

**NON-RANDOMISED CLINICAL TRIAL OF INTENSIVE VERSUS
WEEKLY PHYSIOTHERAPY FOR CHILDREN WITH MINOR
MOTOR DIFFICULTIES**

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DECLARATION

I, Stacey Lisa Edelman, declare that this research report is 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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.....day of....., 2011

ABSTRACT

Developmental Co-ordination Disorder (DCD) is a heterogeneous disorder that is said to present in five to eight percent of the school-aged population. Children with DCD have motor inco-ordination and poor fine function, and will often have associated co-morbidities such as speech and language and attention deficits. For many years parents of children with DCD were told that their children would grow out of it as they developed. However since then many studies have found that young children described as having poor co-ordination for their age or those diagnosed with DCD, continue to have significant motor problems, together with a variety of emotional, social, educational, psychological and behavioural difficulties. Many interventions have been shown to be effective in improving the motor skills of these children, however very little research could be found on the use of physiotherapy in the treatment of these children.

The aim of this study was therefore to determine the effectiveness of two intensities of physiotherapy in improving the motor abilities of children with minor motor difficulties in South Africa. The study was carried out with 34 children (22 males, 12 females) with minor motor difficulties in a private practice setting. An investigation into the effectiveness of weekly 45 minute physiotherapy sessions with no home exercise programme, (which is standard management currently) as compared with a five day intensive intervention (one hour per day) together with a home exercise programme, was conducted. The intervention for each group lasted 12 weeks.

The results showed that for children who received weekly therapy, the mean point scores, scale scores and standard scores for each of the four motor composites as well as for the total motor composite increased from baseline .

A protocol of five days of physiotherapy intervention using an NDT approach together with a home exercise programme may be useful in the treatment of children with minor motor difficulties; as the individuals who participated in this programme showed an improvement in overall motor performance after a five day intervention and at six weeks

and 12 weeks with the use of a home exercise programme. Results showed that all scores apart from fine motor function improved from baseline ($p < 0.05$).

It was concluded that the 45 minutes once a week physiotherapy intervention using an NDT approach which is currently being used is effective in improving the fine and gross motor skills of children with minor motor difficulties. However if parents are unable to afford weekly intervention but are willing to comply regularly with a prescribed, individualised home exercise programme, a possible protocol of an intensive block of therapy with a home programme may be advised. This protocol however cannot be advised for use with all children with minor motor difficulties and the therapists' clinical judgment is imperative in this regard.

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ABBREVIATIONS

ABD- Atypical Brain Development

ADD -Attention Deficit

ADHD- Attention Deficit Hyperactivity Disorder

ADL- Activities of Daily Living

ANCOVA- Analysis of Co-variance

ANOVA- Analysis of Variance

APA- Anticipatory postural adjustments

BC- Body Co-ordination

BCH- Benign Congenital Hypotonia

BOT-2- Bruininks-Oseretsky Test of Motor Proficiency *second edition*

BOTMP- The Bruininks-Oseretsky Test of Motor Proficiency

CNS- Central Nervous System

CO-OP- Cognitive Orientation to Daily Occupational Performance

CPG- Central Pattern Generators

DAMP- Deficits in Attention, Motor control, and Perception

DCD- Developmental Coordination Disorder

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

DVTMI- Developmental Test of Visual Motor Integration

EI- Ecological Intervention

ELBW- Extremely Low Birth Weight

FMC- Fine Manual Control

GLS- General Least Squares

GMFM- Gross Motor Function Measure

HEP- Home Exercise Programme

IQ- Intelligence Quotient

JHS- Joint Hypermobility Syndrome

KT-Kinaesthetic Training

LD- Learning Disability

MABC- Movement Assessment Battery for Children

MBD- Minimal Brain Dysfunction
MC- Manual Co-ordination
MND- Minor Neurological Dysfunction
NDT- Neurodevelopmental therapy
OT- Occupational Therapy
PMT- Perceptual Motor Training
RD- Reading Disability
SD- Standard Deviation
SDQ- Strengths & Difficulties Questionnaire
SIT- Sensory-Integration Therapy
SLI- Severe Language Impairment
StrA- Strength and Agility
TMC- Total Motor Composite
TOMI- Test of Motor Impairment

CHAPTER 1

1. Introduction:

Many children in the private health care sector are being referred to physiotherapy for difficulties with motor learning and coordination as well as having difficulties maintaining an upright posture when sitting on the floor or at their desks. These difficulties are said to interfere with fine motor skills such as drawing, writing and cutting (Miller *et al.*, 2001; Missiuna & Pollock, 1995) as well as gross motor abilities both of which do not fall within the normal age ranges. The child's ability to concentrate on the task at hand is also affected thus having a detrimental effect on educational capacity at school.

Many terms have been used to describe children who may present with minor motor difficulties due to a variety of underlying conditions; such as developmental dyspraxia (DD), the Clumsy Child Syndrome, physical awkwardness, Minor Neurological Dysfunction (MND), Benign Congenital Hypotonia (BCH), Motor Skills Disorder and Developmental Co-ordination Disorder (DCD) to name a few (Wilms-Floet, 2006; Henderson and Henderson, 2003; Hadders-Algra, 2002; Missiuna and Polatajko, 1995).

The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (American Psychiatric Association, 1994 as cited in Mandich *et al.*, 2003) describes children with DCD as having marked impairment in the development of motor coordination that is not explained by mental retardation nor by a known physical disorder, that significantly interferes with academic achievement or activities of daily living. At the London Consensus, DCD was described as a chronic and usually permanent condition characterised by impairment of motor performance that is sufficient to produce functional motor performance deficits that are not explicable by the child's age or intellect, or by other diagnosable neurological or spatial-temporal organisational problems (Missiuna *et al.*, 2003; Dewey & Wilson, 2001).

Children with DCD form a heterogeneous population (Dewey and Wilson, 2001). Some of the problems associated with DCD are difficulties with co-ordination of gross motor skills (Missiuna *et al.*, 2003) and problems with fine motor function such as writing (Rodger *et al.*, 2003; Smits-Engelsman, 2001; Missiuna & Pollock, 1995). Children with DCD may have lower self esteem, more anxiety, fewer friends than their peers and may be more prone to having psychological and social participation problems at later stages in life (Skinner & Piek, 2001; Losse *et al.*, 1991). They may have co-morbid conditions, such as speech and language difficulties and attention deficit disorders (Missiuna *et al.*, 2003). The rate of co-morbidity of DCD with Attention Deficit/Hyperactivity Disorder is said to be close to 50% (Watemberg *et al.*, 2007; Miller *et al.*, 2001; Dewey and Wilson, 2001).

Wilms-Floet (2006) states that the prevalence of motor coordination disorders varies widely, it is estimated that DCD is prevalent in five to six percent of school- aged children around the world (Missiuna & Pollock, 1995) and an additional 10% may have a minor form of the problem (Wilms-Floet, 2006).

Many different approaches have been used in the treatment of children with DCD. Therapists usually choose approaches based on the child's needs, and because children with DCD make up such a heterogeneous group, it is reported that no single approach works for all children and therapists may therefore use a variety of approaches (Mandich *et al.*, 2001).

The treatment intervention used to tackle the problems experienced by children with motor inco-ordination or clumsiness in South Africa is largely based on the Neurodevelopmental Therapy (NDT) approach. There is limited research on the effectiveness of this treatment for children with minor motor difficulties and the research which has been done on the effectiveness of the NDT approach as an intervention for children with cerebral palsy has not shown encouraging results (Butler & Darrah, 2001). This is due to problems with validity of the evidence about NDT which were small sample size, lack of information about power to detect a true difference, heterogeneity of

participants and a variance in therapy treatment across time and therapists (Butler and Darrah, 2001).

In South Africa, in a study by Brenner (2007), it was found that group therapy with a ball exercise programme was effective in the treatment of children with DCD. Another South African pilot study by Stevens (2002), found that children who received physiotherapy which consisted of postural exercises (using the NDT approach) and a home exercise ball programme and lasted for 45 minutes once a week, showed a significantly greater improvement and more reached their desired chronological age for fine motor function, compared to children who received physiotherapy alone.

As seen from above both Brenner (2007) and Stevens (2002) used different types and duration of intervention when treating these children. There has also been no research done on the amount of therapy these children need to make a difference in their motor function. Guidelines in terms of how many sessions per week, and how long the sessions should be, are also needed to inform therapists as to best practice in this regard.

Very few studies could be found comparing the intensities of treatment for children with minor motor difficulties and DCD. There are studies that have been done using children with cerebral palsy however which assessed the effectiveness of two intensities of either intensive (intermittent) or basic (weekly) treatment. Bower *et al.*, (2001) found that there was no statistically significant difference in scores achieved between intensive and routine amounts of therapy, however there was a trend towards a statistically significant difference in children receiving intensive therapy during the treatment period but this was not maintained when therapy reverted to its usual amount. Other studies have also found that children with motor delay including cerebral palsy benefited from more intensive physiotherapy (Schreiber, 2004; Tsorlakis *et al.*, 2004 ; Mayo, 1991), whereas Christiansen & Lange (2008) found that physiotherapy given to children with cerebral palsy as intermittent or continuous therapy, yielded identical outcome measures for these children and propose that their results provide parents and therapists to structure therapy in accordance with resources available.

It is of utmost importance to find the best type and intensity of intervention for children with minor motor difficulties and with DCD; that will achieve the best outcome and provide the most benefit to them. It may also give therapists a choice of which intensity of treatment to use; based on the severity of the child's motor difficulties.

This will also ease the financial burden of parents who may have the time to commit to doing a home programme or it will reduce the stress of parents who may not have the time to do a home programme due to job commitments and due to the responsibility of caring for other family members.

1.1 Aim of the study

The main aim of this study was to determine the effectiveness of two intensities of physiotherapy in improving the motor abilities of children with minor motor difficulties in South Africa.

1.2 Objectives of the study

- To compare results obtained treating intensively for one hour per day Monday to Friday for one week followed by a home exercise programme (lasting 12 weeks) at six weeks and 12 weeks, to results obtained after six weeks and 12 weeks of physiotherapy treatment for 45 minutes weekly.
- To assess whether a possible protocol of intensive therapy for five days with a home exercise programme (lasting 12 weeks) can bring about the same changes at six weeks of treatment; that the current protocol of weekly therapy would at 12 weeks, with regards to positive outcomes achieved in the functional motor abilities of these children.

1.3 Significance of the study

At St Davids Marist Inanda, St Mary's and Crawford Village Schools, children receive physiotherapy once a week for 45 minutes, this is the standard management currently provided, and is the intervention that is used in Group A of the current study.

They are re-assessed at three months and the parents are then given a home ball exercise programme to be done in order to augment this weekly physiotherapy treatment.

In the current economic climate in South Africa many parents struggle to afford this amount of therapy with the amounts that medical aids are paying back to them, being minimal. Many parents also ask how long the intervention is going to take and if they can do anything at home to speed up the improvements in their children's abilities.

Whereas other parents prefer the child to receive the therapy with the physiotherapist once a week at school as this is more convenient for them due to their job commitments and other responsibilities for all family members.

As there has been no research in South Africa conducted on the effectiveness of either one of these intensities of physiotherapy in improving the abilities of these children with minor motor difficulties, this is thus an exploratory study.

There has also been little research conducted in South Africa regarding the effect of physiotherapy using an individualised NDT approach in the treatment of children with minor motor difficulties or DCD.

It is for these reasons that an investigation into the effectiveness of an intense intervention together with a home exercise programme, as compared to weekly physiotherapy sessions (which is standard management currently) is needed.

CHAPTER 2

LITERATURE REVIEW

2. INTRODUCTION

In this chapter an overview of developmental coordination disorder will be given. DCD is a heterogeneous disorder that is said to present in five to eight percent of the school-aged population (Dewey & Wilson, 2001). Children with DCD have motor inco-ordination and poor fine motor function, and may have associated co-morbidities such as speech and language and attention deficits (Missiuna *et al.*, 2003; Dewey & Wilson, 2001). For many years parents of children with DCD were told that their children with motor difficulties would grow out of it as they develop (Mandich *et al.*, 2003; Barnhart *et al.*, 2003; Losse *et al.*, 1991). However since then many authors have found that young children described as having poor co-ordination for their age or those diagnosed with DCD, continue to have significant motor problems, together with a variety of emotional, social, educational, psychological and behavioural difficulties (Cantell *et al.*, 2003; Skinner & Piek, 2001; Cantell *et al.*, 1994; Losse *et al.*, 1991)

Much research was found on the gross and fine motor problems, sensori-motor and psychosocial problems in children with DCD. Many intervention studies were found to investigate the effectiveness of different types of treatment of children with DCD (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001). It has been suggested that future research should assess the effectiveness of different amounts (duration and frequency) of treatment given rather than just assessing the effectiveness of an intervention (Fetters & Kluzik, 1996). Very few studies could be found on the effectiveness of physical therapy in the treatment of children with DCD. Of those found many therapists used eclectic treatment approaches, treated heterogeneous groups of children using group or individual therapy designs and different frequencies and intensities of treatment (Watemberg *et al.*, 2007; Kaufman & Schilling, 2007; Schreiber, 2004; Stevens, 2002; Smits Engelsman *et al.*, 2001; Schoemaker *et al.*, 1994).

As there has been very little research in South Africa conducted on the effectiveness of either one of these intensities of physiotherapy in improving the abilities of these children with minor motor difficulties, this is thus an exploratory study.

Articles were sourced for this review using Pubmed. A search was also conducted through the Health Sciences Library of the University of the Witwatersrand.

Key words used in searches included: Developmental co-ordination Disorder, physical therapy intervention, Neurodevelopmental therapy approach, treatment intensity, gross motor function, clumsiness.

2.1 DEVELOPMENTAL CO-ORDINATION DISORDER

Children with difficulties with motor co-ordination have been described using many terms including ‘clumsiness’, ‘motorically awkward’, ‘motor impaired’, ‘physically awkward’, ‘minimal cerebral palsy’, ‘minimal brain dysfunction’, ‘clumsy child syndrome’, ‘developmental dyspraxia’, ‘sensory integrative dysfunction’, ‘perceptual motor dysfunction’, ‘motor weakness’, ‘psychomotor syndrome’, ‘mild motor problems’ and ‘low tone’ (Barnhart *et al.*, 2003; Missiuna *et al.*, 2003; Dewey & Wilson, 2001).

In London, Ontario, Canada in 1994 an International Consensus Meeting on Children and Clumsiness was held. On the agenda was the need for an agreement on the name and definition of the disability. At this meeting ‘Developmental Co-ordination Disorder (DCD)’ was the name agreed upon that would be given to the condition in which children display motor co-ordination difficulties that are not due to any identifiable neurological defect by the *Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV)*, (Dewey & Wilson, 2001).

2.1.1 DEFINITION

At the London Consensus DCD was described as a chronic and usually permanent condition characterized by impairment of motor performance that is sufficient to produce

functional motor performance deficits that are not explicable by the child's age or intellect, or by other diagnosable neurological or spatial-temporal organisational problems (Missiuna *et al.*, 2003; Dewey & Wilson, 2001).

The *Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV)*, defines DCD as (Dewey & Wilson, 2001):

“Criterion A: a marked impairment in the development of motor co-ordination i.e. performance in daily activities that require motor coordination is substantially lower than expected for the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor developmental milestones (sitting, crawling and walking), dropping things, clumsiness, poor performance in sports, poor handwriting.

Criterion B: The diagnosis is made only if the disturbance in Criterion A interferes significantly with academic achievement (primarily due to poor handwriting) or activities of daily living (e.g. dressing, eating, riding a bicycle, tying shoelaces).

Criterion C: The disturbance and difficulties are not due to general medical conditions (e.g. cerebral palsy, hemiplegia, or muscular dystrophy) and does not meet the criteria for a Pervasive Developmental Disorder.

Criterion D:

If mental retardation is present, the testable IQ of a child must be greater than 70 and the motor difficulties are in excess of those usually associated with it”.

