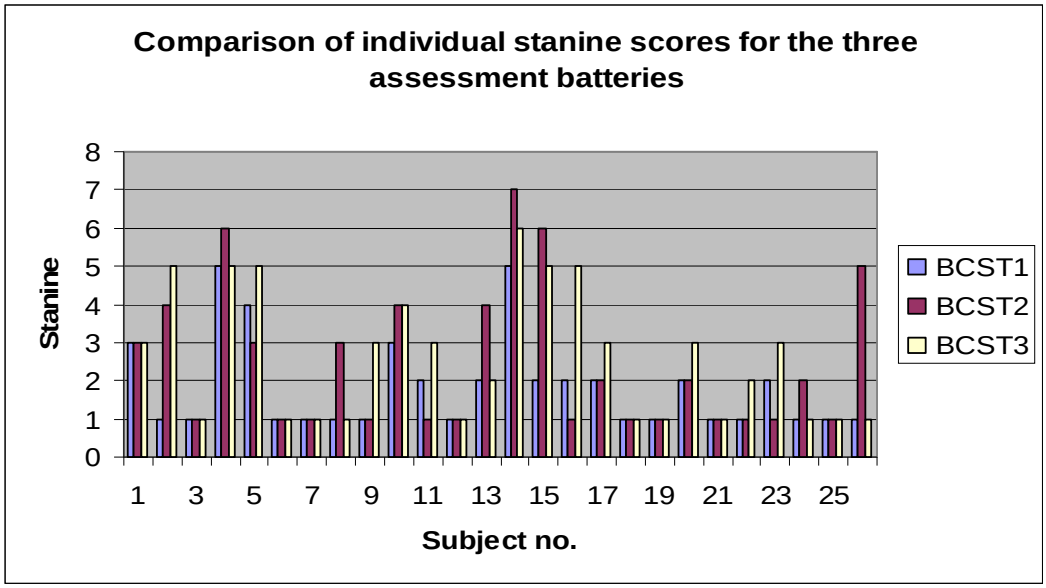

Figure 4.9: Comparison of individual battery composite stanine scores

Figure 4.9 depicts the individual battery composite stanine (BCST) scores for the assessment series 1, 2 and 3. At baseline (assessment 1), only two subjects scored a stanine of 5 and one scored a 4. These were within normal range of motor performance but they were included in the study as a physiotherapist had previously assessed them and

found them to have motor problems. The other 23 subjects in the study scored a BC stanine of 3 or less and were therefore considered as having impaired motor skills. Post-intervention, one child had a BCST of 7, two had a stanine of 6, one had stanine of 5 and three had a stanine of 4. Therefore, 7 children had scores within the normal motor range and 19 were impaired. This means that of the 7 children with stanines of 4 and up post intervention, 4 of them moved from an impaired to normal motor competence category after intervention. At the third assessment, 7 children had maintained stanine scores of 4 or higher.

The results of the statistical analyses of the mean group point scores, composite standard scores and stanines therefore clearly show that physiotherapy in a group had a significantly positive effect on the motor performance of children with DCD. These effects were maintained for at least 8 weeks post intervention.

CHAPTER 5

DISCUSSION

The aim of the study was to measure the effect of eight weeks of gross motor intervention in a group, on the motor abilities of children with developmental coordination disorder with learning disabilities. The results showed a significant improvement in gross and fine motor skills as measured by the BOTMP.

As government special-needs schools in South Africa experience larger learner-therapist ratios due to post cuts, school based physiotherapists are forced to prioritise more severely physically affected children. Therefore, at Forest Town School, children with developmental coordination disorder are treated in groups only once a week. In one school term of approximately 10 weeks, each child may realistically only attend 8 sessions of group physiotherapy due to extraneous events. The intervention programme therefore consisted of 8 sessions in 8 weeks, which is similar to other studies that showed significant improvement in the motor skills of children with DCD (Watemberg et al., 2007; Pless et al., 2000; Peters and Wright, 1999; Schoemaker et al., 1994).

5.1 Gross Motor Improvement

The gross motor intervention programme in the current study utilised different treatment approaches such as strength training, specific task training and NDT principles. It consisted of gross motor activities which included trunk and shoulder strengthening, bilateral co-ordination, balance and ball skills. Analysis of the data with a paired t-test showed a statistically significant improvement in the group gross motor point scores, composite and stanine scores at the second assessment i.e. post intervention. This implies that the gross motor performance of the children improved due to the 8 week gross motor intervention programme. The results of the study demonstrated a greater improvement in the gross motor scores than the fine motor scores after the group intervention. At baseline

the group mean GM composite standard score was 32.54 and post intervention it was 37.35 i.e. a 14.8% increase; whereas the FMCSS only increased 9.8 % from 33.38 to 36.65. Interestingly, the GMCSS was lower than the FMCSS at baseline (i.e. the group fine motor performance exceeded the gross motor performance). Findings were similar for the point scores and stanine scores. The greater improvement in the gross motor scores may be because the intervention programme consisted of only gross motor activities.

The intervention included in the current study included muscle strengthening activities which may have contributed to the significant improvement in the gross motor performance. Raynor et al. (2001) showed that children with DCD have abnormal muscle activation patterns which result in an increased level of muscle co-activation, possibly resulting in decreased power and strength in their muscles. They suggested that the increased level of co-activation may be due to a lack of movement experience and motor planning problems. These abnormal muscle activation patterns and decreased muscle strength leads to "fixing" of joints which is often observed in children with DCD. Fixing in these children results in their slow reaction times, the awkward clumsy appearance of their movement and muscles that fatigue quickly. Kaufman and Schilling (2007), in their case report on a strengthening programme for a child with DCD, found that his proprioception and body awareness as well as his muscle strength improved after the programme. The improvement in the motor skills in the current study may therefore be due to improved muscle strength and power, improved movement experience, neuromotor learning from repetitions of the activities and improved body awareness and proprioception.

The physiotherapy programme also included activities such as sit-up's, push up's, star jumps and balancing on one leg. These activities are similar to some of the test items in the BOTMP. This may partially account for the improvement in the gross motor scores post intervention. Niemeijer et al. (2007) in their study investigating the effect of Neuromuscular Task Training (NTT) on children with DCD, found that the most significant improvement occurred in the tasks practiced in therapy that were similar to the test items of the MABC. They did however also find an improvement in the balance

scores, even though it was not included in the intervention programme. However, in Schoemaker et al.'s (1994) study the treatment programme did not include the same gross or fine motor activities as in the motor tests they used for assessment. Schoemaker et al. (1994) therefore concluded that the effects of treatment were transferred to the untreated skills in the TOMI and ABC tests. Therefore, in the current study there may also have been a transfer of skills to other activities even though some of the activities practised were similar to the BOTMP test items.

Children with DCD are known to have eye-hand coordination as well as inter-limb coordination problems as a result of poor proprioception, motor planning, sequencing and timing. They often find activities such as catching a ball, running, climbing and intercepting objects difficult (Zoia et al., 2006, Missuina et al., 2003). The current study included activities such as star jumps, obstacle courses, skipping, and throwing and catching activities to improve inter-limb as well as eye-hand coordination, which may also have contributed to the improved gross motor scores.