Co-occurrence of Disorders

Over the past 50 years many frameworks have been used to describe the use of one concept in order to explain the increase in the co-occurrence of many different disorders in the same child. They have included Minimal Brain Dysfunction (MBD), Minor Neurological Dysfunction (MND), Deficits in Attention, Motor control, and Perception (DAMP) and more recently Atypical Brain Development (ABD) (Kaplan *et al.*, 2006). MBD was popular in the 1960's and referred to a non-specific problem in a 'damaged' or 'dysfunctional' brain. Its use was discontinued as the word 'damage' was inappropriate for use in developmental disorders and it also tended to group too many developmental

problems and heterogeneous symptoms into one diagnostic category (Kaplan *et al.*, 2006).

MND was used in the 1980's and focused on the affiliation of developmental neurological 'soft signs' with motor dysfunction. According to MND the 'soft signs' were an indication that the nervous system was wired unusually making it more vulnerable to exogenous influences such as disease (Kaplan *et al.*, 2006). DAMP is a concept which was first described by Swedish researchers in the 1980's and is now the preferred term used to encompass both ADHD and DCD (Visser, 2003; Gillberg & Kadesjo, 2003), it represents a specific disorder of attention, motor control and perception.

Lastly, when co-morbidity is the rule rather than the exception, Kaplan *et al.*, (2006) proposed the theory of Atypical Brain Development (ABD) which is based on the proposition that the answer lies in a single under-lying aetiology that is expressed as a group of symptoms which may be expressed in different ways related to attention (e.g. ADHD), motor co-ordination (e.g. DCD) and learning (e.g. Reading Disability (RD) depending upon the timing, location, and severity of the disruption in brain growth and development (Kaplan *et al.*, 2006, 1998). The inclusion of the word 'atypical' denotes that this concept is not only limited to 'damage', 'dysfunction', 'impairments' or 'weaknesses', as are its predecessors, but it also includes brain development which produces exceptionally high skills or strengths in certain areas (Kaplan *et al.*, 2006).

Kaplan *et al.*, (1998) advocated that there should be no discrete diagnostic categories of developmental disorders. Because there is a smaller likelihood of a diagnosis of 'pure' DCD it may be more accurate rather to acknowledge that the brain dysfunction underlying this deficit is diffuse and reflects a more general deficit. Embodied in the ABD concept is the importance for clinicians and researchers to be aware of the different dimensions involved in developmental disorders (Kaplan *et al.*, 2006).

2.1.2 PREVALENCE

DCD should theoretically be present from birth but children differ with respect to the age at which they begin to show their difficulties, and the full extent of these difficulties may not be noted until they reach school age (Zoia *et al.*, 2006, Missiuna *et al.*, 2003). Almost twenty years ago it was estimated that DCD occurred in eight to 15 percent (Willoughby & Polatjko, 1995) and 10 to 19 percent of children in the general primary school population between the ages of six and 12 (Barnhart *et al.*, 2003). However with the present more precise definition of DCD, it is said to be present in five to eight percent of children in the school-aged population (Dewey & Wilson, 2001). More boys than girls are usually diagnosed with DCD at a ratio of approximately 2:1 or 3:1 (Zoia *et al.*, 2006, Barnhart *et al.*, 2003).

In Kwazulu Natal, South Africa, a study which brings evidence of DCD studies to correlate with the study of Benign Congenital Hypotonia (BCH) (a condition in which low muscle tone affects gross and fine motor skills in a developing child) found that the prevalence of children with hypotonia ranged between 14 and 32 percent, and overall 25 percent of the tested children presented with hypotonia. The majority of tested children who failed the tests were male. Overall almost 58 percent of the children tested as having hypotonia came from rural areas (Dawson & Puckry, 2006). These prevalence rates were higher than other westernised countries for which statistics could be found. Five to six percent in the United States of America (Missiuna & Pollock, 1995), six to 8.5 percent in Britain (Roussounis *et al.*, 1987, as cited in Dawson & Puckry, 2006) and in Australia five to 19 percent of children (Piek & Coleman-Carmen, 1995, as cited in Dawson & Puckry, 2006) presented with DCD.

A higher incidence of DCD may be found in children with a history of pre-natal or perinatal difficulties (Barnhart 2003). Davis *et al.*, (2007) tried to ascertain the rate of DCD occurring in a group of children who were born preterm (<27 weeks) and ELBW (extremely low birth weight) (<1000g) when assessed at eight years of age. It was found that these children have significantly worse motor skills than children of normal birth

weight with the greatest peri-natal risk factor being their sex. A higher incidence of DCD was found in males than in females who were ELBW/preterm. They also found that DCD had implications not only for handwriting and physical activity but children also had slower academic progress (especially in arithmetic), more behavioural problems, poorer cognition as well as poorer social skills and lower self-esteem, than their ELBW/ preterm peers without DCD. It was suggested that early identification of DCD in the pre-school age group will facilitate the introduction of early intervention programmes (Davis *et al.*, 2007).

2.1.3 AETIOLOGY

Children with DCD are a heterogeneous group; because of this finding a cause for DCD is difficult to determine. The motor problems especially of co-ordination that children may experience may occur as a result of one or more difficulties in the proprioceptive system, motor programming, timing and sequencing of muscle activity (Barnhart, 2003). Their clumsiness may be due to deficits in several other areas including postural control, visual attention, visual-spatial perception, motor execution, kinaesthetic and sensory-motor deficits (Missiuna *et al.*, 2006).

Research done with children with dyslexia who also have abnormalities in muscle tone and experience motor co-ordination difficulties has suggested that the reduced functioning of the cerebellum is involved due to a mechanism known as the 'automatisation deficit hypothesis' (Visser, 2003). This theory may be of value when explaining the deficits seen in children with dyslexia, DCD, ADHD and learning disabilities (Missiuna *et al.*, 2006; Visser, 2003). This hypothesis suggests that children with this automatisation deficit have difficulty making motor behaviours automatic. They do not have enough attentional resources to focus on more than one thing at a time, therefore when a secondary task is introduced he or she is unable to make the first task more automatic and therefore finds the motor function more challenging (Visser, 2003). These children are therefore easily distracted by external stimuli and may exhibit problems with attention and concentration (Visser, 2003). A skill that is fully automatised

should not require conscious effortful monitoring and should not decrease in quality if another task requiring conscious monitoring is given (Visser, 2003). The cerebellum is involved in the monitoring, co-ordination and automation of movement as well as skill learning, thus making this hypothesis viable for children with DCD (Missiuna *et al.*, 2006; Visser, 2003).

It has been speculated that clumsiness or DCD (Barnhart, 2003; Sigmundsson, 2003):

1. Forms part of the continuum of cerebral palsy (classified as having minimal cerebral dysfunction or brain damage)
2. Is secondary to pre-natal, peri-natal or neonatal insult
3. Is secondary to neuronal damage in the neurotransmitter or receptor systems at a cellular level rather than from damage to specific brain regions
4. Limited exposure to experiences post-natally

Many theories which will be discussed below have been suggested.

2.1.4 THEORIES OF DEVELOPMENT OF MOTOR CONTROL

Advancements in neurophysiology have led to a better understanding of the processes involved in motor control. Forty years ago, it was thought that early motor behaviours were controlled by primitive reflex mechanisms (Heriza, 1991, as cited in Barnhart, 2003; Sherrington, 1906, as cited in Hadders-Algra, 2000). This was known as the reflex-hierarchical theory of postural control (Heriza, 1991, as cited in Barnhart, 2003; Sherrington, 1906, as cited in Hadders-Algra, 2000). It placed great importance on the appearance and subsequent disappearance or integration of certain reflexes which would then lead to the emergence of posture and movement control reflecting the maturation of structures within the central nervous system for this purpose (Shumway-Cook & Woollacott, 2001).

This concept then changed to one that explained movement resulting from spinal and brainstem activities which are modulated by afferent information and controlled by

supraspinal networks (higher cortical centres) (Heriza, 1991, as cited in Barnhart, 2003; Grillner *et al.*, 1995 as cited in Hadders-Algra, 2000; Schomburg, 1990, as cited in Hadders-Algra, 2000).

From the year 2000, it has been suggested that the motor control of reciprocal movements such as walking is due to central pattern generators (CPG). CPGs are neuronal networks which activate the muscles in specific patterns without afferent information (Hadders-Algra, 2000). However, the sensory information from the environment is used to adapt the movement to the demands of the environment (Hadders-Algra, 2000).

Hadders-Algra (2000) explains that there are three theoretical frameworks for the processes involved in the development of motor control, which have been found and described by different authors throughout the years. Each of these theoretical frameworks will be discussed separately:

1. The Neural-Maturationist Theories
(Peiper, 1963, as cited in Hadders-Algra, 2000; Gesell & Amatruda, 1947, as cited in Hadders-Algra, 2000)
2. The Dynamic Systems Theory
(Thelen *et al.*, 1993, as cited in Hadders-Algra, 2000; Kugler *et al.*, 1990, as cited in Hadders-Algra, 2000; Thelen, 1985, as cited in Hadders-Algra, 2000)
3. The Neuronal Group Selection Theory
(Sporns & Edelman, 1993 as cited in Hadders-Algra, 2000)

1. The Neural-Maturationist Theories:

In the middle of the 19th century, motor development was thought to occur through a 'gradual unfolding of pre-determined patterns in the Central Nervous System (CNS)' (Illingworth, 1966, as cited in Hadders-Algra, 2000). Neural-maturationists such as Peiper (1963) believed in the argument of all motor behaviours being controlled by 'nature' rather than 'nurture' (Barnhart, 2003). They considered the degree of maturation that the CNS was in, to be the main constraint for progress in motor development (Hadders-Algra, 2000). The notion that behavioural motor patterns took place in a genetic order led to the thinking that motor behaviour took place with a proximal-to-distal

progression in a series of developmental milestones (Gesell & Amatruda, 1947, as quoted in Hadders-Algra, 2000). Peiper (1963) believed that basic motor skills such as standing and walking do not occur because of experience but rather from cerebral maturation and increasing control by the cortex over the lower reflexes (Peiper, 1963, as cited in Hadders-Algra, 2000).

The Neural-Maturationist theories propose that children will reach their developmental milestones when their central nervous system is mature and ready to do so regardless of the amount of environmental experience. This implies that if a child does not reach a milestone no amount of therapy will assist if his nervous system is not ready. This is not a theory that advocates of therapy follow, this also may not be true for children with severe DCD, as it has been proven that they will not grow out of their motor difficulties (Cousins & Smyth, 2003; Cantell *et al.*, 2003; Skinner & Piek, 2001; Cantell *et al.*, 1994; Losse *et al.*, 1991).

2. The Dynamic Systems Theory:

Thelen (1985) as cited in Hadders-Algra (2000) was not fulfilled with the Neural Maturationist theory. Thelen (1985) adopted the research of Kugler and co-workers who disagreed with the neural-maturationists as they believed that patterns of movement were influenced by the environment (Kugler *et al.*, 1990, as cited in Hadders-Algra, 2000). Kugler and co-workers created the Dynamic Systems Theory. According to this theory, a specific motor pattern of behaviour assumes a specific organisation, as the result of the effects of its component parts such as postural support, body weight, muscle strength, mood and brain development of the infant as well as the effects of the environmental condition and the subsequent requirements of the task, (Ulrich, 1997, as cited in Hadders-Algra, 2000; Thelen *et al.*, 1993, as cited in Hadders-Algra, 2000; Thelen, 1985, as cited in Hadders-Algra, 2000).

The dynamic systems theory suggests that reflexes are one of many influences on the control of posture and movement. It proposes that postural control for the purpose of

stability and orientation appears from a complex interaction between the musculoskeletal and neural systems called the postural control system and the organisation of the influences within this system is dictated by the specifications of the task and the environment (Shumway-Cook & Woollacott, 2001).

In the dynamic systems theory, the components of the musculoskeletal system which are essential for the emergence of postural control include joint range of motion, spinal flexibility, properties of the muscles, biomechanics and the development of muscle strength (Shumway-Cook & Woollacott, 2001).

The neural components which are important include (Shumway-Cook & Woollacott, 2001):

- a) The development of motor processes such as neuromuscular response synergies which are used to maintain balance.
- b) The development of individual sensory processes including the visual, somato-sensory and vestibular systems.
- c) The development of sensory strategies in order to organise these numerous inputs
- d) The development of higher-level integrative processes or internal representations or body schema which are essential in the mapping of perception (the integration of sensory input to assess the position and motion of the body in space) to action (the ability to generate forces to control the position of the body in space) to interpret self motion and co-ordinate actions.
- e) The development of anticipatory and adaptive mechanisms which modify the way in which they sense and move for postural control.

Development can therefore be regarded as a dynamic system (Thelen *et al.*, 1993, as cited in Hadders-Algra, 2000) as there is complex communication among different levels of the CNS (Barnhart, 2003). Sensory information is interpreted by the CNS and the selection of an appropriate movement strategy is based on current experience, continuous changes in the above-mentioned component parts, external environment and memory of similar movements (Barnhart, 2003). Motor behaviours were thought to be controlled by 'nurture' rather than 'nature' (Barnhart, 2003).

The Dynamic-Systems theory is one that is important to consider as it takes into account all the neural components and the musculoskeletal system and the postural control system which is the level at which physiotherapists try to assist in the development of motor skills if there is any form of malfunction at this level. The top-down approaches e.g. task-specific intervention, for the treatment of children with DCD, were greatly influenced by this theory (Barnhart *et al.*, 2003). It also takes into account sensory input which is the level at which occupational therapists may try to intervene. However in this theory the CNS plays more of a minor role to the environmental constraints to developmental progress (Hadders-Algra, 2000).

3. Neuronal Group Selection Theory

This theory believes that movement is not exclusively governed by either the genes (nature) or the environmental conditions (nurture) alone. It involves the ‘nature’ and ‘nurture’ components of both the aforementioned theories involving a complex relationship between information from genes and the environment (Hadders-Algra, 2000).

The neuronal group selection theory attempts to explain the variation in normal development (Sporns & Edelman, 1993 as cited in Hadders-Algra, 2000). In this theory Sporns & Edelman (1993) as cited in Hadders-Algra (2000) proposed that all levels of the CNS (cortical and sub-cortical) consist of functional neuronal groups, which make up variable networks in the brain, development and behaviour dictate their structure and function. Development starts with these multiple neuronal groups which serve as an early primary repertoire for motor behaviour or to receive specific sensory (afferent) information (Edelman, 1993, as cited in Barnhart, 2003). These neuronal groups and their gross connectivity are determined by evolution (Edelman, 1993, as cited in Barnhart, 2003; Sporns & Edelman, 1993 as cited in Hadders-Algra, 2000).

Development then progresses when selection of effective motor patterns is based on the afferent information formed by behaviour and experience (Hadders-Algra, 2000).

Constant exposure to different experiences leads to modification in the strength of the connections within and among these neuronal groups and this leads to the production of variable secondary repertoires of movement (Hadders-Algra, 2000). These 'secondary neuronal repertoires together with their associated selection mechanisms form the basis of mature variable behaviour' (p567) that can be adapted according to environmental limitations (Sporns & Edelman, 1993 as cited in Hadders-Algra, 2000).

When the neuronal group selection theory is used to explain normal motor development, developmental progress can be divided into two phases: primary variability and secondary or adaptive variability and are connected by an intermediate period of selection (Hadders-Algra, 2000).

The primary variability phase can be explained by using the general movements which are the patterns of movement which are used the most often by a human foetus or newborn infant (Prechtl, 1990, 1984 as cited in Hadders-Algra, 2000).

These movements are of various speed and amplitude, involve all parts of the body and are characterised by erratic motor activity in which different muscles are involved and difference in the timing and quantity of muscle activation is noted (Prechtl, 1990, 1984 as cited in Hadders-Algra, 2000). During this phase the neural systems dedicated to a specific motor function investigate all avenues available for that function (Hadders-Algra *et al.*, 1998, as cited in Hadders-Algra, 2000). This investigation and processing of afferent information leads to the intermediate phase of selection in which moderate motor variation is allowed reducing the extent of motor possibilities, leading to the selection of the most appropriate and efficient movement pattern to carry out the specific function (Hadders-Algra *et al.*, 1998, as cited in Hadders-Algra, 2000). This intermediate phase is relatively long. It takes many years and experiences to enable the second phase to start producing competent motor solutions for each specific situation enabling the child to begin to perfectly adjust his or her behaviour accordingly to a new situation (Hadders-Algra, 2000).

The phase of secondary or adaptive variability involves providing a repertoire of adaptive motor strategies (Hadders-Algra *et al.*, 1998, as cited in Hadders-Algra, 2000). Variability increases again, giving various solutions for a single motor task (Hadders-Algra, 2000). This phase combines sensory and motor information to establish more intercellular links to produce more specific and complex patterns of muscle contraction to enable co-ordinated goal-directed movement to occur (Barnhart, 2003). In this phase motor performance can be adapted exactly and efficiently depending on the specific conditions of the task with afferent information such as sensory input playing an important role in this adaptation (Hadders-Algra, 2000).

With repetition and specific practice secondary variability is reduced and the appropriate reciprocal synaptic circuits are reinforced and are then established (Barnhart, 2003). Continuous repetition and practice of motor tasks leads to the ability to select the most efficient movement pattern out of the repertoire of adaptive motor patterns (Pedotti *et al.*, 1989, as cited in Hadders-Algra, 2000; Darling *et al.*, 1988, as cited in Hadders-Algra, 2000).

One cannot reduce the importance of the central nervous systems involvement when treating children with DCD but its maturity may not be the only reason why the motor development of these children is not at the level of their peers. It is therefore more appropriate to give equal importance to the central nervous system and genetic involvement as well as the environmental conditions and experience.

Therapists who treat children with DCD might therefore advocate the Neuronal Group Selection theory of motor control as it involves a complex relationship between information from genes and the environment (Hadders-Algra, 2000) and emphasises the importance of both the above components. This theory which proposes that continuous repetition and practice of motor tasks leads to the ability to select the most efficient movement pattern out of the repertoire of adaptive motor patterns (Barnhart, 2003; Hadders-Algra, 2000), resounds with the principles of the Neurodevelopmental Therapy

technique which was incorporated into the intervention for the children who participated in the current study.

2.1.5 EFFECTS OF DCD ON MOTOR FUNCTION

One cannot describe a ‘typically clumsy child’ (Dewey & Wilson, 2001). They may differ in the degree of involvement from a mild to a severe form of inco-ordination, the extent to which activities of daily living are disturbed and the extent to which co-morbid conditions, such as speech and language difficulties and attention deficit disorders, are displayed (Missiuna *et al.*, 2003).

2.1.5.1 GROSS MOTOR FUNCTION

The following signs can be noted in a child with DCD when examining gross motor function:

In the earlier stages of motor learning

Co-ordinated and efficient motor control relies on a mature stage of motor learning. The child must have the ability to integrate cues from the environment when choosing an appropriate movement strategy in order to be ready to adjust to any new situation (Missiuna *et al.*, 2003). This “state of readiness” (Missiuna *et al.*, 2003, p.34) is seen in preparation of the postural system before the movement can occur. Anticipatory motor control involves movements which prepare the body for function which serve to support the movement in the task and occur before and during the task (Missiuna *et al.*, 2003).

Children with DCD have difficulty selecting the most appropriate and efficient motor pattern for a task especially if they are learning a new task and will perform a task in the same way repetitively regardless of whether they achieved it or not (Missiuna *et al.*, 2003). This is because they have difficulty understanding what the task is asking of them as well as understanding the components of a task and do not interpret sensory feedback adequately (Missiuna *et al.*, 2003). They also do not use the knowledge of how they

executed the task previously to assist them in selecting the most efficient movement pattern (Missiuna *et al.*, 2003).

Children with DCD may demonstrate awkward gait and running patterns, fall frequently, drop items, have difficulty following two-to-three step motor commands and imitating different body positions (Barnhart *et al.*, 2003). They may also show impairment in midline crossing when performing movements which places demands on movement preparation and anticipatory control in which significant postural adjustments are required (Zoia *et al.*, 2006).

Reliance on visual input

Children with DCD differ in many aspects and have a wide range of dysfunctions; however some specific difficulties seem to be widespread (Missiuna *et al.*, 2003). These children have been found to have consistent problems with the control of the speed of their movements. Studies have described these children as having ‘slowness of movement’ in reaction time and movement time (Missiuna *et al.*, 2003, p 33).

A child with DCD has poor anticipatory control mechanisms and therefore needs to rely on visual input for a longer period of time than a child who is developing typically would need to do so (Missiuna *et al.*, 2003).

They use vision more than any of the other senses and need constant cueing from the environment to guide the execution of a task and to assist in controlling movement, this usually makes the movement or task more challenging and effortful (Missiuna *et al.*, 2003). However because a child with DCD is unable to place less attention on external feedback and use more internal feedback, he/she will also be unable to automate a movement (Missiuna *et al.*, 2003). This represents an early stage of motor learning because as a skill is learned the child should rely more on proprioceptive and kinaesthetic feedback and less on the visual input (Missiuna *et al.*, 2003).

Soft Neurological signs

Children with DCD have been found to display soft neurological signs which include: dysmetria (inaccuracy in the range and direction of movements), dysdiaochokinesis (an irregular pattern of alternating movements), mirror movements and a choreiform twitch (a form of finger tremor) (Visser, 2003). Neurological soft signs may also include the persistence of primitive reflexes, hypotonia and immature balance reactions (Barnhart *et al.*, 2003). This gives further evidence for the aforementioned notion that DCD may stem from cerebellar deficits.

Reduced muscle strength and power

Muscle strength and power in children influence their daily activities such as sprinting, hopping and jumping (Raynor, 2001). Raynor (2001), in a recent study on a cohort of children with DCD between six and nine years of age, found that these children produced significantly lower levels of force and were less powerful with the deficit in power becoming more pronounced with increased velocity. Raynor (2001) suggested that further investigation is warranted into differences in muscle fibre distribution which may be a possible cause of reduced strength and power in children with DCD.

Inefficient patterns of muscular activation

Children refine their muscular activation patterns through experiencing different movements and interacting with their environment. Children with DCD often have limited movement experiences and thus have inefficient patterns of muscle activation (Raynor *et al.*, 2001). This may have contributed to the high levels of muscle co-activation, which Raynor (2001) also found in this study, which in turn may have led to the decreased power and muscular strength noted above (Raynor, 2001).

Children with DCD tend to use different neuromuscular strategies and activate their muscles differently to children of the same age in tasks requiring co-activation (Missiuna *et al.*, 2003). In a task involving reaching with one arm, children with DCD were slower to activate their antagonist muscles, and their agonist muscles were active for a longer amount of time. In a task involving reaching with both hands, children with DCD were

shown to either change the onset or the duration of one or both the antagonist and agonist muscles, while their peers only changed the duration of the antagonist muscles (Missiuna *et al.*, 2003).

These patterns of muscular activation and organization are a less effective than typically developing children and are thought to be a contributing factor to their slower and more variable movement times (Missiuna *et al.*, 2003). This could be seen in the study by Raynor (2001) in which the children with DCD had increased levels of muscle co-activation leading to less effective muscular activation and thus maximum force production than in their normally co-ordinated peers (Raynor, 2001).

Joint Hyper-mobility or ligament laxity

Kirby & Davies (2006) found thirty seven percent of children in their study with DCD had symptoms of Joint Hyper-mobility Syndrome (JHS) as compared with only 7.4 percent of typically developing children. JHS occurs in persons whose range of movement exceeds the norm for that person (Kirby & Davies, 2006). However not only do they have generalised joint hyper-mobility including pes-planus (flat-feet) but they also have additional symptoms including pain (Kirby & Davies, 2006). Children with joint hyper-mobility have greater degrees of joint freedom to control than their peers. If a child has joint hyper-mobility together with DCD they will find it even more difficult to have efficient control over their fine and gross movements (Kirby & Davies, 2006). For example children with DCD who present simultaneously with hyper-mobility in their thumbs may find handwriting tasks that much more difficult (Kirby & Davies, 2006).

Poor postural control

Children with DCD have been described as having poor sensori-motor co-ordination which involves co-ordination within and between limbs, sequencing of movements and the use of timing, feedback and anticipation for the co-ordination of movement (Geuze, 2005). They also have challenges with motor learning involving learning new motor tasks, adapting to change, planning a movement and automatisisation (Geuze, 2005). Among these characteristics they have been described as having poor postural control

involving moderate hypotonia, poor distal control and poor static and dynamic balance (Geuze, 2005). Evidence of poor postural control in children with DCD can be seen in the use of muscle co-contraction patterns which assist in reducing the degrees of freedom they need to control (Geuze, 2005; Westcott & Burtner, 2004).

Postural control involves controlling the body's position in space for both stability and orientation purposes (Shumway-Cook & Woollacott, 2001). Postural stability or balance is defined as the ability to maintain one's body in equilibrium involving the maintenance of one's centre of mass over one's base of support (Shumway-Cook & Woollacott, 2001). Postural orientation is defined as the ability to maintain an appropriate relationship for a task, between the body segments as well as between the body and the environment (Shumway-Cook & Woollacott, 2001). Postural control is a requirement for all functional tasks; however the demands of stability and orientation change with each task (Shumway-Cook & Woollacott, 2001). Postural muscle activity provides a foundation for movement and is an important part of the neurophysiology of motor co-ordination (Johnston *et al.*, 2002).

Postural control also involves the generation and co-ordination of forces that produce certain movements which are effective in controlling the body's position in space (Shumway-Cook & Woollacott, 2001). The effect of forces such as gravitational forces which tend to pull the body off centre in a downward direction are minimised by having ideal biomechanical body alignment.

Background muscle tone also prevents the body from collapsing in response to the pull of gravity (Shumway-Cook & Woollacott, 2001). Some factors which contribute to normal background muscle tone in a quiet stance position are the intrinsic stiffness of the muscles themselves as well as the level of activity within certain antigravity muscles, known as postural tone (Shumway-Cook & Woollacott, 2001).

Different inputs from the somato-sensory- (proprioceptive, cutaneous and joint receptors), visual- and vestibular systems influence postural tone. These inputs each provide unique information about the body's position and movement in space with respect to gravity and the environment and provide a frame of reference for effective

postural control. Postural control involves organising these sensory inputs and ensuring that the appropriate sense is selected for the environment and the task in order to maintain stability (Shumway-Cook & Woollacott, 2001).

It has been suggested that the presence of postural tone in the trunk muscles is the most important element for the control of normal postural stability in an upright position but many other muscles have been found to be tonically active namely tibialis anterior, gastrocnemius, soleus, gluteus medius, tensor fasciae latae, iliopsoas, abdominals and thoracic erector spinae (Shumway-Cook & Woollacott, 2001).

As noted above, the sensory, motor and musculoskeletal systems contribute to the co-ordination of postural activity. The sensory system gives the individual cues that there has been a perturbation as well as feedback for adjustments that need to be made during the movements and after the movements have taken place to inform the individual how effective the postural activity produced has been (Westcott & Burtner, 2004). The motor system cues the individual as to the appropriate activation of the muscles to be used and the musculoskeletal system creates the forces to produce the postural activity and provides the framework on which our movement is based (Westcott & Burtner, 2004). If the state of any of these systems is disturbed, the overall postural activity is challenged. An individual will vary their postural activity according to the task and environment, their behavioural state and alertness and the instructions given (Westcott & Burtner, 2004).

Many children with DCD have poor postural and balance control and may have disturbances in more than one if not all of the above-mentioned systems (Geuze, 2005). The major characteristics of poor postural control in these children are inconsistent timing of muscle activation sequences, muscular co-contraction, lack of automatization and slowness of response. The quality of postural and balance control is influenced by the difficulty of the task as well as the availability and integration of sensory information (Geuze, 2005).

The development of postural control has also been associated with a predictable sequence of motor behaviours referred to as motor milestones. A therapist is able to evaluate the performance of a child on age appropriate functional skills or motor milestones that require postural control and use this information together with observation of their quality of movement to identify children who are at risk for developmental problems such as DCD (Missiuna *et al.*, 2003; Shumway-Cook & Woollacott, 2001).

Fixation methods

The muscular co-contraction or ‘fixing’ of certain body parts is used by children with DCD to gain stability when they have poor postural control and stability (Missiuna *et al.*, 2003). ‘Fixing’ is a form of ‘postural fixation’ which is used as a means of compensation to control for surplus degrees of freedom of muscles and joints (especially when there is additional joint hyper-mobility as described above) and is likely to lead to fatigue in children with DCD (Missiuna *et al.*, 2003). This fixation and constraint of muscles and joints also leads to reduced flexibility, adaptability and efficiency of movement (Missiuna *et al.*, 2003). This hinders effective movement and leads to reduced range of motion and tight musculature which changes the ideal alignment and leads to the requirement of additional effort to maintain the body in an upright posture (Missiuna *et al.*, 2003; Shumway-Cook & Woollacott, 2001).

Children with DCD tend to ‘fix, freeze or constrain their joints’ awkwardly and stiffly, meaning that they tend to hold certain parts of their body stiff with great amounts of effort to improve their stability so that another part of their body can move more fluidly with greater amounts of control (Missiuna *et al.*, 2003). This fixation method of joints may make movements appear awkward and stiff and increase the time it takes for children with DCD to adapt to changes in their environment (Missiuna *et al.*, 2003).

Children with DCD will experience difficulty with the flexibility and adaptability required for running, jumping, hopping and skipping as well as activities which involve hand-eye co-ordination such as in ball sports involving throwing and catching (Missiuna *et al.*, 2003). Children with DCD not only have difficulty attending to controlling for the

degrees of freedom of movement but show challenges with duration, sequencing and timing of their movements (Missiuna *et al.*, 2003). This poor competence in motor skills not only leads to withdrawal from physical activity causing them to have a more sedentary pattern of activities but also leads to secondary impairments including decreased strength and power (Raynor, 2001) and reduced physical fitness and endurance. This leads to a further decrease in participation in various sports and leisure activities resulting in fewer opportunities for social interaction as well as poor self esteem (Barnhart *et al.*, 2003; Mandich *et al.*, 2003; Missiuna *et al.*, 2003).

2.1.5.2 FINE MOTOR FUNCTION AND ACTIVITIES OF DAILY LIVING

Fine Motor function

Fine motor skills, such as drawing and writing, require not only manual dexterity, but also require sustained attention and a stable posture. One who is drawing or writing needs to continuously focus on the task at hand, while filtering out irrelevant information from within oneself and from the external environment. Small-muscles and hand-eye coordination must be supported by large muscles that maintain and adjust posture and balance (Miyahara *et al.*, 2008). Due to the fact that both attention and posture play crucial roles, it is important to determine whether those who have difficulties in fine motor skills have problems in attention, or postural control.

Due to the developmental principle of the development of motor control occurring from proximal (head and trunk) and progressing distally towards the hands and feet (Exner in Case-Smith & O'Brien, 2010). It is a common assumption that postural control of the trunk and centre of the body has an influence on fine manual dexterity skills (Shumway-Cook & Woollacott, 1995). The development of trunk stability and improvement of postural control is thought to be an important pre-requisite for upper limb and hand function resulting in improvement in fine motor skills (Exner in Case-Smith & O'Brien, 2010; Shumway-Cook & Woollacott, 1995). It has been hypothesised that proximal stability allows the arm and hands to be used independently for tasks involving manipulative dexterity (Shumway-Cook & Woollacott, 1995). This assumption has lead

to clinicians to intervene in sequential manner proceeding from proximal to distal control thus, starting at the level of postural control in order to enhance the performance of a child's hands (Exner in Case-Smith & O'Brien, 2010; Rosenblum & Josman, 2003). However, this strong correlation has not consistently been found to be true which was noted in a study by Rosenblum & Josman (2003) who recommended that studies with larger samples and longitudinal designs should be conducted further to ascertain this relationship.