At the third and final assessment, after 8 weeks without physiotherapy, the mean group gross motor composite (GMC) point scores, standard scores and stanines all decreased, however not significantly (the assessment 2/3 p-values for the GMC PS, CSS and ST were all greater than 0.05- see Table 2). This implies that although the gross motor performance of the group was slightly poorer after 8 weeks of no intervention, the decline was not significant and therefore treatment effects were still evident.

5.2 Fine Motor Improvement

One of the most common problems experienced by children with DCD is difficulty with skilled upper-limb movements during tasks such as writing, reaching, grasping and dressing. Postural adjustments and complex patterns of postural muscle excitation and inhibition contribute to the efficiency of these skilled tasks. Fine tuning of this intricate muscle activity is essential for skilled movement. Postural muscle activity controls the body's position in space for stability (maintaining the centre of mass in the base of

support) and orientation (relationship of body segments and environment). Postural muscle activity therefore provides a foundation for movement and is an important part in the neurophysiology of motor coordination (Johnston et al., 2002).

Anticipatory postural adjustments (APA) occur during voluntary movements. They are feed-forward adjustments and occur to maintain postural stability and balance by preventing the disruption of the centre of mass. Anticipatory postural adjustments are initiated before or simultaneous to the prime mover. Reactionary postural adjustments (RPA) occur in response to an external force that has already disrupted the individual's stability and acts to restore the centre of mass to within the base of support i.e. to restore balance and stability. RPA's occur in postural muscles after the external impact has occurred, or after the prime mover has been activated in voluntary movements. Altered timing of postural muscle activity may therefore result in poor background postural control which is likely to be a contributor to upper-limb coordination difficulties in children with DCD (Missuina et al., 2003; Johnston et al., 2002).

A study by Johnston et al. (2002) investigating the neuromuscular components of postural stability and coordination in children found that children with DCD took longer to respond to visual signals and longer to complete goal-directed upper-limb movements. They attributed this to the altered muscle activity they recorded in the postural muscles. They found that shoulder muscles (except serratus anterior) and posterior trunk muscles of children with DCD demonstrated early activation; whereas the anterior trunk muscles demonstrated delayed activation when goal directed upper-limb reaching was elicited. They also found that anticipatory postural adjustments were not present in 3 of the 4 anterior trunk muscles. Johnston and colleagues (2002) concluded that their findings supported the hypothesis that altered postural muscle activity leads to poor proximal stability which results in poor upper-limb coordination in tasks such as writing, grasping, cutting, dressing and sports in children with DCD.

In a study to investigate the effect of postural stability on fine motor control, Miyahara and colleagues (2008) assessed the kinematics of the head, shoulder, elbow and the pen of 24 children during a drawing task. The children were divided into two groups, an

accurate drawing group (AD) and an inaccurate drawing (ID) group based on their ability in a manual dexterity task from the MABC. The study revealed that the ID group had more movements in the body parts adjacent to the drawing hand (i.e. the head and shoulder) directly before the commission of a drawing error compared to the accurate drawers. They also found that there were more coincident errors (i.e. drawing errors occurring at the same time as movements of a part of the body) in the proximal body parts of the head and shoulder than in the elbow. They therefore suggested that postural stability is important in fine motor control (Miyahara et al., 2008).

In the current study, the improvement in the fine motor (FM) composite standard scores and point scores post intervention (which were statistically significant with $p<0.05$), may be due to a carry over or transfer of skills from the gross motor intervention programme. The programme included activities to strengthen and improve the stability of the shoulder girdle and trunk muscles, and improve limb and hand-eye co-ordination. As the intervention programme included activities aimed at strengthening the children's postural muscles (trunk and shoulder girdle) and improving their muscle activation patterns and timing (to improve stability), it may have resulted in improved distal hand function and improved upper limb coordination. This improved hand function and upper limb coordination may have affected an improvement in their fine motor skills such as writing, cutting and upper limb dexterity, which were tasks measured by the BOTMP.

These results are similar to those found in a study by Stevens (2002) on the effect of physiotherapy and a home programme on the fine motor performance of children with DCD. Stevens (2002) compared the BOTMP fine motor age scores of 2 groups of children after physiotherapy intervention which consisted of postural exercises. One group acting as the control received 3 months of individual therapy, whereas the experimental group received the same 3 month physiotherapy intervention as well as a home programme that was carried out 3 times a week. The results showed that both groups improved in their fine motor ages, however significantly more children in physiotherapy and home programme group reached their desired chronological fine motor age. Therefore the study showed that postural exercises had a positive effect on

the fine motor function in children with DCD and that more intensive intervention (physiotherapy and a home programme) was more effective (Stevens, 2002).

Physiotherapy is often recommended by teachers when children are found to have writing difficulties at school. There is however a lack of research investigating the impact of physiotherapy on the fine motor function of children with DCD. In a study by Smits-Engelman et al. (2001), they investigated the prevalence, underlying deficit of motor control and effect of physiotherapy on the handwriting of children with DCD. They used standardised tests to measure the quality of the children's handwriting before, after a 3 month physiotherapy intervention programme, and 9 months later. The physiotherapy programme was administered individually and addressed each child's specific problems. It concentrated on pre-writing exercises training force generation, training spatial and temporal constraints, fine motor manipulative skills and gross motor training if necessary. It did not include training to write actual words or letters. Smits-Engelsman and colleagues (2001) found that children with handwriting difficulties also had fine motor deficits and that the children who received physiotherapy improved their handwriting and the improvement was still evident 9 months later. Even though Smits-Engelman et al. (2001)'s study did not use an exclusively gross motor programme, the activity of writing was not practiced. However, there was an improvement in the quality of the children's handwriting due to the improved execution, grading and muscle activation that was achieved whilst practicing other activities which was carried over to handwriting skills.

In the current study, the FM composite point scores, stanines and standard scores at the third assessment were higher than at the second assessment. The group mean fine motor performance had therefore improved in the 8 weeks after the intervention had ceased. However, the FMC t-test p-values for assessment 2/3 were all greater than 0.05 and therefore not significant. Therefore, the fine motor performance of the group continued to improve even after the gross motor intervention was over, possibly due to carry over or transfer of skills to fine motor tasks due to more efficient proximal postural muscle activation and timing, and therefore improved upper limb coordination and distal hand function. These tasks such as drawing, cutting and writing may have been used and

practised in class during the 8 weeks post intervention, which may have further improved their skills.

The improvement in the FM scores at assessment 2/3 (i.e. 8 weeks post intervention) were not statistically significant. If the improvement in the fine motor scores at the third assessment were due to familiarity or improved confidence or knowledge of the BOTMP test items, the gross motor scores would also have improved in the third assessment, which they did not (see Table 4.1). It is therefore probable that the improvement in the fine motor scores can be attributed to the carry over of the effects of the gross motor intervention to fine motor skills.