There may be a biomechanical or functional relationship between proximal and distal control, in which postural control has an influence on the positioning of the upper limb and providing support of the hand when performing a fine motor skill (Exner in Case-Smith & O'Brien, 2010). However the child's degree of distal dexterity may not necessarily be directly linked or determined by the degree of postural control (Exner in Case-Smith & O'Brien, 2010). This is explained by Pehoski's (2005) theory of neurological control of hand function, based on the work by Lawrence & Kuypers (1986) (Exner in Case-Smith & O'Brien, 2010). In this theory two motor systems are responsible for the control of the upper extremity. One system is responsible for isolated finger movements, in-hand manipulation and fine motor dexterity. The corticospinal tracts which originate from neurons in the primary motor cortex synapse directly onto alpha motor neurons of the muscles of the hand in the ventral horn in the spinal cord (Pehoski, 2006). Whilst the ventromedial brainstem pathways synapse on interneurons before synapsing with the motor neurons for the trunk, shoulder girdle and hips (Pehoski, 2006). This system is responsible for postural control and proximal stability. Therefore the postural muscles and hand muscles have different neurological control thus the development of upper limb control occurs as a result of proximal and distal control mechanisms rather than a proximal to distal mechanism (Exner in Case-Smith & O'Brien, 2010).

Johnston *et al.*, (2002) investigated what effects the neuromuscular components of postural control and co-ordination may have on upper-limb function in children. Results showed that children with DCD took longer to respond to visual signals and longer to

complete goal-directed upper-limb movements. In addition it was verified that the postural muscles of the children with DCD had altered muscle activity. They found that in the children with DCD the muscles of the shoulder girdle (except serratus anterior) and the posterior trunk muscles demonstrated early activation, while the anterior trunk muscles demonstrated delayed activation during a goal-directed upper-limb reaching activity (Johnston *et al.*, 2002). They also found that children with DCD demonstrated altered muscle timing during a rapid, voluntary, goal-directed arm movement when compared to the group of children without DCD (Johnston *et al.*, 2002).

Anticipatory postural adjustments (APA) occur directly before or simultaneous to the prime mover during voluntary movements. They are produced using a feed-forward mechanism and work to maintain postural stability and balance by preventing disturbance of the centre of mass (Johnston *et al.*, 2002). Johnston *et al.*, (2002) found that these anticipatory postural adjustments were not present in three of the four anterior trunk muscles of those children with DCD.

Altered timing of postural muscle activity may thus result in insufficient background postural control and poor implementation of skilled movement and is likely to be a major contributor to upper-limb coordination difficulties including handwriting difficulties in children with DCD (Johnston *et al.*, 2002).

Johnston and co-workers (2002) earlier found evidence to the contrary of Rosenblum & Josman (2003). They concluded that their findings supported the hypothesis that altered postural muscle activity may lead to poor proximal stability which consequently results in poor upper limb control and coordination in activities such as writing, cutting, dressing and certain sporting activities in children with DCD.

Miyahara and colleagues (2008) more recently found similar findings to Johnston *et al.*, (2002) to support their conclusion that alteration in posture stability affects the execution of fine motor skills and that gross motor problems of postural instability is mechanically linked with the execution of fine motor skills.

Miyahara *et al.*, (2008) set out to examine the effect that postural stability has on fine motor control, they assessed kinematics of the head, shoulder, elbow, and the pen. The children were divided into a group of accurate drawers and inaccurate drawers based on their performance in a manual dexterity task from the MABC. Results showed that the group of inaccurate drawers had more movements in body parts adjacent to the drawing hand immediately prior to the commission of a drawing error compared to the group of accurate drawers. They also found that there were more coincident errors occurring in the proximal body parts of the head and shoulder than in the elbow. Miyahara and colleagues (2008) noted that an improvement in the postures of inaccurate drawers would require not only training of their proximal postural control, but the postural control also needs to be learned in the functional context of drawing. They concluded that inaccurate drawing i.e. poor fine motor control occurred as a result of postural instability rather than fidgeting caused by inattention or hyperactivity/impulsivity (Miyahara *et al.*, 2008).

Handwriting is a task which requires a high level of co-ordination and a high-precision force regulation (Smits-Engelsman *et al.*, 2001). It is therefore understandable that children with DCD are often referred for occupational therapy and physiotherapy intervention for difficulties with handwriting and drawing (poor grapho-motor performance) being one of their frequently mentioned fine motor impairments (Barnhart *et al.*, 2003; Smits-Engelsman *et al.*, 2001).

Missiuna & Pollock (1995) found that children with DCD tend to work slower to achieve more accuracy. Therefore they are able to achieve higher scores on a standardised test but they may take longer to do so. This speed-accuracy trade off is well documented in children with motor impairments. Working under the pressure of time may then be more difficult for them leading to a need for extra time, which may be problematic in a classroom setting (Rodger *et al.*, 2003; Missiuna & Pollock, 1995). It was also found that older children (with the mean age of seven years old) with DCD tended to use significantly delayed, immature or transitional pencil grip patterns namely: a cross thumb grasp, static tripod grasp or a four fingers grasp, which are more typical of a three to four year old child (Missiuna & Pollock, 1995). It was noted that although an awkward grip

may not hinder handwriting it may lead to unnecessary and early fatigue when the child needs to write larger amounts of information, or it may slow down their letter formation leading to performance challenges and again a slow pace of work (Rodger *et al.*, 2003; Missiuna & Pollock, 1995).

In a study by Rodger *et al.*, (2003) the same prehension grasps as noted above were found in children with DCD. In addition 31% of the sample used other immature grasps which involved either three or four fingers on the pencil with fingers relatively extended. These children tended to move their hand as a unit with limited finger movement (due to finger extension). The thumb approximated opposition to the index finger and sometimes the thumb was crossed over the pencil to the extended index. It was noted that children with DCD may revert to a more immature pencil grip when copying shapes as compared to when writing (Rodger *et al.*, 2003).

Not only have immature grips been noted but the use of excessive pressure of the pencil on the page has also been noted (Smits-Engelsman, 2001; Missiuna & Pollock, 1995). This excessive force is attributed to poor control of distal movement as well as using an excessive amount of muscular tension (increased muscular co-contraction) to perform the fine motor activity (Smits-Engelsman, 2001; Missiuna & Pollock, 1995). Children with DCD may use this strategy to provide them with increased awareness of their joints (proprioceptive input). This strategy is inefficient as it may lead to tiring easily and prematurely before completion of the fine motor task (Missiuna & Pollock, 1995).

Rodger *et al.*, (2003) used videotape analysis of a cutting task involving cutting out a line, a square and a circle. They found that in these three tasks the majority of children with DCD used immature scissors prehension patterns (which fingers the scissors is held with) and immature scissor loop positions (position of the fingers in the scissors loops). Children with DCD were also found to use poor cutting and paper strategies. This refers to from where the child chooses to start cutting and whether they are able to cut with one continuous cutting action (i.e. without stopping and starting) as well as the way in which the paper is held when cutting. Due to the fact that cutting is a task which involves

bilateral integration, the non-dominant hand needs to be able to manipulate the paper in a co-ordinated manner in order to ensure accurate end products (Rodger *et al.*, 2003). It was noted further that as the cutting task became more complex children with DCD used more immature strategies (Rodger *et al.*, 2003).

Activities of Daily Living

A diagnosis of DCD is made if impairment in the development of motor co-ordination interferes with academic achievement or activities of daily living (Dewey & Wilson, 2001). Rodger *et al.*, (2003), found children with DCD to be less capable in self care tasks. Summers *et al.*, (2008) confirmed this finding, suggesting that children with DCD experienced more challenges when performing activities of daily living (ADLs) such as dressing, personal hygiene and eating (Summers *et al.*, 2008). Poor performance on these tasks of self care was attributed to the difficulties they had with postural control and with their fine motor skills (Summers *et al.*, 2008).

During tasks involving personal hygiene, children with DCD had difficulties turning taps on and off, with temperature control of the water, drying their bodies and their hair (Summers *et al.*, 2008). Younger children with DCD even had difficulty with brushing their hair, needed help controlling the squeezing of the toothpaste onto the toothbrush and had poor oral awareness, which was also noted with eating (Summers *et al.*, 2008). In addition, poor co-ordination with the eating utensils was noted during eating, they were often messy and preferred to eat with their fingers (Summers *et al.*, 2008).

During certain activities of daily living, children with DCD demonstrated poor postural control such as during tooth brushing having to lean on the basin or during meal times, being fidgety (having to stand up and sit down constantly, change position, rock on the chair) and being unable to orientate and align themselves with the plate and table or maintain an upright posture often slouching in their chair (Summers *et al.*, 2008). Children with DCD were also found to have difficulties initiating dressing and were slower in the execution of the activity (Summers *et al.*, 2008). In dressing they had difficulty with balance (having to sit down to put pants on, being unable to balance on

one leg to put pants on), with fine motor manipulation of fasteners, zips and shoelaces as well as with spatial orientation of the clothing (putting two legs into one pants leg, orientation and manipulation of the socks, buttons in wrong holes, clothing back to front, socks upside down and shoes on the wrong feet) (Summers *et al.*, 2008).

2.1.6 PSYCHOSOCIAL FUNCTION

Children with DCD when compared to matched control groups have been found to have fewer friends, less self-perceived competence in several areas, lower levels of self worth and higher levels of anxiety, with adolescents experiencing these feelings more than younger children with DCD and significantly more than their non-DCD counterparts (Skinner & Piek, 2001).

Children with DCD may act out in class, behave like the class clown and try other less socially acceptable means of gaining acceptance and friends (Barnhart *et al.*, 2003). It has been found that children as young as six years of age, who have movement problems and who lack confidence in their physical competence also lack social competence and are more introverted and anxious than their peers who are well co-ordinated (Dewey & Wilson, 2001).

A qualitative study by Mandich *et al.*, (2003) found that the inability to acquire competence in simple skills, for example tying their shoelaces in children with DCD, had long-reaching emotional consequences (Mandich *et al.*, 2003). The children were very aware of their difficulties and their repeated inability to master certain activities led to a deep sense of failure which made the children feel stupid, inadequate and inefficient and led further to their unwillingness to try again (Mandich *et al.*, 2003). Their performance incompetence was also noted by their peers and often led to them being bullied, teased or excluded from activities (Mandich *et al.*, 2003; Losse *et al.*, 1991).

According to teachers' observations in class at school, children who were clumsy had more behavioural problems, poor concentration and were disorganised in class (Losse *et*

al., 1991). Children with DCD avoided the playground, were asked less often to play with their peers, had fewer friends and tended to spend more playground time on their own than with their peers leading to less positive interaction with their peers (Chen & Cohn, 2003).

Green, Baird & Sugden (2006) explored the prevalence of emotional and behavioural problems in children with motor difficulties. It was found that a high proportion of the children with DCD were at risk of psychopathology (Green, Baird & Sugden, 2006). Eighty five percent of these children were reported to have significant problems on at least one of the subscales of the SDQ (Strengths & Difficulties Questionnaire) and many parents reported a significant impact of these symptoms on daily life (Green, Baird & Sugden, 2006). These behavioural and emotional difficulties could not be connected to age, gender or degree of motor impairment. However they did find that over-activity and inattentiveness was noted more often in seven and eight year-olds and girls were more likely to have peer problems (Green, Baird & Sugden, 2006).

2.1.7 DCD IN ADOLESCENCE AND ADULTHOOD

For many years, parents' worries about their children's motor development have often been trivialised; they have been sent to many different health professionals or they have been left to deal with their children's problems on their own (Mandich *et al.*, 2003). This is because it was believed that children with motor impairments i.e. children with DCD, would outgrow this condition and that it was only confined to childhood. In the past parents were told that their children's difficulties would disappear with maturation (Mandich *et al.*, 2003; Barnhart *et al.*, 2003; Losse *et al.*, 1991).

Many studies since have found evidence to the contrary (Cousins & Smyth, 2003; Cantell *et al.*, 2003, 1994; Skinner & Piek, 2001; Losse *et al.*, 1991). Many authors have found that young children described as having poor co-ordination for their age or those diagnosed with DCD, continue to have significant motor problems, together with a

variety of emotional, social, educational, psychological and behavioural difficulties (Losse *et al.*, 1991; Skinner & Piek, 2001; Cantell *et al.*, 1994, 2003).

Losse *et al.*, (1991) in trying to determine the current motor, psychological and educational status of 16 year old teenagers who were previously described as children having poor co-ordination at six years old, found that the children continued to have motor difficulties (poor co-ordination, difficulties in physical education, handwriting, handling equipment in science class and arts and crafts). Cantell *et al.*, (2003) also did a follow-up study on a group of Finnish adolescents between the ages of 17 and 18 years old; who were originally evaluated at the age of five years as having motor difficulties and found similar findings. In Cantell *et al.*, (1994) these same children were re-assessed at the age of 15 years old and it was found that 47 percent of the original experimental group had persistent motor problems, while 53 percent had persistent minor motor problems during their teenage years (Cantell *et al.*, 2003).

Among these findings Losse *et al.*, (1994) noted similar findings to those of Skinner & Piek (2001) who examined the psychosocial implications of poor motor co-ordination on a group of children aged eight to 10 years and 12 to 14 years old. In both the studies the adolescents continued to have emotional and psychological problems such as lower self worth and social problems such as less social acceptance, less satisfaction with physical appearance, poor physical competence, fewer friends, social isolation and withdrawal from social situations in order to prevent failure (Losse *et al.*, 1991; Skinner & Piek, 2001).

Skinner & Piek (2001) also found that adolescents have a more realistic and objective view of the self which occurs due to cognitive maturation and more life experience than younger children. The adolescents in their study therefore had more symptoms of anxiety, lower levels of perceived social acceptance as well as less social support which contributed to their significantly lower levels of global self-worth than the younger children with DCD (Skinner & Piek, 2001). The younger group of children however

reported to have lower perceived competence on the scholastic domain which was not found in the adolescents (Skinner & Piek, 2001).

Teenagers with poor physical abilities and motor inco-ordination are very aware of their problems which may significantly influence their physical and social well being (Dewey & Wilson 2001). Their perceptions of being incompetent physically may make them less motivated to practise motor skills and thus exacerbate their inco-ordination further by leading to avoidance, withdrawal and exclusion from physical, sporting and social activities (Chen & Cohn, 2003; Dewey & Wilson, 2001).

Children with DCD were also found to have behavioural problems such as difficulties with peer relations and social immaturity; which persisted or became more severe (Losse *et al.*, 1991). In all the above studies the children with DCD were also found to have lower athletic competence as well as educational problems such as learning difficulties and lower scholastic competence (Cantell *et al.*, 2003; Skinner & Piek, 2001; Cantell *et al.*, 1994; Losse *et al.*, 1991). Cantell *et al.*, (2003) found that the children with DCD had the lowest intelligence scores and the shortest school careers. The IQ results together with vocational choices made by adolescents with persistent DCD indicate that many of them have a history of low school achievement and motivation (Cantell *et al.*, 2003). They chose vocational training rather than a long high school career. They were also reported to be performing at a developmentally younger age than their peers and were considered immature in their behaviour by their parents (Cantell *et al.*, 2003). They suggested that children with DCD and perceptual motor difficulties followed one of two developmental patterns of perceptual motor outcome in adolescence, that of 'persistence' or 'catching up' (resolution) (Cantell *et al.*, 2003).

Interestingly Cantell *et al.*, (2003) showed that children who had more definite problems in the DCD group were still distinguishable from their peers at 17 years of age, whereas the distinction between the intermediate group and control group became less clear with increasing age. The intermediate group with a similar early diagnosis, who had only

minor perceptual problems at the age of 15, were functioning close to the level of the control group, at the age of 17 (Cantell *et al.*, 2003).

Cousins & Smyth (2003) in their study investigating the effects of DCD in adulthood showed that adults with DCD performed more poorly than controls across all tasks (Cousins & Smyth, 2003). Many individuals had considerable problems with sequencing and with dual task performance and slowness and variability of movement was a distinguishing feature of their performance (Cousins & Smyth, 2003). Using six performance measures, a discriminant function analysis was conducted and correctly classified participants as car drivers or non-drivers. This meant that inability or unwillingness to drive in adulthood because of poor motor abilities or difficulties in learning new skills restricts social and employment opportunities (Cousins & Smyth, 2003). They concluded that for the adults who retain motor difficulties these difficulties continue to profoundly affect their lives and lead to their exclusion from important activities of daily living (Cousins & Smyth, 2003).

Although some of the motor problems experienced by children with less severe symptoms of DCD may resolve in half these children by adolescence, the other half of the adolescents still remain uncoordinated and experience motor difficulties as well as additional social and emotional problems which persist throughout their adult lives. It is therefore of utmost importance to include effective intervention programs that offer efficient strategies and movement experiences, early in childhood as well as vocational counselling for adolescents. This might help adolescents to avoid the carry over of negative motor experiences to academic and social spheres of life (Cantell *et al.*, 2003).

2.1.8 SUBTYPES AND ASSOCIATIONS

As mentioned previously, children with DCD are a heterogeneous group, not all children given the diagnosis of DCD are alike, as DCD is not a uniform disorder (Visser, 2003). Children with DCD have been found to exhibit problems involving sensory and motor

components, difficulties with postural control and their fine motor skills as well as poor proprioception and poor visuo-motor integration (Visser, 2003), to name a few.

Differing prognoses have been found in children with DCD. While some children with mild forms are said to grow out of it with or without intervention, others with more severe forms continue to live with poor motor skills throughout adolescence and adulthood, as noted above. These differences in outcome may be evidence in itself of the existence of subtypes of DCD (Visser, 2003). Further compounding our poor understanding of aetiology and prognosis is the existence of co-morbidity; it is unlikely that “pure” cases of DCD occur very often, they are more likely to have a combination or overlap of difficulties, such as problems with attention and concentration, behavioural, speech and language impairments and learning disabilities (Visser, 2003; Kaplan *et al.*, 1998).

Much research has been conducted on subtypes and co-morbidity. Researchers have begun to use cluster analysis to formalise the search for subtypes (Visser, 2003). However the cluster structure has been found to be influenced by the different samples and measures used and have thus been inconclusive (Macnab *et al.*, 2001). Diversity in defining subtypes is usually based either on the extent of movement problems or on whether fine motor difficulties are in excess to gross motor difficulties and visa versa (Green *et al.*, 2008).

In their review of the literature Macnab *et al.*, (2001) noted that Hoare identified five subtypes based on both motor and perceptuo-motor measures using kinaesthetic acuity, visual perception, visual-motor integration, manual dexterity, static balance and running speed as variables. Hoare’s subtypes identified were 1) Good balance, 2) Good visual motor performance, 3) Generalised perceptual dysfunction, 4) Good kinaesthetic ability and 5) Motor execution problems.

Macnab *et al.*, in 2001, found fairly similar groupings or profile patterns to that in Hoare’s study in their investigation of the use of cluster analysis to find subtypes of

DCD. The groupings that they found, using a similar protocol to Hoare's study, were as follows:

1) Good standing balance and visual perception within normal range (gross motor skills were better than fine motor skills but still below average), 2) Poor kinaesthetic acuity and balance, but good visual-motor integration, visual perceptual skills and upper limb speed and dexterity (fine motor skills were better than gross motor skills but impairment was still noted relative to typical population), 3) severe difficulties in all areas (greatest overall involvement) with poor visual and kinaesthetic skills. 4) Poor performance in fine motor skills, visual-motor integration, visual perception and dexterity but had better kinaesthetic ability and 5) Poor performance on complex gross motor task of running speed and agility, better visual-motor integration and visual perceptual skills but fine motor impairment still noted relative to typical population.

More recently, Green *et al.*, (2008) inquired whether there would be a differential effect on different perceptual and motor subtypes or those with co-morbidity, after a group treatment programme consisting of 20 one-hour long group sessions for 20 weeks.

Forty three children were randomly divided into four groups who participated in an intervention programme. They were re-assessed every six months for two and a quarter years. Green *et al.*, (2008) found similar clusters to those noted in Macnab *et al.*, (2001) above 1) Weak kinaesthesia (with relative strength across perceptual motor items i.e. visual-motor integration), 2) Poor static balance (relative strength in perceptual functions and fine motor skills), 3) Poor static and dynamic balance (with relative weakness in visual-motor integration and visual perceptual skills, better manual dexterity and kinaesthetic acuity) 4) Poor manual dexterity and perceptual skills (with relative strength in balance items) and 5) Poor across all items (poor visual-perceptual as well as gross motor functions).

In terms of the influence that the different subtypes had on their outcomes; Green *et al.*, (2008) found that children in clusters 4 and 5 had the most children with the highest degrees of motor impairment. Children in clusters 2, 4 and 5 did not improve at all or

improved very little without treatment. Those in cluster 2 even deteriorated further before their intervention took place but responded very well to treatment. Children in cluster 1 and 4 responded so well to treatment that some even changed category, the change in the extent of their motor impairment was so large. Those in category 2 and 4 had poor sustainability of their improvements following the intervention block and there were fewer children in cluster 3 and 5 that changed category. More children in cluster 5 still had difficulties at the end of the study period (Green *et al.*, 2008).

From these findings, Green *et al.*, (2008) suggested that children who have visual perceptual difficulties have a poorer outcome whether they receive therapy or not and whether or not they have associated co-morbidity. It was noted that severity of motor impairment is directly related to therapy necessity and it was encouraging to note that 76 percent of children with severe motor impairment had improved by the end of the study of group intervention (Green *et al.*, 2008). No conclusive evidence was found to support the constancy of distinct subtypes. However it was noted that improvement in motor skills following therapy was completely unrelated to the initial severity and subtype and that children with more complex problems show more difficulties at an intense level but they can respond well to intervention (Green *et al.*, 2008).

Co-morbidities

In the literature on childhood disorders, Reading Disability (RD), dyslexia, Attention Deficit Hyperactivity Disorder (ADHD), Attention Deficit Disorder (ADD), Learning Disability (LD) and Severe Language Impairment (SLI) are considered to be distinct conditions despite the fact that they are likely to be co-morbid conditions in the same child especially a child with symptoms of DCD (Visser, 2003; Kaplan *et al.*, 2006).

Kaplan *et al.*, (1998) found that among a group of 115 children, 53 were found to be 'pure' cases of ADHD, DCD or RD. Sixty-two were classified as 'co-morbid cases'. Of the 62 'co-morbid cases', 39 children had problems in at least two areas whereas 23 had difficulties in all three areas. It was noted that co-morbidity and overlap of disorders in the DCD population seemed to be the rule rather than the exception (Kaplan *et al.*, 1998).

Children with ADHD especially with the combined subtype (ADHD-C) have been found to have a variety of motor-related difficulties scoring lower than controls in both gross and fine motor skill tests (Watemala *et al.*, 2007; Meyer & Sagvolden, 2006; Hui Tseng *et al.*, 2004; Tervo *et al.*, 2002).

Watemala *et al.*, (2007) in their study on physical therapy intervention for children with ADHD/DCD found that 55.2 percent of their 96 children with ADHD had DCD. Specific learning disabilities and phonological disorder were also more prevalent among children with both ADHD and DCD than in those with ADHD alone. A study conducted in Limpopo province in South Africa found that African children especially those between the ages of six and nine years, from different ethnic groups, with ADHD (especially with ADHD-C) had associated motor control problems (Meyer & Sagvolden, 2006). Problems with impulse control, inattention and hyperactivity were found to be good predictors of motor skill deficits (Hui Tseng *et al.*, 2004). Tervo *et al.*, (2002) also found that 22 of the 63 children with ADHD-C had significant motor dysfunction (ADHD-MD) with significantly impaired motor skills and 'soft neurological signs' (e.g.: mixed laterality and mirror or overflow movements), marked delays in speaking, severe learning problems, social problems, functional problems at home and at school (Tervo *et al.*, 2002).

In 2006, Kaplan *et al.*, found that the terms 'continuum' or 'co-occurrence' should be used instead of 'co-morbidity' with regards to explaining the associations among developmental disorders. Co-morbidity inaccurately assumes that the underlying pathologies of the disorders have different causes and are independent from one another. There has been a surge of research that is growing investigating a possible single cause for all the possible associated disorders reflecting a more generalised deficit (Visser, 2003). These concepts imply that these developmental disorders are connected to inconsistent brain development (Kaplan *et al.*, 2006). It has been realised that a term is needed in clinical practice which acknowledges both attention and motor types of deficit

(ADHD and DCD) as they are commonly associated with each other (Gillberg & Kadesjo, 2003).

2.2 THERAPEUTIC INTERVENTION

Children with DCD may be treated by a physiotherapist for motor-based impairments such as problems with balance, strength, endurance and delays in the development of gross motor skills (Missiuna *et al.*, 2006). They may be treated by an occupational therapist for fine-motor based problems i.e. handwriting, organisational problems as well as spatial, perceptual and sensory problems and self-care difficulties. They may also be treated by a speech/language pathologist for receptive or expressive language delays, articulation problems and auditory processing (Missiuna *et al.*, 2006). In addition they may need to see a psychologist for co-morbid conditions such as hyperactivity, attentional problems and learning difficulties (Missiuna *et al.*, 2006). Each child may receive intervention from one or all of these therapists at any given time.

2.2.1 INTERVENTION APPROACHES

A combination of approaches is used by any one therapist to treat children with DCD. Given the heterogeneity of this group of children, no single approach has been shown to be effective for all children and there has been much debate on the efficacy of many of these approaches with no one approach being found to be more effective than any other (Sugden, 2007; Mandich *et al.*, 2001). Most occupational and physical therapists tend to use an eclectic approach or an approach which they have found to have a positive effect on improving the motor skills and functional performance of these children (Mandich *et al.*, 2001).

Approaches to intervention can be divided into one of two categories with some being able to fit into both. The first category of approaches can be called “*functional skill approaches*” (Sugden, 2007) or “*top-down approaches*” (Mandich *et al.*, 2001) and the

second category of approaches can be called “*process or deficit approaches*” (Sugden, 2007) or “*bottom-up approaches*” (Mandich *et al.*, 2001).

Top-down Approach

The “functional skill approaches” or “top-down approaches” to intervention uses a problem-solving approach to motor skill acquisition which is influenced by the dynamic systems theory of motor learning and control. This approach centres around the belief that motor skill outcomes develop from the interaction of many systems including internally i.e. the resources the child brings to the situation, and externally i.e. the environmental context in which the child functions as well as the way in which the task is presented to the child. These interventions all use a variety of cognitive models applied to functional skills (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

This approach includes therapies such as:

a) Task Specific Intervention which is the intervention which was incorporated into the treatment programme in the current study. It focuses on the direct teaching of a specific task that needs to be learned. The specific motor task is broken down into smaller units, each unit is then taught separately and then all the smaller units are then organised and linked together to enable accomplishment of the whole task. Transference and generalisation to other similar tasks are important elements in this approach and tend to be difficult to carry over and must be worked on and taught specifically (Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

b) Cognitive Approaches emphasize active independent problem solving. Many different cognitive approaches have been proposed, for example the Cognitive motor approach proposed by Henderson and Sugden (1992) as quoted in Mandich *et al.*, (2001), in which the therapist acts as a guide to help the child solve how he/she will improve their own motor performance however they must learn how to plan, execute and analyze their movements (Barnhart *et al.*, 2003; Mandich *et al.*, 2001), It has recently been revised and renamed the Ecological Intervention (EI) (Sugden, 2007) which places a greater emphasis on lifelong participation and the inclusion of the family, community and ecological

setting. It also places greater emphasis on control of the movement using ideas from both dynamic systems approach and information processing (Sugden, 2007). Another recent approach used is the Cognitive Orientation to Daily Occupational Performance (CO-OP) programme proposed by Polatajko and colleagues (2001) as quoted in Mandich *et al.*, (2001). This is a child-centred approach in which the child chooses the goals (activities with which he/she is struggling) and motor skills are learnt with specific attention given to the specific aspects of performance of the task that are making the task difficult for the child (Sugden, 2007; Mandich *et al.*, 2001).

Both the task specific and cognitive approaches provide opportunities for practice and repetition of specific motor tasks which is essential to promote learning. These approaches include both spatial and motor learning sequences as well as the necessity to maintain attention to the task as well as promoting working memory as the child engages in active problem solving activities (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

Bottom-up Approach

The “process or deficit approaches” or “bottom-up approach” are traditional approaches based on neuro-maturational, hierarchical theories of motor control and focus on the remediation of some underlying process deficit through activation of higher levels of neuronal functioning by targeting the intervention at a neural structure, such as the cerebellum, or at sensory processes such as vision or proprioception. It is thought that if this deficit is remedied the benefits will be seen in everyday tasks that this structure or process controls (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

This approach includes therapies such as:

a) Sensory-Integration Therapy (SIT), which is based on providing the child with appropriate sensory information processing and integration skills in order to promote motor adaptation. It is a commonly used intervention by occupational therapists (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

b) Process-Oriented Treatment which is based on specifically designed kinaesthetic training activities. Kinaesthesia is defined as the perception of one's own body parts weight, and movement; and is considered integral to the acquisition and performance of motor skills in this treatment (Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

c) Perceptual Motor Training which is an approach that assumes a causal relationship between underlying perceptual processes and motor behaviour. Motor improvement in a child with DCD is as a consequence of their experiences with a wide range of sensory and motor tasks and many opportunities to practice these skills (Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

In the studies in which improvements in motor function have been seen using this approach, it has been criticised saying that these improvements may be strongly attributed to general learning principles which are built in to this intervention. These include the use of constant positive feedback and re-enforcement, presenting the child with activities to do in which he is capable of succeeding and slow progression of the level of difficulty of the task, giving the child a sense of self-competence and motivation (Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

In their systematic review of the literature found between 1985 and 2000 on the various types of interventions used to treat children with DCD, Mandich *et al.*, (2001) found that the evidence was either inconclusive or the specific approach was found to be as effective as any other approach used (Mandich *et al.*, 2001). Not one approach or combination of approaches was found to be superior to any other approach in improving motor skills of children with DCD (Mandich *et al.*, 2001).

They also found very little evidence to support the effectiveness of the bottom-up approaches in improving the motor skills of children with DCD or to support the assumption that remediation of the underlying processes may lead to improved functional performance (Mandich *et al.*, 2001).

Sugden (2007) has concurred with Mandich *et al.*, (2001) noting that empirical support for the bottom-up approaches is at best equivocal and lacks strong evidence due to its

inability to specify the exact sensory component of a specific skill or due to a lack of explanation of the motor components underlying a skill (Sugden, 2007).

On the other hand, the use and success of “top-down” or “functional skill” approaches seems to be more promising than “bottom-up” approaches and seem to be more effective in improving the functional performance in children with DCD (Sugden, 2007; Barnhart *et al.*, 2003; Mandich *et al.*, 2001).

However few controlled trials with large enough samples have been conducted using these approaches, therefore a definitive argument for the use of only this type of approach can not be made (Sugden, 2007; Mandich *et al.*, 2001). Approaches that integrate both dynamic systems theory and motor learning theory may be the most effective for children with DCD (Barnhart *et al.*, 2003).

In agreement with Willoughby & Polatajko (1994), after their review of the literature Peters & Wright (1999) concluded that most interventions appear to work with no specific approach being superior and Mandich *et al.*, (2001) concurred that there is still no one way or best way of treating these children. In the absence of strong empirical data to support evidence based practice, Mandich *et al.*, (2001) and Willoughby & Polatajko (1994), suggested that therapists should try a variety of approaches and rely on their clinical judgement to find the one approach that works best for each child. In this way the particular needs of each child are taken into consideration and therapy is individualised. Therapists are still encouraged to keep their own visual, auditory and tactile systems open in order to be able to see, hear and feel what works best for the child (Mandich *et al.*, 2001; Willoughby & Polatajko, 1994). It is still however very important to develop a systematic evidence based approach to the treatment of these children (Mandich *et al.*, 2001).