5.3 Maintenance of Treatment Effects

The t-test p-values comparing the gross motor, fine motor, battery composite and short form point scores, composite standard scores and stanines for the baseline and final assessment (assessment 1/3) were all significant ($p < 0.05$). Thus, a significant improvement in the mean group gross motor, fine motor and general motor performance from baseline to the final assessment (i.e. 4 months later) was found. It therefore supports the theory that the physiotherapy intervention programme improved the motor performance of children with DCD, and that the treatment effects were maintained and still evident 8 weeks post intervention.

Schoemaker et al. (1994) reassessed 11 children who had improved TOMI scores, which were high enough to discontinue physiotherapy after the intervention programme, three months post intervention. The comparison between the TOMI results directly after intervention and 3 months later were not significant, implying that the children with DCD were able to maintain their improved performance for up to 3 months post intervention. . Smits-Engelman et al. (2001) found that in their study children with DCD improved their handwriting skills after physiotherapy intervention and that the improvement was still evident 9 months after the intervention.

There has been a lack of research evaluating the long term effects of a physiotherapy programme on the motor performance of children with DCD. Further studies should be conducted to determine whether the effects are maintained years later and whether improving the child's motor performance impacts on his/her academic and psychosocial outcome as an adolescent and adult. It is still unclear whether a child who has improved their motor performance after a physiotherapy programme will maintain their improved motor competency in the long term, or whether repeated evaluation and assessment of their skills is needed with repeated periods of physiotherapy treatment.

Children with DCD in the mild impairment range at Forest Town School receive physiotherapy in a group for a 6 month period. They are then either discharged if they have made significant progress and no longer need physiotherapy, or are placed on the waiting list for further group physiotherapy. Children in the severe impairment range receive ongoing physiotherapy.

5.4 Spontaneous Motor Development

Spontaneous motor development needs to be considered in a study in which developing children are involved as an improvement in their motor scores may be a result of development which may have taken place without intervention.

The GMC, FMC, and the Battery Composite score t-test p-values between the second and third assessment (assessment 2/3) in the current study are not significant ($p > 0.05$), which eliminates the chance that spontaneous development might be responsible for the improvement in motor performance over an 8 week period. Schoemaker et al. (1994) also found no spontaneous motor development in a three month period pre-intervention in the experimental group of clumsy children, or in the control group of typically developing children.

Niemeijer et al. (2007) concurred with Schoemaker et al. (1994), concluding that the control group of children with DCD in their study who did not receive intervention had stable MABC scores in a 3-4 month period. A study by Watemberg et al. (2007) on the effects of physiotherapy intervention in children with ADHD/DCD, also demonstrated that the control group did not show an improvement in their MABC scores after 4 weeks of no intervention, whereas the experimental group did significantly improve.
We can therefore conclude that spontaneous motor development rarely occurs in a 3 to 4 month period and therefore the improvement in the GM, FM, and battery composite scores after the intervention programme and at 8 weeks post intervention in the current study are due to treatment effects.

5.5 Individual versus Group Intervention

There is a lack of available research comparing the difference between the effectiveness of group verses individual physiotherapy programmes for children with DCD. As children with DCD are a heterogeneous group, it stands to reason that an individualised programme to cater to the child's specific problems would be most beneficial. More attention could be placed on achieving better alignment, motivation and correction of motor tasks during the activities if there is individual, one-on-one, hands-on instruction from a physiotherapist, especially if the child has severe motor, perceptual and planning problems, as well as co-occurring developmental disorders (Pless et al. 2000).

However, treatment in a group also has its benefits. It may provide more motivation for the child to attempt and achieve a task at a higher level to be more competitive with his/her peers. It also provides the opportunity for the child to observe an activity whilst a peer is performing it and enable them to process and analyse the task before they attempt it. Therapy in a group is also more cost effective, especially when resources and therapists are scarce (McNevin et al., 2000).

In a study on stability and change in children with DCD, Sugden and Chambers (2006) investigated the effect of an individual therapy programme carried out by teachers and

parents over a 4 year period, on 26 children. The mean group MABC scores improved from 17.4 to 9.0 over the 4 year period (a score of above 13 indicates the lowest 5 %, from 10 and 13 indicates a range between 5 % and 15 % - a score below the 5th percentile indicates definite impairment and between 5th and 15th percentile indicates a borderline impairment). The study found that 14 of the 26 children (53.8 %) showed stability and improvement in all areas i.e. educational progress and self concept, and they no longer displayed symptoms of DCD. Eight children (30.8%) showed varying profiles improving their motor scores during the intervention period, but slipping back to impaired scores after intervention. A third group of 4 children consistently scored poorly in their motor performance and received ongoing support. They concluded that intervention was very effective in over half the children with DCD and that the effectiveness was relatively permanent (Sugden and Chambers, 2006).

Schoemaker et al. (1994) found that of the 18 children in their study who received individual physiotherapy, 8 children (44.4%) moved from an impaired category on the TOMI to a borderline or normal category, and 1 moved from borderline to normal (5.5 %). Eight of the children remained in the impaired category, but all improved their scores.

Watemberg et al. (2007) established that in their study of children with DCD/ADHD who received motor intervention in a group, 50% (7 of the 14) attained normal MABC scores (above 15th percentile) after treatment and 35% showed an improvement without reaching normal scores.

In an investigation by Peters and Wright (1999) on the effect of an interdisciplinary group physical activity programme on the motor skills of children with DCD, they found that the mean group MABC scores improved from 15.54 pre-intervention (below 5th percentile) to 9.64 post-intervention (just in the normal range). Six out of the 14 children in the study scored within the normal range on the MABC post intervention as opposed to 2 who scored just within the normal range pre-intervention. Therefore, after the intervention 43 % of the children scored within the normal range on the MABC. Pless et al. (2000) found that only children in the borderline motor impairment category improved

their motor performance to a normal score after treatment in a group. The mean group MABC score improved from 16.3 (definite impairment) pre- to 11.8 (borderline) post-intervention in the study group of DCD children. Pless and colleagues (2000) recommended a more specific individualized treatment for children with definite motor difficulties.

The children in Schoemaker et al. (1994) and Sugden and Chambers (2006) studies were treated individually, where as the children in Pless et al. (2000), Peters and Wright (1999), and Watemberg et al. (2007) were treated in groups. The percentage of children in each study to improve their motor performance to within normal limits is similar ranging from 43% and 53%. The available mean group MABC scores for both Pless et al.(2000) and Peters and Wright (1999)'s studies in which group intervention was used, were similar to Sugden and Chambers (2006)'s mean group MABC scores pre- and post-intervention in which individual therapy programmes were evaluated . All of the above studies' mean pre-intervention scores were in the definite impairment range (i.e. above 13). Both Peters and Wright (1999)'s and Sugden and Chambers (2006)'s mean group MABC scores post intervention were below 10 and in the normal range. Both studies were therefore successful in improving the motor proficiency of children with DCD.

The small number of subjects, different standardised tests used in the studies, different types of treatment programmes and similar success rates make it difficult to compare the studies and to distinguish between the effectiveness of individual or group therapy for children with DCD.