Sugden (2007) suggests general principles or guidelines that support interventions from a combination of cognitive, dynamic and ecological perspectives:

1. The child should be actively involved in the intervention process.

2. Functional activities that are relevant to daily living and meaningful to both the children and their caregivers should be prioritised.
3. The functional activities should be taught with specific skills (functional components of a task) and then taught using similar activities in different situations to promote generalisation. Cognitive strategies should then be used by encouraging the child to search for similarities in situations and then match these up to skills they have already learnt.
4. Any approach used should be evidence based from the motor learning and control literature. Different teaching methods should be used according to where the child with DCD is in their learning process. The amount and type of instructions given to the child, the nature of the feedback, the type of demonstration and practice situations and the degrees of freedom over which a movement must be controlled must all be varied and progress according to the child's level of competence.
5. Intervention in a child with DCD is not usually a quick fix it is therefore important that the intervention be altered to accommodate the family life and family routines.
6. It is important to involve a number of individuals who can contribute to the intervention process such as teachers, parents and health professionals with one person co-ordinating and overlooking the whole intervention process.

2.3 DIRECT INTERVENTIONS

2.3.1 NEURODEVELOPMENTAL THERAPY/ THE BOBATH TECHNIQUE

As mentioned previously the Bobath technique was designed to treat children with cerebral palsy however it is adapted for use in clumsy children as it is proposed to be an effective method to normalise abnormal muscle tone (even lowered muscle tone) and to improve balance in children with DCD using the belief that postural control is a prerequisite for mature motor development (Schoemaker *et al.*, 1994). NDT based postural exercises were used for the treatment of children with minor motor difficulties ‘low muscle tone’ (DCD) in the current study.

The NDT approach is another name used in some countries for the Bobath concept (Raine, 2006). The Bobath concept was conceptualised and pioneered by Berta and Karel Bobath over 60 years ago in the United Kingdom and Europe (Mayston, 2008) and made its appearance in the scientific literature in 1948 (Damiano, 2007). Because of its longstanding use, evidence of its effectiveness in current practice is under discussion in the literature (Raine, 2006; 2007) and has been questioned and criticised due to a lack of scientific evidence and proof of efficacy (Damiano, 2007).

The Bobath concept was developed as a living concept (Raine, 2006) it should be evolving continuously. As our knowledge base widens so too should the Bobath concept evolve to include a variety of techniques; and therapy should include evidence-based techniques where possible (Mayston, 2001b; Raine, 2006).

The Bobath concept is a problem-solving approach to the assessment and treatment of individuals with disturbances of tone, movement and function due to a lesion of the central nervous system (Raine, 2006).

It is also defined as a way of observing, analysing and interpreting the performance of specific tasks, which includes the assessment of the child’s potential as well as problem

solving to improve on function and participation (Mayston, 2001b). The Bobath concept is concerned with how a child performs a movement and recognises the importance of improving quality of movement (Knox & Evans, 2002). The way in which a movement is performed affects the efficiency of the movement and leads to the development of secondary impairments (Knox & Evans, 2002). It also emphasises the importance of providing the child with opportunities to practise as well as the importance of parent education and training on how they can assist their children (Knox & Evans, 2002).

One has to be mindful of the fact that Bobath was not considered to be a technique or method, it was not limiting, it was changing and is in the process of changing still today (Mayston, 2001b). However Mayston (2008) in her editorial suggested that one use a “Bobath-based approach”. Rather than discard the Bobath’s original ideas, one should acknowledge them and retain those that have current scientific evidence, keeping the Bobath concept intact (Mayston, 2008). However one should also accept that there are other approaches which complement Bobath practice and may even be preferable to it (Mayston, 2008) depending on assessment of the needs of the child. It is important to use and promote a family-, child- and/or client-centred, holistic approach; this can include all forms of scientifically sound or evidence-based techniques and can be used together with the Bobath concept (Mayston, 2006). This was the approach adopted for the treatment of the children who participated in the current study.

A study by Raine (2007) set out to identify the current theoretical assumptions of the Bobath concept using a four-round Delphi technique and the British Bobath Tutors Association, who are responsible for spreading the knowledge of the Bobath concept in the United Kingdom, as the experts in this study. This study contributes greatly to the body of knowledge available on the Bobath concept. However these opinions represent only those of the members of the British Bobath Tutors Association. It was suggested that it would be beneficial to record those opinions of the members of the International Bobath Instructors Training Association to identify the current principles of the Bobath concept as they are practised around the world (Raine, 2007; Mayston, 2006).

Some current principles of the Bobath concept are as follows (Mayston, 2008; Raine, 2006):

1. One needs to control unwanted movement patterns, however the client's overall participation should never be interrupted as a result.
2. Rather than focusing on achievement of normal movement one should aim to optimise postural strategies and to provide the client with more movement choices. The core of treatment is 'change of functional outcome'. One must promote 'more normal/optimal muscle activity' or efficient movements in their activities of daily living, to achieve the client's maximum potential.
3. The client's participation in treatment is more active rather than passive with facilitation techniques used as needed, with the aim of the client achieving as much independence as is possible. Therapy should be goal-oriented and task specific. Therapy can include the components of movement as well as the functional activity itself and should be an interaction between the therapist, client, task and environment. Involvement of the family and caregivers is of utmost importance for the client to promote carryover and to achieve improved participation in everyday life.
4. Treatment must be holistic and is individualised to take into consideration the bio-psycho-social needs of the client. A multidisciplinary approach is necessary for adequate treatment. The concept involves the client's sensory, perceptual and adaptive behaviours as well as their motor difficulties.
5. The rehabilitation programme should include opportunities for practice to improve efficiency and promote generalisation. Repetition is also important for the consolidation of motor control but does not mean performing movements in the same way. Therapy should take into account the everyday, all day management of the client. Therefore carers and clients should be taught a home exercise programme to implement frequently in between therapy sessions.
6. Other modalities and adjuncts can be used to complement the NDT approach for example structured practice and muscle strengthening.

(Mayston, 2008; Raine, 2006)

Several of the components of the Bobath concept also known as the NDT approach have been re-evaluated and new developments have occurred (Mayston, 2001b) but advocates of this concept have been criticised for not keeping detailed records of these changes (Raine, 2006). For the Bobath concept to be represented with accuracy the advances in clinical practice must be acknowledged and recorded with the help of current scientific evidence (Raine, 2006). Although the basic elements of the Bobath concept remain intact the theory behind the practice has been re-interpreted and explained with the help of scientific evidence and advances in neuroscience (Mayston, 2008). A few examples of this are expounded by Mayston (2001a, 2001b) as follows:

1. The Bobaths thought that the establishment of normal movement patterns would lead to functioning however this has been grossly misinterpreted. Teaching movement patterns is part of the motor re-learning process, however learning them alone will not lead to function. For therapy to be effective the client needs to practise functional, meaningful tasks in the correct context for carryover to take place into daily life. Preparation is of no value if it is not incorporated into a functional task (Raine, 2007; Mayston, 2008; 2001a; 2001b).
2. Tone has both neural (arousal level of the CNS, proprioceptive reflexes) and non-neural (visco-elasticity of muscles) components. By changing muscle length and range through stretch both the muscle spindle firing and the abnormal reflex activity is reduced and the visco-elastic properties of the muscles change. This allows the muscle to function in a better alignment biomechanically, and enables the therapist to teach the patient how to perform movements efficiently in a functional activity (Mayston, 2008; 2001a; 2001b).
3. Agonist and antagonist muscles act together to maintain stability. For the provision of components of stability and mobility a complex relationship between the muscle groups is needed, muscles need adequate activity to generate force for action and they also need length and range to improve alignment and enable efficient activation and effective movement (Mayston, 2008; 2001a; 2001b).

Muscle strengthening is contrary to the Bobaths' original views and may not be included under the Bobath concept but can be used as an adjunct to complement intervention (Mayston, 2008; 2001a; 2001b). This is the way it was used in the current study for the treatment of children with DCD. In the current study the intervention involved muscle strengthening, as an adjunct to NDT, which included the use of body-weight and gravity as well as repetition of movements, weight-bearing and specific, graded, resisted strengthening exercises.

Children with DCD tend to 'fix' or 'freeze' their joints during task performance, this is a method of compensation which is used in order to stabilise that part of the body so that another part of the body can be moved with greater control (Missiuna *et al.*, 2003). This postural fixation leads to tight musculature and the use of inefficient patterns of movement and is more likely to lead to fatigue (Missiuna *et al.*, 2003). This will then lead to withdrawal from participation in physical activity, which will subsequently lead to poor strength and fitness and decreased self-esteem and self-efficacy leading to reduced social participation (Missiuna *et al.*, 2003). Therefore NDT aims to improve this quality of movement by using specific handling techniques and by lengthening the tight musculature to promote better alignment and efficient movement patterns. The amount of hands-on assistance is then reduced once the child progresses emphasising the importance of active participation of the child in therapy and in every day life (Knox & Evans, 2002).

Children with DCD have greater difficulty co-ordinating newly learned skills such as handwriting and ball sports, they tend to repeat tasks in the same manner, regardless of whether their achievement of the task or not (Missiuna *et al.*, 2003). It is therefore important to teach them how to use their sensory feedback as well as their feedback from their knowledge of the execution of previous tasks in order to automate the task through successful task repetition and practise (Missiuna *et al.*, 2003). An NDT-based approach now recognises the importance of getting the child to practice functional, meaningful tasks in the correct context for carryover to take place into daily life (Raine, 2007;

Mayston, 2008; 2001a; 2001b). It is therefore important to educate the families or caregivers of children with DCD regarding the type of physical activity in which a child should take part, in order to achieve success. It is of great importance to work with the parents to encourage the children to engage in activities which involve continuous, repetitive movements which will improve their strength and endurance and promote physical activity and social participation (Missiuna *et al.*, 2003).

2.3.2 PHYSIOTHERAPY INTERVENTION

The reason for using physiotherapy as a possible intervention for children with DCD is based on the supposition that motor control and performance of motor skills as well as the ability to cope with different motor tasks will improve by using muscle strengthening, techniques to improve trunk control and repeated training with increases in the degree of difficulty (Watemberg *et al.*, 2007). Very few studies could be found on the effectiveness of physiotherapy in the treatment of children with DCD. Of those found many therapists used eclectic treatment approaches, treated heterogeneous groups of children using group or individual therapy designs and different frequencies and intensities of treatment (Watemberg *et al.*, 2007; Kaufman & Schilling, 2007; Schreiber, 2004; Stevens, 2002; Smits Engelsman *et al.*, 2001; Schoemaker *et al.*, 1994). No studies were found on the effectiveness of an intensive block of physiotherapy treatment based on Neurodevelopmental therapy, with core strengthening exercises as an adjunct, with a home programme for the treatment of children with DCD.

2.3.2.1 INDIVIDUAL THERAPY

Many studies have used individual physiotherapy to treat children with DCD. They have used different types of therapy and different intensities of treatment that have been found to be effective.

Schoemaker *et al.*, (1994) studied the effectiveness of a physiotherapy programme based on an eclectic approach using sensori-motor training (which is comparable to perceptual motor training) and to an extent the Bobath or NDT technique as an intervention for

clumsy children (i.e. children with DCD). This study proposed to use a design which had none of the methodological flaws of previous studies (Schoemaker *et al.*, 1994).

In the study by Schoemaker *et al.*, (1994), after a stringent selection process 18 clumsy children (14 boys and three girls with a mean age of seven years and four months accounting for one drop-out) were selected to form the sample. Twelve out of eighteen showed low muscle tone and three had speech problems (Schoemaker *et al.*, 1994). After being tested on the Test of Motor Impairment (TOMI) if they fell into the five percent of children who were the lowest-performing according to their age level they were considered to be in need of treatment. It was felt that any previous experience of treatment may influence the effects of their intervention. Exclusion criteria therefore encompassed children who previously received any intervention for movement problems as well as those who were attending schools for special education (Schoemaker *et al.*, 1994).

In order to form a control group 18 children matched for age and sex who passed the motor tests on their school medical examination and scored within the normal range on the TOMI were selected (Schoemaker *et al.*, 1994). Each child was assessed by the therapist with her own assessment and then on the TOMI and on the ABC (which is a general motor co-ordination test) by therapists who were not involved in the treatment of the child (Schoemaker *et al.*, 1994).

The clumsy children then had a period of three months with no intervention thus acting as their own controls. This was done in order to determine the spontaneous rate of motor development without intervention. Both the study and control groups were then re-assessed again pre-intervention. After this second pre-test assessment the clumsy children then received physiotherapy for 45 minutes twice a week, for three months, while the control group received no intervention. Both groups were re-assessed again. After a further three months of no intervention they were re-assessed post-intervention to establish the stability of the treatment effects (Schoemaker *et al.*, 1994).

Schoemaker *et al.*, (1994) found that after three months of intervention the study group of clumsy children improved their performance on the TOMI meaning that their movement skills improved. A general transfer effect of treatment was also found on untreated motor skills in these children. This is important to note as the therapist who treated these children believed, as do many treatment programmes such as those based on the Bobath technique, that postural control is a pre-requisite for mature motor development. In addition the parents of these children noted that the transfer of the treatment effects were also found in their daily life situations (Schoemaker *et al.*, 1994). In contrast, the test performance for those in the control group remained the same on their pre-test and post-test measurements during their three months of no intervention (Schoemaker *et al.*, 1994).

Eleven of the seventeen clumsy children were discharged and when tested after three months with no intervention at follow up it was found that their test results remained similar to those directly post-intervention. It was therefore suggested that these children could maintain their increased level of motor performance for up to three months after the end of treatment but did not improve further. This study concluded however that physiotherapy is definitely an effective form of intervention for clumsy children (Schoemaker *et al.*, 1994).

The above study was a methodologically sound study. They used valid and reliable assessment tools, the therapist was blinded from the assessment results, the effects of normal development were accounted for by having a three month period of no intervention in which incidentally no improvements in their motor skill performance were found, and they used a control group to compare the results of the study group (Schoemaker *et al.*, 1994). Some limitations to this study were mentioned in that it is difficult to generalise these treatment effects to other treatment situations as one therapist was involved in the study. It was also noted that due to the fact that an eclectic approach was employed it is uncertain which elements of the intervention produced the statistically significant improvements. The small sample size does not allow for generalisation of the results; however this study did provide promising results for the use of physiotherapy

(and to some extent the Bobath technique) in the treatment of children with DCD (Schoemaker *et al.*, 1994).

The study by Schoemaker *et al.*, (1994) was incidentally the only article which could be found on the positive effects of a physiotherapy treatment regime, which included NDT or the Bobath technique, for children with DCD. This is important as the approach used in the current study uses a combination of the Bobath technique (which has been adapted for the treatment of children with minor motor difficulties or 'low muscle tone'), strengthening exercises and task-specific training.

Another study by Smits-Engelsman *et al.*, (2001), investigated the incidence of handwriting problems and other fine motor deficits in a group of grade four and five pupils. They also studied the effectiveness of an individualised child-specific physiotherapy regimen on those children found to have poor hand-writing and other fine motor deficits. After a concise assessment of children's handwriting, 34% of the 125 pupils tested were found to have poor grapho-motor skills (i.e. poor hand-writing) and this was accompanied by other fine motor deficits. Twelve of these children were referred for physiotherapy (eight boys and four girls with a mean age of eight years and four months). They were tested on the Motor Assessment Battery for Children (M-ABC) and on the Motor Performance school readiness test. They were then treated by one of two therapists 18 times over a period of three months. They were then re-assessed post-intervention (three months) and 12 months after their initial assessments. A control group of children (six boys and six girls with a mean age of eight years four months) was randomly selected from those children who were formally assessed and were found to have good handwriting skills (Smits-Engelsman *et al.*, 2001).

Results showed that at three months after their initial assessments the children who received the intervention had higher quality handwriting and their writing speed improved. Children were also able to increase their copying speed without reducing the quality of their handwriting. These improvements were maintained when they were

assessed again 12 months later. This study gives further evidence of the effectiveness of a child-specific individual physiotherapy treatment (Smits-Engelsman *et al.*, 2001).

Despite the fact that other studies have found physiotherapy effective for children with DCD, these studies have used different frequencies and durations of treatment or group therapy has been administered (Brenner, 2008; Watenberg *et al.*, 2007; Stevens 2002; Smits-Engelsman *et al.*, 2001). It is therefore still unknown how long a session should be and how many times a week these children should be treated in order to bring about a significant amount of change in their motor skill acquisition and daily life.

2.3.3 STRENGTHENING EXERCISES

Raynor (2001) in her study of strength, power and co-activation in children with developmental co-ordination disorder (DCD) found that these children had less powerful knee extension and flexion with the deficit becoming even more pronounced with increased velocity, as compared with their normally co-ordinated peers. She suggests that this decreased muscular strength and power has an impact on everyday activities (Raynor, 2001). Therefore the difficulties that children with DCD usually have with fundamental motor skills, especially the weight-bearing propulsive types such as hopping, jumping and running, are not only confounded by their use of inefficient movement patterns may be associated with their poor levels of muscle strength and power (Raynor, 2001). Children with DCD were also found to have increased levels of muscular co-activation which is seen as a stiffening of the body and represents a less effective method of muscular activation and thus may contribute to their lower levels of muscle strength and difficulty with producing a maximum force (Raynor, 2001). This muscular co-activation is a very inefficient strategy for the recovery of balance and postural control (Shumway-Cook & Woollacott, 2001).

Their lack of general movement experiences combined with planning and programming problems with which children with DCD are faced also contributes to their inability to refine their muscular activation patterns (Raynor, 2001). Raynor (2001) recommends that

the results achieved from using a task-oriented approach may be enhanced further by identifying these underlying deficits in strength, power and muscular activation and implementing effective interventions addressing these problems. This may in turn lead to improved performance of fundamental gross motor activities by these children with DCD (Raynor, 2001).

In a case study by Kaufman & Schilling (2007), the above recommendation was found to be true. In this case report, a 12 week strength training programme given twice a week for 30 minutes was implemented for a five year old boy with DCD. He had poor body awareness, poor co-ordination, muscle weakness, hyper-extensibility, postural instability and overall significantly delayed gross motor skills. The therapist chose 12 weeks as he had poor co-ordination and she therefore wanted to give his neuromotor system time to adapt and wanted to allow for more practice. Their results showed that minimal improvements were noted in the scores of his Bruininks-Oseretsky test of Motor Proficiency (BOTMP); however improvements were noted in his level of muscular strength and endurance, proprioception, general functioning and confidence. They noted that neural adaptation and neuromuscular activation may have occurred as the programme was so structured. They also noted that neuromotor learning may have occurred due to the repetitions which gave him proprioceptive input into his limbs as he lifted them against resistance (Kaufman & Schilling, 2007).

Due to the fact that the results of this strength training programme were so positive in this child, Kaufman & Schilling (2007) suggested that further research should be conducted to explore its effectiveness in improving proprioception in children with poor body awareness both with and without DCD. The limitation to this case study is that because of the nature of its design as a case report of one child results should not be generalised to other children with DCD especially as DCD is a heterogeneous condition (Kaufman & Schilling, 2007).

There is a common assumption that postural control of the trunk has a great influence on abilities in fine manual dexterity, this relationship has influenced treatment procedures in

both occupational and physiotherapy. The development of postural control and trunk stability is considered to have an effect on upper limb and hand function. It is a common hypothesis that proximal stability allows the independent use of the arms and hands in purposeful activities and manipulative tasks (Rosenblum & Josman, 2003). Rosenblum & Josman (2003) investigated the relationship between postural control and fine motor performance in typically developing children aged five to six years old. This relationship was not supported by the results of their study. However their results could not be generalised and they suggested that more extensive longitudinal studies should be undertaken with bigger sample size to confirm this relationship (Rosenblum & Josman, 2003).

Pehoski's (2006) theory has also noted that the child's degree of distal dexterity may not necessarily be directly linked or determined by the degree of postural control due to their particular muscle groups being governed by different neurological pathways (Exner in Case-Smith & O'Brien, 2010).

Stevens (2002) found results on the contrary. Stevens (2002) investigated the effects that postural exercises using a Neurodevelopmental approach would have on the fine motor function of children with minor motor difficulties. The results suggested that postural exercises which affect central stability may have a very important role in improving fine motor function in children with minor motor difficulties with more intensive intervention showing better results (Stevens, 2002).

Similar Neurodevelopmental therapy based postural exercises to those used in the study by Stevens (2002) together with some ideas for intervention in order to improve postural control suggested by Westcott & Burtner (2004) were used in the therapy sessions given to the children who participated in the current study in both intervention groups.

2.4 INDIRECT INTERVENTIONS

2.4.1 PARENT INVOLVEMENT AND COMPLIANCE WITH A HOME EXERCISE PROGRAMME

It has been estimated that up to 50 percent of parents do not adhere to the home exercise programmes that they are given (Law & King, 1993).

Tetreault *et al.*, (2003) noted that compliance with a home exercise programme depends on five factors:

1. A satisfactory parent-therapist relationship with frequent supervision and contact with the parents.
2. Type and severity of the disability in the clientele studied.
3. Family size as it may be more difficult for families with more children to set aside time for compliance with a home programme as they have less time.
4. The age of the child with developmental delay
5. Marital stability of the parents

The study by Tetreault *et al.*, (2003) suggested that each therapist should be aware that their home exercise programme (HEP) may be increasing the demands on parents. Their HEP may not be the only one as the child may have HEPs from other therapists too. It is important as a therapist to remember that parents should be parents and not the child's home therapist (Tetreault *et al.*, 2003). The HEP should not create conflict between the parent and child, to avoid this, the suggested exercises and tasks should not be time-consuming, should fit into a family's daily routine, should be easy to administer and playful (Tetreault *et al.*, 2003). Before giving the HEP to the parents, the therapists should administer it to the child first in order to teach the parent how to perform the activities or exercises and to assess how the child may respond to the HEP (Tetreault *et al.*, 2003).

Research has shown that involvement of the parents in the rehabilitation of their children produces better outcomes and speeds up the achievement of established therapeutic goals

(Law & King, 1993). The high incidence (five percent) of DCD in children has led to the important necessity to involve support structures (such as parents) other than specialists such as physiotherapists in the treatment of children with DCD through the use of a home exercise programme (Sugden & Chambers, 2003). Many reasons have been noted to support the need to incorporate home exercise programmes, such as less families with medical insurance, changes in re-imburement structure and budget cutbacks (Rone-Adams, Stern & Walker, 2004). The above, together with the fact that inclusion of parents in the rehabilitation of their children is a vital part of the Neurodevelopmental Therapy approach (Law *et al.*, 1991) is reason enough to include parents in any if not all parts of their child's therapy.

Home exercise programmes are either used to complement the intervention being given or as an alternative to it (Tetreault *et al.*, 2003). It is essential to individualise intervention given to a child with developmental delay and the therapist must consider the needs of each family and child before making decisions about the frequency and intensity of treatment for children with developmental delays (Watemberg *et al.*, 2007; Schreiber, 2004). This is because not all children and families will be able to replace one-on-one intervention from a therapist with an intensive therapy regime and a home exercise programme (Watemberg *et al.*, 2007; Schreiber, 2004). Schreiber (2004) noted that one of the factors involved in determining the dosage of physical therapy for a child is the willingness, interest and ability of the parent to take part in the different intervention. Not all families will be able to take part in an intervention that involves an increased frequency or intensity of treatment or their own involvement in implementing a home exercise programme, as this requires more time and energy than the usual protocol of once a week therapy (Schreiber, 2004). It is important to remember that parents have other responsibilities such as the care of other family members, job commitments or limited resources (Schreiber, 2004).

Increasing the involvement of family members in the treatment of children with DCD appears to enhance the improvements in their motor skills and self esteem (Watemberg *et al.*, 2007). Sugden & Chambers (2003) set out to determine the extent to which parents

and teachers were able to provide an effective intervention for children with DCD and whether this can be a possible method of intervention for these children.

Results showed that when there was no intervention no improvement took place. There was even a slight deterioration between the first and second assessments in the period before the intervention (Sugden & Chambers, 2003). Significant improvements in motor performance were noted during the intervention phase as a result of the treatment and were maintained during a period of no intervention. There were no significant differences between the children who received teacher intervention and the children who received parent intervention (Sugden & Chambers, 2003). The results therefore confirmed that parents and teachers were able to provide effective intervention to children with DCD, with the majority of children improving during the two intervention periods as well as maintaining their scores during a rest period of seven weeks (Sugden & Chambers, 2003).

From interviews conducted with the parents and teachers it was ascertained that the intervention had many positive results such as an improvement in the children's confidence and self esteem was noted. It also encouraged the involvement of other family members such as younger or older siblings making the activities enjoyable for all involved (Sugden & Chambers, 2003). On the other hand, many parents and teachers noted that it was not easy to incorporate the activities into the normal daily routine. The reasons parents gave for this were mainly that the children were too tired after school and it was not easy to persuade them to co-operate (Sugden & Chambers, 2003). Parents who participated in a study by Tetreault *et al.*, (2003) concurred with these two points noting in addition that it was difficult to integrate the home exercise into daily life and to get the children to collaborate with them as they would get frustrated, have tantrums and cry or show a lack of interest (Tetreault *et al.*, 2003).

The HEP involves the use of the ball and is therefore designed to be a playful experience for the child. It was also designed to incorporate activities which are performed in the therapy sessions themselves and specific tasks were chosen which would be easy for a parent to administer. The home exercises were divided into activities directed at

improving weight-bearing, strength and control in the abdominal and back extensor musculature as well as in the hip and shoulder girdle. The parent was directed to do two of each exercise under each muscular category and change to the next exercises when the exercises before have become visibly easy for the child. The exercises in the programme were designed to increase with difficulty as they advance in each section. The parent was requested to do the exercise programme for the equivalent of at least 45 minutes per week. The parents could therefore choose how much time they had to administer the programme and could perform the home programme when it was convenient for them so that it was not time-consuming and could thus fit it into their family's daily routine. They could even administer the programme on the weekend as this would prevent conflict and resistance from the child and would prevent the child from having to do the HEP after school when they are already tired.

Before giving the HEP to the parents, the therapists administered it to the child first in order to teach the parent how to perform the activities and ensured that the parents themselves were able to administer the exercises easily through hands-on guidance by the therapist. In doing so the therapist was also able to assess how the child responded to the exercises. The parents were also shown the methods of compensation of which to be aware, were able to take their own notes if they needed to do so and were taught how to progress the exercises.

2.5 DURATION OR FREQUENCY OF INTERVENTION

2.5.1 INTERMITTENT VERSUS CONTINUOUS PHYSIOTHERAPY

It has been suggested that future research should assess the effectiveness of different amounts (duration and frequency) of treatment given rather than just assessing the effectiveness of an intervention (Fetters & Kluzik, 1996). Many studies in the literature on children with cerebral palsy have been undertaken to determine whether an intensive block of therapy may be more effective than weekly or monthly therapy sessions.

Mayo N. (1991) designed a randomised controlled trial to study the effectiveness of two intensities of physiotherapy. It compared the effects of receiving comparatively intensive weekly NDT therapy, to those receiving more basic monthly NDT, for children under 18 months old. Both the weekly and monthly regimens were maintained over six months and consisted of a therapy session, lasting one hour, based on NDT principles. This included instructions on carrying out a home exercise programme individually tailored to the child.

The results of this study showed that the group treated with more intensive (weekly) NDT performed higher, on average, on all seven outcome measures used. Weekly rather than monthly NDT with a home exercise programme, succeeded in changing the motor development of the children involved. Therefore Mayo N. (1991) recommended more intensive treatment for children with motor delay including those with cerebral palsy.

Bower *et al.*, (2001) and Tsorlakis *et al.*, (2004) conducted studies in which a group of children with cerebral palsy who received an increased intensity of therapy five times a week for a certain amount of weeks i.e. six months and 16 weeks (four months) respectively, was compared to a group of children who received their conventional amount of continuous therapy i.e. once or twice a week.

Bower *et al.*, (2001) found that there was a trend that was not statistically significant, towards an increase in motor function in the children receiving the intensive therapy

however this change was not maintained over the subsequent six months in which therapy reverted back to its regular amount. Therefore intensive treatment produced only a limited and temporary improvement. The disadvantage of this intensive therapy regime (five times a week for six months) was that it was considered tiring, stressful and demanding by the therapists, children and parents and therefore there was low compliance to therapy and many cancellations.

Tsorlakis *et al.*, (2004) on the other hand showed that there was a greater improvement in the Gross Motor Function Measure (GMFM) scores i.e. in the gross motor functioning, of the children who received a greater intensity of treatment over the children who received conventional therapy i.e. once or twice a week. In response to the findings of Bower *et al.*, (2001), Trahan *et al.*, (2002) designed a pilot study in order to compare the changes in gross motor function in children with cerebral palsy in two groups of children receiving different intensities of treatment based on the Neurodevelopmental therapy (NDT) approach. One group received a short, intensive therapy block which involved therapy sessions for 45 minutes, four times a week, for four weeks separated by periods without any physiotherapy for eight weeks, while the other group received their conventional amount of physiotherapy for 45 minutes twice a week (Trahan *et al.*, 2002).

Their results confirmed that the regimen of short intensive (four times a week) periods of therapy with no therapy in between can optimise therapy effects. Motor skill acquisition was accelerated in children receiving this regimen as compared to those receiving conventional therapy (twice a week). It was well tolerated with a high level of compliance. A disadvantage of this study was that there was no control group and only five children participated (Trahan *et al.*, 2002).

One of the advantages noted in this study was that the experimental phase had a lower mean number of treatments than the baseline phase and the scores still improved meaning that the rate of treatment delivery was more important than the number of treatments received (Trahan *et al.*, 2002). This was a crucial finding due to the limited financial resources in most health care systems, which similarly can be inferred to the current

economic climate in South Africa. It would be ideal to have less treatment sessions with the same improvements in skill acquisitions.

A recent prospective randomised controlled trial by Christiansen & Lange (2008) had a similar design to that of Trahan *et al.*, (2002). Their participants were randomised into an intermittent, intensive (I) group and a continuous group (C). Group I received physiotherapy for 45 minutes, four times a week for four weeks followed by six weeks of no physiotherapy. This process was repeated three times over a period of 30 weeks with the possibility of having a maximum of 48 sessions during this time. Group C received physiotherapy for 45 minutes, once or twice a week for 30 weeks and with a maximum of 48 sessions allowed. They found that the scores of the children in both the groups improved significantly and demonstrated the positive effects of pauses (intermittent periods of no treatment) in an intensive regimen (Christiansen & Lange, 2008). They also noted that compliance was greater in the group who took part in the intermittent intensive group than it was in the group receiving continuous therapy (Christiansen & Lange, 2008).

The above studies support the notion for the provision of an increased intensity of physiotherapy. They give therapists and parents a choice to structure their therapy at either intensity depending on the child and resources available.

A case study on a 31 month old infant with a chromosomal abnormality was carried out by Schreiber (2004), in which the physiotherapist changed the child's therapy programme from one hour of therapy once every two weeks to four times a week for one hour for a full month. A number of clinical factors led to the decision to increase the intensity of her therapy namely the child was displaying gross motor behaviours that showed she was ready to acquire new skills and she was able to tolerate more interaction from the therapist, the parents were keen and willing to increase the frequency and intensity of therapy for their child, the parents were also able to participate fully in the more intensive programme (Schreiber, 2004). The willingness and ability of the parents to participate is an important factor to take into consideration (Schreiber, 2004).

The results showed that the child's Gross Motor Function Measure (GMFM) scores improved corresponding to the increased intensity of physiotherapy over the 4 weeks (Schreiber, 2004).

Schreiber (2004) suggested that an increased intensity of physiotherapy based on the child and family factors as mentioned above, followed by the resumption of the normal protocol of therapy (i.e.: in this case once a week every two weeks) may lead to a more cost-effective and valuable implementation of physiotherapy for children with movement difficulties (Schreiber, 2004). Although this report does provide support for using an intensive programme of physiotherapy, as this was a case report these results can not be generalised to the population (Schreiber, 2004).

In contrast, very few articles could be found on the effectiveness of intensive physiotherapy for children with DCD. The current study was thus undertaken to determine the effectiveness of a possible protocol of an intensive five day block of treatment for one hour a day with a home exercise programme as compared to a once a week treatment for 45 minutes over 12 weeks; in improving the motor abilities of children with minor motor difficulties in South Africa.