5.6 The Effects of Treatment on Children with DCD and Co-occurring Developmental Disorders

Demographic information obtained from the information questionnaire in the current study revealed that of the 26 children in the study, all had learning disabilities and 12 were on medication for ADD/ADHD (11 on Ritalin and 1 on Strattera) i.e. 46 % of the

study group had ADHD. This concurs with Kaplan et al.'s (1998) study in which they found that of 81 children with DCD, ten (12.3 %) also had ADHD and 23 (28.4%) had both ADHD and RD (reading disability). Therefore, a total of 40.7 % of children in Kaplan et al.'s (1998) study had co-occurring DCD and ADHD.

Kaplan et al. (2006), in a study on the co-occurrence and continuum of various developmental disorders such as ADHD, reading disabilities (RD), DCD, and psychosocial problems, concluded that co-occurrence of more than one disorder was more common than not for children with DCD. They also concluded that there was a linear relationship between the severity of DCD and impairments in cognitive and psychosocial behaviors.

Watemberg et al. (2007) found in their study on intervention in children with ADHD/DCD, that 55 % of the 96 children they assessed with ADHD also had DCD. They showed that children with ADHD/DCD had a higher incidence of specific learning disorders and phonological problems than children with only ADHD. Green et al. (2008), in their study on the outcomes of different subtypes of DCD after intervention, concluded that children with more severe and complex difficulties at the baseline assessment, even though they showed improvement after intervention, were more likely to have continuing difficulties at the end of the study.

At baseline in the current study, 3 children had gross motor CSS, 4 had fine motor CSS and 3 had battery composite standard scores within the normal range (CSS above 42 and a stanine of 4 or more). After the intervention programme, 10 children had GMCSS, 8 had FMCSS and 7 had BC standard scores within the normal range i.e. above 42. Therefore, 7 children improved in gross motor competency from impaired to normal, 4 children improved in fine motor performance from an impaired score to normal, and 4 improved in battery composite scores from impaired to a normal scores post intervention. The battery composite score of the BOTMP is the sum of the GM, FM and upper limb co-ordination composite scores. Therefore, a BC standard score above 42 i.e. within average population norms may still consist of one of the GM, FM or upper limb co-ordination scores being in the impairment range.

After the second assessment in the current study, only 4 of the 7 children with BCSS above 42 had both GM and FM CSS above the impairment range. It would therefore stand to reason that these 4 children would not require further therapy (i.e. 15.4 % of the study group) as both their gross motor and fine motor scores were within the normal range.

At the third and final assessment, 8 weeks post intervention, 10 children had GMCSS, 11 had FMCSS and 7 had BCSS above 42 and within the normal range. Of the 7 with BCSS above 42, six had both GM and FM composite standard scores within the normal range. Therefore 8 weeks post intervention and 4 months after the commencement of the study, six of the 26 children (23%) did not require further physiotherapy treatment. However, a limitation of the BOTMP is that it does not assess the quality of the subjects movement, therefore a clinical assessment from a qualified physiotherapist as well as the BOTMP scores should be considered before treatment is discontinued.

The studies conducted by Schoemaker et al. (1994), Sugden and Chambers (2006), Pless et al. (2000), Peters and Wright (1999), and Watemberg et al. (2007) show a larger percentage of the children achieving normal motor performance scores after the intervention programme (from 43% to 53%) than in the current study. Only 7 of the 26 (27%) children in the current study scored within the normal range for the battery composite, and only 6 of these had both GM and FM scores above the impaired range. The previous studies were conducted on children from mainstream schools, whereas the current study was conducted on children with DCD in a special school for children with learning disabilities. It therefore stands to reason, that if the mean group score in the current study was in the severe impairment category at baseline with a BCSS of 30.92 and BCSS of 1.85 (i.e. ±2 SD below the average population norms), that fewer children would reach normal motor scores after an 8 week intervention than a study group of less impaired children.

It could therefore be assumed that children in a special-needs school would have more severe impairments and more co-occurring developmental disorders and therefore poorer

performance in their every day functioning, motor skills, cognitive and psychosocial performance than children with DCD in a mainstream school.

5.7 Implications of the Study

The current study has shown that the group physiotherapy programme for children with DCD at Forest Town School is effective in improving their gross and fine motor skills. It therefore endorses the use of physiotherapy in groups to treat children with DCD when there is a lack of therapists to treat these children individually. The physiotherapy programme for children with DCD at Forest Town School should therefore be continued as it is effective in improving the gross motor and fine motor performance of children with DCD and learning disabilities.

Most South African special schools for children with learning difficulties are staffed with Physiotherapists and Occupational Therapists who are able to identify and carry out gross and fine motor intervention programmes to treat children with DCD. However, as DCD has a prevalence rate of 5-8 % of all school-going children, learners in mainstream schools that may be affected are often not identified and diagnosed and therefore not treated by the appropriate professionals. Children with DCD have marked impairment in their motor skills and coordination which impacts on their academic progress and social functioning as well as their activities of daily living. Current research into the prognosis of DCD has found that children do not outgrow their motor problems, and without intervention they will not improve (Barnhart et al., 2003). As a result they often have poor social and employment outcomes. Early intervention and treatment is therefore important to promote a favourable outcome for these children.

The majority of children in South African Government-funded schools that do not have therapists on staff and do not have access to private therapists, rely on government hospital services for their health care and therapy needs. These government hospitals are poorly staffed and therapists do not prioritise children with DCD. Therefore, these

children with DCD who cannot afford private therapists, very seldom receive physiotherapy intervention even if they are identified and referred for therapy by a teacher. It may therefore be useful to promote the treatment of children with developmental coordination disorder in groups to therapists in government hospitals who would otherwise not be able to offer treatment due to lack of staff. Teachers should also be educated about the value of generalized gross motor programmes that they can carry out during physical education periods.

Research has shown that after intervention approximately half the children with DCD score within normal ranges on standardized tests and the rest improved even though they did not reach normal scores (Watemberg et al., 2007; Peters and Wright, 1999; Schoemaker et al., 1994). Therefore it is important that children with DCD are identified and treated early to improve their educational, social and employment outcomes. As DCD often occurs with other developmental disorders, early screening and diagnosis of motor difficulties in nursery school and junior primary school may identify at-risk children for learning disabilities and ADHD. Teachers need to be educated about how to identify and refer these children to the appropriate therapists and doctors.

At Forest Town School a teachers' training course on how to identify and refer children with developmental and learning problems has been newly implemented and sponsored by the Gauteng Education Department. Talks by Speech, Occupational and Physiotherapists as well as specialist doctors and remedial therapists are included in the programme. This initiative may aid in achieving earlier treatment and more favourable outcomes for many more children with DCD.

5.8 Limitations of the Study

The results of the current study were encouraging in supporting the theory that physiotherapy in a group improves the gross motor and fine motor skills of children with DCD. The study does however have limitations in that no measure of the functional implications of the motor improvement was employed.

The Bruininks- Oseretsky Test for Motor Proficiency (BOTMP) is a widely used standardised test of motor performance. It however also has its limitations, as all standardised tests do, in that it does not measure the quality of movement, motor planning problems or slowness of movement that is often associated with children with DCD. It also does not measure the impact of the motor performance on activities of daily living, such as dressing, eating, writing, playground skills e.g. climbing, and problems in the classroom e.g. dropping objects, bumping into furniture and other children, posture when seated at the desk and writing, as well as psychosocial consequences such as self esteem and confidence. These are all functional problems often reported by parents and teachers of children with DCD, which were not measured before and after the intervention programme to measure the effect of the gross motor improvement on their social functioning and activities of daily living.

Of the 26 children in the current study, 24 had previously had physiotherapy, whether it be in a group at school or individually privately. Only 2 children had never had physiotherapy prior to the study. Previous on-going therapy may have limited the effect of the 8 session intervention programme as some of the children may have already reached a plateau or their full potential in their motor skills as a result of previous therapy. Children who were receiving private therapy at the time of the study were excluded to limit the effect it might have on the results. The children in the study still continued with their Occupational and Speech Therapy sessions, as usual, during the study. Ethically, the children in the study could not have been excluded from the holistic therapy setting, however attending these therapies, especially O.T., in which Visual-Motor, Perceptual and Sensory Integration therapy may have been used, may have contributed to the improvement in the BOTMP GM and FM scores during the study. Therefore the effects of these added therapies were unknown, although consistent throughout the study

As 24 of the 26 subjects' BOTMPSF scores were available from their original assessments when they were admitted to Forest Town School, a comparison between these original assessments to their baseline assessments from the current study would

have been valuable. It may have indicated whether the repeated courses of group physiotherapy at Forest Town School had improved their motor performance in the longer term, i.e. since their admission into the school, and could also be compared to those children who were on the waiting list previously and had not yet received group physiotherapy as yet. However, the BOTMPSF assessments were administered by a number of therapists and hence the inter-rater reliability could be questioned. Secondly, the inter-rater scoring may not have been consistent; or the scoring criteria may not have been strictly adhered to, as specified in the BOTMP manual. Therefore the original score could not be compared to the current study's assessment scores as their reliability is unknown and questionable.

A further limitation of the study is that the gross motor intervention programme used a few activities that were similar to items in the BOTMP. Improvement in the performance of these activities may have caused the improvements in the gross motor composite scores. However, the fine motor composite scores also showed a significant improvement after intervention even though the intervention programme consisted only of gross motor activities. This aids in supporting the theory that there was a carry over or transfer of skills to the other gross motor as well as fine motor activities that were not included in the intervention programme but are tested in the BOTMP.

5.9 Recommendations for further Research

Further studies on the impact of physiotherapy on the motor skills in children with DCD should include the use of standardised tests that measure the impact of gross motor intervention on ADL and psychosocial performance measures in children with DCD, as well as parent and teacher questionnaires. Further studies of the physiotherapy programme at Forest Town School should include questionnaires to parents and teachers to establish the impact that physiotherapy has on the child's school work and academic progress as well as their independence and efficiency in performing every day tasks at home e.g. dressing, eating etc. A measurement tool such as the Pediatric Evaluation of

Disability Inventory (PEDI) or the DCD Questionnaire may be valuable to establish functional improvements.

In the current study it is postulated that the improved fine motor scores may be due to a carry-over or transfer of skills from the purely gross motor intervention to the subjects' fine motor performance. A number of studies, as mentioned in Section 5.2 of this research report, have been found to support this theory. However, due to the inherent weakness of the BOTMP to pick up problems with quality of movement, motor planning or slowness of movement, further studies into the effect of gross motor intervention on fine motor function using a standardised measurement tool that is more sensitive to fine motor changes than the BOTMP, are needed to support the current studies' findings that the fine motor scores improved due to carry over after a gross motor intervention.

Investigation into the difference between the effectiveness of group and individual physiotherapy should also be looked into as there is a paucity of research on this topic. There is also a lack of evidence evaluating the long term effect of a physiotherapy programme in children with DCD.

CHAPTER 6

CONCLUSION

The once a week, eight session group physiotherapy intervention programme at Forest Town School showed a significant mean group improvement in 26 children's motor proficiency as measured by the BOTMP. This improvement was maintained for at least 8 weeks post intervention.

The intervention programme consisted of gross motor activities which included trunk and shoulder strengthening, bilateral co-ordination, balance and ball skills and therefore addressed the gross motor activities that children with DCD have difficulties with. Analysis of the data showed a statistically significant improvement in the group gross motor point scores, composite and stanine scores after the intervention. A carry over to fine motor skills was also found even though the intervention only included gross motor activities.

The impact that this improved motor proficiency had on the children's ADL and psychosocial functioning was lacking in this study. It is recommended that further studies investigating the effect of group physiotherapy on the motor performance of children with DCD should examine the psychosocial and ADL consequences of the physiotherapy programme and improved motor performance.

The gross motor intervention programme that is currently in place at Forest Town School is therefore effective in treating children with DCD and learning disabilities and will be continued. Children will continue to receive physiotherapy in a small group for a 6 month period and will then be discharged if they have made sufficient progress, or be placed on the waiting list for further group therapy if they need further intervention.

Government funded schools and hospitals in S.A. usually have a limited number of therapists available to treat children with DCD. These therapists have to prioritise clients

with more severe disabilities. Physiotherapy in a group can therefore be effective to treat a larger number of children with fewer therapists.

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Information Sheet (Appendix 1)

Good day,

I am Julie Brenner from the Physiotherapy Department at Forest Town School. I am currently a student at the University of the Witwatersrand in the process of completing my Masters Degree in Physiotherapy. I am conducting a study on the effectiveness of the group physiotherapy your child currently receives at Forest Town School. I would be most grateful if you and your child would consider participating in this work.

Why am I doing this study?
As the case loads of the physiotherapists at Forest Town School have increased, every child who needs physiotherapy cannot be seen individually. Therefore, your child and other children with minimal motor problems are treated in groups. They are treated once a week for a period of 6 months and then they are put back on the waiting list so that the other children can be treated. I would like to evaluate if this group therapy is helping your child.

What do I expect from the participants in the study?
I will include your child in my study if you give consent. It would also mean that you have given me permission to use your child's records from school. I would appreciate it if you would fill in the questionnaire sheet about your child's birth and medical history. All your child's details and medical history will be kept confidential.

The first week of the third term, your child will have a full motor skill assessment (running, jumping, balancing, and drawing). It will take about one hour. After the assessment he/she will be put into a group and will attend physiotherapy once a week, as usual, for the next 8 weeks. In the last week of the third term he/she will again have the same motor assessment. Then in the fourth term he/she will not receive physiotherapy, but will be assessed for the last time in the middle of November. Assessing your child before and after the treatment programme will help to see if he/she has improved. Therefore, your child will have physiotherapy as usual in the third term but not in the last term (therapy in the last term is often interrupted by exams, prize giving and other school events anyway).

Are there benefits to the study?
Yes. It will help us to see if our physiotherapy programme is working or if it needs to be changed.

May I withdraw my child from the study?
Yes. You may do this at any time without giving a reason. The study is completely voluntary and not taking part in it or withdrawing from it will not influence your child's treatment in any way. He/she will still receive treatment.

What about confidentiality?
Your child's identity will be kept confidential and only the researcher will have their personal details. Each child will be assigned a number in the study to keep them anonymous.

If you have any queries, more information may be obtained from
Julie Brenner at (011) 646-0131.

If you are happy for your child to take part in the study please read and sign the attached consent form.

If you are interested in the results of the study and would like written feedback at the end of the year, please indicate so on the bottom of the Parent Consent Form.

Thank you

Julie Brenner

No:

Parent/Guardian Consent Form (Appendix 2)

I agree to allow my child to participate in the study at Forest Town School conducted by Julie Brenner on the effects of group physiotherapy as outlined in the information sheet. I agree to allow the researcher access to my child's school file.

Parent's name: _____ Date: _____

Signature: _____

Please return this section to Julie Brenner in the Physiotherapy Department.

Would you like written feedback of the results of the study when it is completed?

Yes / No (please circle)

No:

Learner Assent Form (Appendix 3)

The study being done by Julie Brenner in the Physiotherapy Department at Forest Town School on the effects of group physiotherapy has been carefully explained to me. I willingly agree to be assessed and treated in the study.

Signed: _____

Date: _____

Learner Information Sheet (Appendix 4)

Hello

I am Julie Brenner from the Physio Department at Forest Town School. I would like to invite you to take part in my study on how strong you are and how well you can run, hop, throw and jump after physiotherapy in a group for one term. I will first have to check how well you can do these things at the beginning of the term and then at the end of the term. This will take an hour at the beginning and an hour at the end of the term. I will also have to re-check these things once more in November.

You do not have to take part in my study if you don't want to. You will still be able to come to physio in a group if you choose not to take part. You can at anytime choose not to be a part of the study anymore and still carry on with physio.

If you have any more questions about what you will have to do, please ask me.

Thanks

Julie

No:

Information Questionnaire (Appendix 5)

Child's date of birth: **Child's age:**

Birth history: (Premature, on oxygen, in incubator)

Medical History: (Epileptic, meningitis, any syndrome, hospitalisation)

Medication: (E.g. Ritalin, Epilim)

At what age did your child first:

Sit:
Crawl:
Walk:

Does your child have or has he/she ever had private therapy? (Physio, O.T., Speech Therapy)

Does your child play any sports outside of school?

Ethical Clearance (Appendix 6)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Brenner

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M070414**
PROJECT	The Effect of Physiotherapy in a Group on the Motor Function of Children with Develomental Coordination Disorders?
INVESTIGATORS	Miss J Brenner
DEPARTMENT	Department of Physiotherapy
DATE CONSIDERED	07.05.04
DECISION OF THE COMMITTEE*	APPROVED UNCONDITIONALLY

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 07.05.28 **CHAIRPERSON** .....
(Professors PE Cleaton-Jones, A Dhai, M Vorster, C Feldman, A Woodiwiss)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Baillieu N

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Exercise Programme (Appendix 7)

-Therapist to correct each child's posture and alignment in each exercise
- The therapist should demonstrate and give instruction to a child if he/she is struggling with an exercise.

Session 1: *Equipment: 30cm balls, wedges, 55cm balls, hula hoops*

1. Lie supine on floor with a wedge under their head- legs straight and together and arms next to their body. Therapist throws a 30cm ball at them from at their feet. The child catches the ball and throws it back to the therapist. Each child gets 10 chances to catch and throw the ball. The exercise can be progressed by using a larger or heavier ball.

2. In supine lying on the floor with their head on a wedge, the child flexes both legs at the hips and knees and lifts their legs off the floor. The therapist throws a 30cm ball to them and they kick it back to the therapist with both feet.

3. Children lie prone on the floor in pairs facing each other about 5m apart. Each pair has a 55cm ball. They push the ball to each other with both their hands and arms stretched out. They must lift their arms off the floor. They must each push the ball 20 times.

4. Ladies Push Ups. Start in a 4 point position on the floor. Hook their feet together. Tell them to put their chin and stomach on the floor and keep their backs straight. Do not let them flex at their hips when they go down or come up. They must bend their elbows. Do one set of 10 push ups.

5. Put a hula hoop on the floor. The child stands in the middle of the hula hoop with their feet together. Then they jump and open their legs so that their feet are at the inside edge of the hula hoop. They then jump and close the legs with their feet together. They repeat this in a smooth, rhythmic manner 20 times. Children who cannot get the correct timing should be guided and be demonstrated to until they can do it.

6. Star jumps in the hula hoop. With a hula hoop on the floor, the children are instructed to start with their feet together in the middle of the hula hoop and hands at their side. They then have to jump and open their legs whilst clapping their hands above their heads. Each child should be given an opportunity to demonstrate and the therapist should correct or assist if necessary. A set of 20 should be done together.

7. Standing on one leg. Keep the hula hoop on the floor. Stand on one leg in the hula hoop for 20 seconds. Children should not hook the lifted leg around the other. Change legs and stand on the other leg for 20 seconds.

8. Put 6 hula hoops next to each other on the floor in a line. Each child then hops with one hop in each hula hoop, down the line. On their next turn they must use the other leg. Each child should have 3 turns with each leg.

Session 2*: Equipment: Long yellow blocks, rollers, bean bags*

1. Sit on a long block or roller with arms extended and externally rotated at the shoulder behind and both legs to one side. Put 10 bean bags to one side of the roller. The children must lean back and weight bear on the arms behind him/her and pick up the bean bag with his/her feet and transfer them to the other side of the block by flexing the hips and knees. Then transfer them back to the other side.

2. Children sit in pairs, facing each other about 5 m apart, each on their own roller or block with both feet to one side (2 children can share a roller). Six bean bags are placed behind the rollers of the children on one side, 3 on each side (left and right). The first child rotates their trunk to the right and places the right arm on the floor and grasps a bean bag on the right with their left arm, then sits up and throws it to their partner opposite them. The second child then rotates to the right and places their right hand on the floor and puts the bean bag on the floor on the right with their left hand and sits up. The first child then rotates to the left and picks up a bean bag with the right hand and sits up and throws to their partner. The second child then who rotates to the left and places their left hand on the floor and places the bean bag on the floor. Continue alternating sides until all the bean bags are at the second child. Repeat the exercise until all the bean bags are at the first child again.

3. Two children may share a block. They lie perpendicular across the block in prone with only their thighs on the block and their hands on the floor, weight bearing through their arms. Lift one arm as high as possible and for 5 seconds, then swap arms and lift the opposite arm for 5 seconds. Lift each arm 5 times each.

4. Ladies push ups as described in session 1(ex 4). Two sets of 10 push ups.

5. Star jumps as in session 1(ex 6- without the hula hoop). Do 20 star jumps giving each child a turn to do it individually.

6. Children get into pairs. Each pair gets a bean bag. The pairs line up a meter apart in the middle of the room facing each other. Each partner takes a step back then the one holding the bean bag throws to their partner. If they catch it, that pair takes another step back and throw again. If they miss then that pair is out. Carry on until the last pair is standing.

7. Standing on 1 leg for 20 seconds (as in session 1, ex 7). Swap legs.

8. Hopping relay. Line up. Each child hops on their right leg for a distance of 5m and turns back. The next child starts once the previous one gets back. Once everyone has had a chance the same procedure is repeated whilst hopping on the left leg. Each child must have 4 chances (twice on each leg).

Session 3: *Equipment: 55cm balls, hula hoops,*

1. Sit on a 55cm ball. Lift the right leg up whilst balancing on the ball without using their hands. Hold for 10 seconds. Then lift the left leg up and hold for 10 seconds. Repeat 5 times for each leg.

2. Whilst sitting on the ball, slide down so that their back is leaning on the ball and their feet are on the floor and knees flexed to 90 degrees. Make sure their necks are flexed and they are looking forward. Tell them to keep their arms out straight in front of them and to touch their knees. Do these mini sit ups 20 times i.e. touch their knees 20 times.

3. As above in supine on the ball, touch hands to opposite knee so as to get rotation (oblique abdominal muscles). Repeat 20 times i.e.10 times to each side.

4. Roll forward on the ball in prone so that they are weight bearing through their arms on the floor and their thighs are resting on the ball. Make sure their stomachs and shoulders are not sagging. Hold for 20 seconds.

5. As above in ex 4, then flex hips and knees and bring ball forward whilst still weight bearing through the arms. Hold for 10 seconds. Then extend the hips and knees so that the ball is again under the thighs. Repeat 10 times (flexing and extending the hips and knees).

6. Stride/scissor jumps. Put a hula hoop on the floor in front of each child. Ask them to put one foot into the hula hoop. Then jump up and swap feet so that the opposite foot is in the hoop. Check that each child is doing it correctly. Repeat 20 times.

7. Leave the hula hoop on the floor. Tell each child to step into the centre. Then jump and open their legs so that their feet are touching the hula hoop on the inside rim. Then jump and cross their feet in the middle. Repeat opening their legs and then crossing them. Repeat 20 times.

8. Group to line up at the end of a 5m line drawn on the floor (in the physio gym). Each child must walk along the line heel-to-toe trying to balance. If they lose their balance they should continue from the same point. Each child should have 5 turns.

Session 4: *Equipment: 55cm balls*

1. Each child to sit on an appropriately sized ball (hip and knees at 90 degrees and feet on the floor). The children are to slide down on the ball in supine without using their hands until only their upper thoracic area and scapulae are in contact with the ball. They should keep their necks flexed and look forward. Hold the position for 10 seconds then sit back up without using their hands. Repeat exercise 10 times each.

2. Lie supine on the floor. Put the 55cm ball between their ankles and lift into the air until their hips are at 90 degrees and their knees straight. Hold the position for 10 seconds then lower the legs to the floor. Repeat 10 times.

3. Lie in prone on the floor in pairs facing each other or all facing the therapist. Roll a 55cm ball to each child or to each other in pairs. They must push the ball away with both hands. Each child should have 10 turns to push the ball.

4. Each child puts their ball in front of them on the floor and rolls forward over it and walks forward on their hands until the ball is supporting them under the knees. Make sure their stomach does not sag. Tell them to lift up their right arm for 3 sec while maintaining their balance, then put it down. Then lift the left hand for 3 seconds and put it down. Repeat 5 times for each hand.

5. Standing in a line in pairs 5m apart facing each other, the children on one side hold the 55cm balls. They must lift it above their heads then throw to their partner by bouncing it on the floor in the middle. The other child catches it, raises it above their head and throws back. Each child must throw and catch 20 times i.e. each pair must throw 40 times.

6. Using the red and green ladder on the floor, each child must walk across on the white line in the middle and balance. Each child is to have 10 chances.

7. Skipping (step-hop on one leg then the other). Each child is to attempt to skip for a distance of 10m. The therapist is to assist and instruct if the child is struggling. Each child should have 3 turns.

8. Hopping relay. Each child is to hop 5m on one leg, then to return hopping on the other leg. Each child has 3 turns to hop.

Session 5: *Equipment: Half circle, long yellow blocks, hop scotch mat, bean bags*

1. Sit ups. Supine on the floor with their knees flexed. Hold their arms extended and at 90 degrees at the shoulders. They must lift their head and shoulders up and touch their knees with their hands, then lie down. Do 10 sit ups.

2. As above in ex 1, lie supine with knees flexed and raise head and shoulders and touch alternate hand to knee I the sit up. Repeat 5 times to each side.

3. Ladies push ups (as in ex 4 in session 1). Get into 4 point position on the floor. Hook feet together. Tell children to put their chin and stomach on the floor then push up again. The children are to keep their backs straight and not to flex at hips. Do 2 sets of 10 push ups.

4. Put a table or half circle flat on its side, with a long yellow block on the floor touching it at a perpendicular angle. A child is to stand with both feet on one side of the block and their hands on the table or half circle. They are to keep their hands on the t5able and push on it as they jump with both feet over the block to the other side. They are to jump from one side to the other 20 times each. Two blocks can be used a t one half circle so 2 children can jump at a time.

5. Using the same equipment as ex 4 above, the child keeps his hands on the half circle with one leg each side of the block. The child pushes on his/her hands and jumps up with both feet onto the block, and then jumps down. Hands are to remain on the table or half circle. Each child is to jump onto the block 20 times.

6. Hop scotch. Using the hop scotch mat, each child must have 5 turns to play hop scotch.

7. Children are to skip 10m each. Each child is to have 5 turns.

8. Each child is to get 2 bean bags. The therapist is to demonstrate how to juggle with 2 bean bags. Then each child has a turn individually and is assisted. Then they must all practice until they are able to do 3 throws in a row.

Session 6: *Equipment: 55cm balls, different sized blocks, bean bags*

1. Each child to sit on a 55cm ball. Each child is to move from sitting to supine on the ball as in ex 1 session 4. When lying supine with only their upper thoracic area and scapulae in contact with the ball, they are to lift one leg up and try to maintain their balance, not using their hands. They are then to put their foot down and lift the other foot. They are to lift alternate feet 5 times each then push up to sit on the ball.

2. Lie prone on the ball, walk forward on their hands until the ball is under their knees. The therapist rolls a 55cm ball to in turn to each child and they have to push it back with one hand whilst maintaining their balance and weight bearing on the other. They must alternate using their hands to push. Each child must have 6 turns to push.

3. Sit ups as in session 5 ex 1 & 2. They are to lie supine with their knees flexed and touch their knees with their hands. They are to do 10 in a straight plane, then 10 alternately touching opposite hand to knee.

4. Standing up each child holds their ball with both hands in front of them with their arms extended at shoulder height. The therapist throws a ball in turn to each child who his it away with their ball. Each child is to have 10 turns.

5. Star jumps. Each child is to do 20. The therapist is to instruct and assist if necessary.

6. Scissor or stride jumps. Each child is to do 20.

7. Six different sized blocks are to be placed small distances apart in a circle. The children are to each stand on a block. They are then to move in a clock wise direction and move and step onto the block in front of them. The therapist should count so that they move simultaneously. When instructed they should also change direction.

8. Juggling. Each child is to receive 2 bean bags and practice to juggle until they are able to.

***Session 7**: Equipment: 55cm balls, various blocks and half circle, hop scotch, bean bags*

1. Sit on a 55cm ball. Lift the right leg up whilst balancing on the ball without using their hands. Hold for 10 seconds. Then lift the left leg up and hold for 10 seconds. Repeat 5 times for each leg.

2. Whilst sitting on the ball, slide down so that their back is leaning on the ball and their feet are on the floor and knees flexed to 90 degrees. Make sure their necks are flexed and they are looking forward. Tell them to keep their arms out straight in front of them and to touch their knees. Do these mini sit ups 20 times i.e. touch their knees 20 times.

3. Lie prone on the ball, walk forward on their hands until the ball is under their knees. The therapist rolls a 55cm ball to in turn to each child and they have to push it back with one hand whilst maintaining their balance and weight bearing on the other. They must alternate using their hands to push. Each child must have 6 turns to push.

4. Standing in a line in pairs 5m apart facing each other, the children on one side hold the 55cm balls. They must lift it above their heads then throw to their partner by bouncing it on the floor in the middle. The other child catches it, raises it above their head and throws back. Each child must throw and catch 20 times i.e. each pair must throw 40 times.

5. Children are to sit on the floor in a circle, place their hands on the floor behind their back and flex their knees so that their feet are on the floor. Then they must push down on their feet and hands and lift their buttocks off the floor (spider position). One child starts and crawls under the other children in a circle until they reach their original position and assumes the same position then the child next to them crawls around the circle. Each child must have a chance to crawl around the circle. The children must not put down their buttocks.

6. Place various size blocks and the half circle next to each other to make an obstacle course. The children are to crawl along the blocks in turn. They can change the activity. Next, crawl sideways on the blocks (i.e. with their knees on the blocks and hands on the floor). Do with hands to other side of the blocks. They can also spider crawl over the blocks.

7. Hop scotch. Using the hop scotch mat, each child must have 5 turns to play hop scotch.

8. Each child receives one bean bag. They stand in pairs 5m apart facing each other. They throw the bean bag at the same time to their partner, and must simultaneously catch their partner's bean bag.

Session 8*: Equipment: Rollers, long yellow blocks, 55cm balls, half circles/tables, ladder, various sized blocks*

1. Each child to sit on a 55cm ball. Each child is to move from sitting to supine on the ball as in ex 1 session 4. When lying supine with only their upper thoracic area and scapulae in contact with the ball, they are to lift one leg up and try to maintain their balance, not using their hands. They are then to put their foot down and lift the other foot. They are to lift alternate feet 5 times each then push up to sit on the ball.

2. Children sit in pairs, facing each other about 5 m apart, each on their own roller or block with both feet to one side (2 children can share a roller). Six bean bags are placed behind the rollers of the children on one side, 3 on each side (left and right). The first child rotates their trunk to the right and places the right arm on the floor and grasps a bean bag on the right with their left arm, then sits up and throws it to their partner opposite them. The second child then rotates to the right and places their right hand on the floor and puts the bean bag on the floor on the right with their left hand and sits up. The first child then rotates to the left and picks up a bean bag with the right hand and sits up and throws to their partner. The second child then who rotates to the left and places their left hand on the floor and places the bean bag on the floor. Continue alternating sides until all the bean bags are at the second child. Repeat the exercise until all the bean bags are at the first child again.

3. Two children at a time lie prone over the roller. They must work together to walk forward on their hands to both pick up a bean bag placed 4m away. Then push back to the starting point. They must not fall off the roller. Each pair should have 3 turns.

4. Put a table or half circle flat on its side, with a long yellow block on the floor touching it at a perpendicular angle. A child is to stand with both feet on one side of the block and their hands on the table or half circle. They are to keep their hands on the table and push on it as they jump with both feet over the block to the other side. They are to jump from one side to the other 20 times each. Two blocks can be used a t one half circle so 2 children can jump at a time.

5. Using the same equipment as ex 4 above, the child keeps his hands on the half circle with one leg each side of the block. The child pushes on his/her hands and jumps up with both feet onto the block, and then jumps down. Hands are to remain on the table or half circle. Each child is to jump onto the block 20 times.

6. Place various size blocks and the half circle next to each other to make an obstacle course. The children are to crawl along the blocks in turn. They can change the activity. Next, crawl sideways on the blocks (i.e. with their knees on the blocks and hands on the floor). Do with hands to other side of the blocks. They can also spider crawl over the blocks.

7. Hopping and skipping relay. Children line up and first child must hop to 5m mark on one leg, then turn around and hop back on other leg. Then next child goes. Once all the children have hopped to 5m mark and back twice they must skip there and back in a relay. Each should have 2 turns.

8. Put the red and green “ladder” on the floor. Each child must walk on the middle white beam heel-to-toe 5 times.

BOTMP Score Sheet (Appendix 8)

BRUININKS-OSERETSKY TEST OF MOTOR PROFICIENCY / Robert H. Bruininks, Ph.D.

INDIVIDUAL RECORD FORM

COMPLETE BATTERY AND SHORT FORM

NAME _____ SEX: Boy ☐ Girl ☐ GRADE _____

SCHOOL/AGENCY _____ CITY _____ STATE _____

EXAMINER _____ REFERRED BY _____

PURPOSE OF TESTING _____

Arm Preference: *(circle one)*
RIGHT LEFT MIXED

Leg Preference: *(circle one)*
RIGHT LEFT MIXED

	Year	Month	Day
Date Tested			
Date of Birth			
Chronological Age			

Complete Battery:

SUBTEST	POINT SCORE Maximum	POINT SCORE Subject's	STANDARD SCORE Test (Table 23)	STANDARD SCORE Composite (Table 24)	PERCENTILE RANK (Table 25)	STANINE (Table 25)	OTHER
GROSS MOTOR SUBTESTS:							
1. Running Speed and Agility	15						
2. Balance	32						
3. Bilateral Coordination	20						
4. Strength	42						
GROSS MOTOR COMPOSITE			* SUM				
5. Upper-Limb Coordination	21		*				
FINE MOTOR SUBTESTS:							
6. Response Speed	17						
7. Visual-Motor Control	24						
8. Upper-Limb Speed and Dexterity	72						
FINE MOTOR COMPOSITE			* SUM				
BATTERY COMPOSITE			* SUM				

*To obtain Battery Composite: Add Gross Motor Composite, Subtest 5 Standard Score, and Fine Motor Composite. Check result by adding Standard Scores on Subtests 1-8.

Short Form:

	POINT SCORE Maximum	POINT SCORE Subject's	STANDARD SCORE (Table 27)	PERCENTILE RANK (Table 27)	STANINE (Table 27)
SHORT FORM	98				

DIRECTIONS

Complete Battery:

1. During test administration, record subject's response for each trial.

2. After test administration, convert performance on each item (item raw score) to a point score, using scale provided. For an item with more than one trial, choose best performance. Record item point score in *circle* to right of scale.

3. For each subtest, add item point scores; record total in circle provided at end of each subtest and in Test Score Summary section. Consult *Examiner's Manual* for norms tables.

Short Form:

1. Follow Steps 1 and 2 for Complete Battery, except record each point score in *box* to right of scale.

2. Add point scores for all 14 Short Form items and record total in Test Score Summary section. Consult *Examiner's Manual* for norms tables.

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