As there has been very little research in South Africa conducted on the effectiveness of either one of these intensities of physiotherapy in improving the abilities of these children with minor motor difficulties, this is thus an exploratory study.

2.5.2 INTENSITY OF PHYSIOTHERAPY IN THE TREATMENT OF CHILDREN WITH DCD

Stevens (2002), in a South African pilot study examined the effects of postural exercises on fine motor function in children with minor motor difficulties, with and without a home exercise programme. A sample of 16 children between the ages of five and eight was used. The children were randomly assigned to one of two groups. Group A received physiotherapy once a week for 45 minutes and Group B received physiotherapy once a week for 45 minutes and they were instructed on a home exercise programme which was

to be carried out three times a week. The study period took place over three months. All children were treated in the same practice using the same standardised programme. All children were also assessed pre-intervention and post-intervention on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Stevens, 2002).

A general improvement which is greater than would be expected over a developmental three month interval was found when comparing fine motor and test age scores, indicating that the intervention improved the fine motor ability of the children in both groups (Stevens, 2002). However the results indicated that a more intensive physiotherapy treatment with the inclusion of a home programme carried out over three months would be more beneficial for improving fine motor skills of children with minor motor difficulties (Stevens, 2002). It was found that 75 percent of the children in Group B who received the more intensive physiotherapy programme reached their desired fine motor chronological age as compared with only 25 percent of the children in Group A, who received physiotherapy alone. This result was statistically significant ($p=0.04$) (Stevens, 2002). This study not only favoured an increased intensity of treatment but also showed that by strengthening postural muscles one may positively influence the fine motor function of a child with DCD (Stevens, 2002). This study was a pilot study and the sample size was small it is therefore difficult to generalise these results to the general population of DCD children which is a heterogeneous group (Stevens, 2002).

A study by Watemberg *et al.*, (2007) aimed to determine if intensive physiotherapy carried out in groups (rather than on an individual basis) would have an impact on the motor performance of children with a combination of DCD and Attention deficit-hyperactivity disorder (ADHD). The physiotherapy approach used included a combination of a cognitive task specific approach, perceptual motor training (PMT), sensory integration therapy (SIT), kinaesthetic training (KT) and Neurodevelopmental treatment (NDT) (Watemberg *et al.*, 2007).

Results showed that 50 percent of the children in the intensive group (physiotherapy twice a week for four weeks) improved their scores on the Movement Assessment

Battery for Children (MABC) from less than five percent (confirmed DCD) to above 15 percent (normal range) and a further five children out of 14 improved their scores to the borderline DCD (MABC score five to 15 percent) (Watemberg *et al.*, 2007). When tested again after four weeks of no intervention none of the children in Group B reached normal MABC scores. In contrast, all children in Group B (no intervention) stayed below the five percent range of confirmed cases of DCD. The differences between the groups was statistically significant ($p=0.001$) (Watemberg *et al.*, 2007).

This study confirmed the results found by Stevens (2002) and supported the notion that a brief intensive course of physiotherapy is very effective in improving the motor function of children with DCD and ADHD. This study differs from Stevens (2002) in that it involved children with both DCD and ADHD and the physiotherapy was given in small groups.

The fact that a shorter course of physiotherapy has been found to be effective in the treatment of these children may have important economic implications for their families (Watemberg *et al.*, 2007). Focusing on the intensity of physical therapy is important due to the need for the provision of cost-effective care (Schreiber, 2004) especially in this difficult economic climate. It is also important to determine the optimum dosage of physical therapy necessary in order to improve the motor functioning in children (Schreiber, 2004).

One of the reasons why the current research was undertaken was due to the fact that many parents were experiencing the economic pressures of the financial recession, they were therefore looking for a way to shorten the intervention period which would normally be done by the therapist once a week in order to lessen the costs involved as they still wanted the necessary therapy in order to give their children the required help.

2.6 CONCLUSION

DCD is a persistent and lasting condition found in children which often affects them as they mature into adolescents and even adulthood. It impedes not only on the child's gross and fine motor function but also on their activities of daily living, psychological and social development and scholastic abilities. Many studies have been found on the effectiveness of different types of therapy in improving the motor function of these children; however the treatment in these studies was provided in different durations, frequencies and intensities. Very few articles could be found on the effectiveness of intensive physiotherapy for children with DCD.

The current study was thus undertaken to determine the effectiveness of a possible protocol of an intensive five day block of treatment for one hour a day with a home exercise programme as compared to a once a week treatment for 45 minutes over 12 weeks; in improving the motor abilities of children with minor motor difficulties in South Africa. The physiotherapy intervention was based on Neurodevelopmental Therapy based postural exercises, which have been shown to be effective in treating the motor difficulties of children with DCD.

As there has been very little research in South Africa conducted on the effectiveness of either one of these intensities of physiotherapy in improving the abilities of these children with minor motor difficulties, this is thus an exploratory study.

CHAPTER 3

ASSESSMENT TOOL

The Bruininks-Oseretsky Test of motor proficiency- Second edition (BOT-2)

The BOT-2 is an individually administered, standardised, norm referenced, valid and reliable tool used to assess the overall motor functioning (including fine and gross motor control skills) of children between the ages of four and 21 years (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005). The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) is one of the most common tests used by physical and occupational therapists as well as other professionals, in clinic and school practice settings (Deitz *et al.*, 2007; Crawford *et al.*, 2001).

The Bruininks-Oseretsky test of Motor Proficiency was recently revised and published as the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2), by Robert and Brett Bruininks in 2005. It is used to differentiate between individuals with motor impairment and those with no motor impairment, as a screening tool to identify children who may have potential motor deficits, to help make educational placement decisions, to develop and evaluate motor interventions (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005). The BOT-2 retains 70% of the original BOTMP items. Both have eight subtests but not the same eight (Bruininks & Bruininks, 2005). The BOT-2 includes a total of 53 test items.

There are four motor area composites with each composite consisting of two subtests.

1. Fine Manual Control Composite (FMC) which comprises two subtests:
Subtest 1 Fine Motor Precision: involves seven items namely filling in shapes: a circle and a star, drawing lines through paths: crooked and curved, connecting dots, folding paper and cutting out a circle.

- Subtest 2 Fine Motor Integration: involves 8 items namely copying the following shapes: a circle, a square, overlapping circles, a wavy line, a triangle, a diamond, a star and overlapping pencils (Bruininks & Bruininks, 2005).
2. Manual Co-ordination Composite (MC): which comprises two subtests:
- Subtest 3 Manual Dexterity: involves five items namely making dots in circles, transferring pennies, placing pegs into a pegboard, sorting cards, stringing blocks.
- Subtest 7 Upper Limb Co-ordination: involves seven items namely dropping and catching a ball: one hand and both hands, catching a tossed ball-one hand and both hands, dribbling a ball- one hand and alternating hands, throwing a ball at a target (Bruininks & Bruininks, 2005).
3. Body Co-ordination Composite (BC): which comprises two subtests:
- Subtest 4 Bilateral Co-ordination: involves seven items namely touching nose with index fingers-eyes closed, jumping jacks, jumping in place-same sides synchronised, jumping in place-opposite sides synchronised, pivoting thumbs and index fingers, tapping feet and fingers-same sides synchronised, tapping feet and fingers-opposite sides synchronised.
- Subtest 5 Balance: involves nine items namely standing with feet apart on a line-eyes open and eyes closed, walking forward on a line, standing on one leg on a line-eyes open and eyes closed, walking forward heel-to-toe on a line, standing on one leg on a balance beam-eyes open and eyes closed, standing heel-to-toe on a balance beam (Bruininks & Bruininks, 2005).
4. Strength and Agility Composite (StrA): which comprises two subtests:
- Subtest 6 Running Speed and Agility: involves five items namely shuttle run, stepping sideways over a balance beam, one-legged stationary hop, one-legged side hop, two-legged side hop.
- Subtest 8 Strength: Strength is an important component of gross motor performance in daily activities. This subtest involves five items namely standing

long jump, knee push-ups or full push-ups, sit-ups, wall sit and V-up (Bruininks & Bruininks, 2005).

A fifth motor composite called the Total Motor Composite is the sum of each of the FMC, MC, BC and StrA standard scores. It comprises the sum of all eight subtests and gives the most reliable measure of overall motor proficiency (Bruininks & Bruininks, 2005).

The eight subtests as mentioned above each have between five to nine different test items in each subtest (Bruininks & Bruininks, 2005).

Bruininks & Bruininks (2005) reported extremely high inter-rater reliability co-efficients of .98 and .99 for the subtests of Manual Co-ordination, Body Co-ordination and Strength and Agility Composites. The co-efficient for the Fine Manual Control composite was also quite high at .92. The co-efficients for all the subtests and composites were above .90 except for Fine Manual Precision which was .84 (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005).

Test-Retest Reliability is a measure of the stability of an individual's scores over a brief span of time generally two to four weeks (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005). The BOT-2 was administered to the study participants on two occasions, separated by an interval ranging from seven to 42 days. The reliability co-efficients were reported to be quite high. The reliability co-efficients for the three age groups (four through seven, eight through 12 and 13 through 21) for Fine Manual Control, Manual Co-ordination and Body Co-ordination and for their related subtests were highly variable with figures ranging from .69 to the low .80s. A small practice effect was noted in the Manual Co-ordination and Body Co-ordination composites. The reliability co-efficients for the three age groups for Strength and Agility and their related subtests were all above .80, indicating that examiners can have more confidence in the stability of scores related to Strength and Agility (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005).

For internal consistency reliability, the overall subtest reliabilities were high with figures ranging from high .70s to the low .80s. Composite reliabilities were high falling between the high.80s and low .90s, indicating that subtest and composite scores on the BOT-2 are highly accurate (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005).

The DCD sample in the standardisation of the BOT-2 consisted of 50 individuals, aged between four and 15. On average the individuals scored 15 points or 1.5 standard deviations below the reference group on the motor area subtests, composites and the Total Motor Composite, which is statistically significant (Bruininks & Bruininks, 2005).

To determine the strength of the relationship between scores on the BOT-2 and scores on the BOTMP, its predecessor; both the tests were administered to 49 children and youth, aged six through 14. This study allows clinicians who have had experience in using the BOTMP to use this experience in the interpretation of the BOT-2 (Bruininks & Bruininks, 2005). The correlation between the Total Motor Composite (on the BOT-2) and the Battery Composite is strong at .80 with similar standard score means, indicating that performance across the two measures is comparable. Correlations between the Fine Manual Control Composite (on the BOT-2) and the Fine Motor Composite (on the BOTMP) were moderately strong (.60) as was the relationship between scores on the Body Co-ordination and Strength and Agility Composites (on the BOT-2) and the Gross Motor Composite (on the BOTMP) (Bruininks & Bruininks, 2005). Correlations between subtests with similar content were moderately strong and were usually stronger than correlations between the composites. These correlations support the validity of the BOT-2 (Bruininks & Bruininks, 2005).

The normative sample used in the standardisation of the BOT-2 included 1,520 children and youth with typical development dispersed across the United States of America (Bruininks & Bruininks, 2005). However in the BOT-2 sample, 11.4% of the children were also receiving special education and therefore a variety of disabilities were included such as attention deficit hyperactivity disorder, emotional and behavioural disturbances, specific learning disabilities, mental retardation, developmental delay and speech and

language impairments (Bruininks & Bruininks, 2005). In contrast the normative sample of the BOTMP did not include children with disabilities therefore if school districts use 1.5 to 2 standard deviations below the mean as a criterion for receiving intervention, it is likely that the BOT-2 will identify fewer children as in need of services than the BOTMP would (Deitz *et al.*, 2007; Bruininks & Bruininks, 2005).

The author of the BOTMP suggested that the assessment is valid to be re-administered within a three- to four week period and that the test was developed to evaluate the effectiveness of motor programmes (Wilson *et al.*, 1995; Bruininks, 1978). It was recommended that the BOTMP be used to measure changes in motor development over time rather than as a diagnostic tool (Yoon *et al.*, 2006)

In the current study, the BOT-2 was used as a valid ‘evaluative’ measure which is one of its uses (Bruininks & Bruininks, 2005), meaning that it may be used to measure change over time as a result of maturation or a response to an intervention as it is considered to be able to detect meaningful change (Missiuna *et al.*, 2006). It was reported to be sensitive to the changes taking place in a child over time with the ability to quantify these changes in each child (Wilson *et al.*, 1995). It was therefore used in the current study as a valid tool to measure the change in the motor skills of children after a five day and after a six week physical therapy intervention.

Wilson *et al.*, (1995) investigated the usefulness of the BOTMP for both descriptive (diagnostic) and evaluative (change over time) purposes for children with mild motor problems. It was suggested that for evaluative purposes the subtest point scores be used rather than the normative (standard and composite standard scores). Wilson *et al.*, (1995) noted that in a child who has motor problems and who is receiving treatment, re-administering the BOTMP may verify a clinician’s impression that the child’s skills have improved.

However it was noted that if the progress was slow, the normative scores (i.e. the standard and composite scores) may not show the change as these normative scores were

based on a sample of children who did not have motor delays. The normative scores may only demonstrate progress if the child did not change age groups between pre-test and post-test and if the rate of change is faster than typical development, which is a rate of progress that few children with mild motor problems are able to achieve. It was therefore suggested that for treatment outcome purposes and when measuring a child's progress, it would be more useful to compare the performance of a child to his or her own previous performance (with point scores) than to compare their performance to that of the normative sample (with the standard and composite scores) (Wilson *et al.*, 1995) .

Although no studies could be found validating the use of the BOT-2 for use in South African children, the BOT-2 was still the most suitable assessment to use in the current study for the reasons mentioned previously.

CHAPTER 4

METHODOLOGY

4.1 POPULATION

The subjects in the study were children attending Crawford Village Pre-Primary School in Rivonia, St Davids Marist Inanda Preparatory (Mini Marists) and Primary School in Illovo and St Mary's Preparatory (Little Saints) and Primary School in Waverley. These are all private schools in Johannesburg, South Africa.

4.2 SAMPLE SIZE DETERMINATION

A successful intervention is assumed when the groups improve by one stanine i.e. at least 4 Bruininks-Oseretsky Composite Standard Score points. A standard deviation of six points is assumed. The standard deviation was assumed to be six points (maximum change/ 6 = $36/6 = 6$), i.e. the total range is assumed equal to six standard deviations).

A sample of 23 children in each group would then have had 90% power to detect a difference in change from baseline of one standard deviation, when utilising a two group t-test at the 0.05 level of significance. To account for a drop-out of 20%, the total sample should have been 28 children in each group.

4.3 INCLUSION CRITERIA

- Children who had been identified by an experienced physiotherapist as needing physiotherapy intervention after clinical observation and formal assessment.
- Children with Developmental Coordination Disorder, Low muscle tone or minor motor difficulties.
- Children aged between four and 10 years
- Normal school education

4.4 EXCLUSION CRITERIA

- Children with clinically apparent neurological abnormalities
- Children who were already receiving physiotherapy for the treatment of motor inco-ordination.

4.5 STUDY DESIGN

This study was a non-randomised controlled trial.

4.6 PROCEDURE

4.6.1 RECRUITMENT

Children were referred to therapy by class teachers through normal observations of the children in the classroom (including posture whilst sitting at the desk and during ring time) and their performance in gross motor activities in general and on the playground.

The school then contacted the parents advising them of their child's need for a full physiotherapy assessment which is the standard protocol presently followed. The parent contacted the practice and the child was assessed using a non-standardised assessment which is based on observation of the child's posture when performing desk-top activities and other fine motor skills as well as their quality and efficiency of movement in certain gross motor skills. Once the child was found to need physiotherapy, the parent was contacted and given feedback from the assessment. They were then invited to take part in the study via a telephone call and letter which was given to them with information stating the purpose, length and conditions of the study. It also included a parent consent form which was signed, allowing the children to participate in the study. The child gave verbal assent. Once the appropriate consent and assent was obtained, the child was assessed on the BOT-2 by the researcher to get a baseline score.

4.6.2 DATA COLLECTION

Prior to commencement of data collection, the researcher was trained in the use of the BOT-2.

Children were placed in one of two groups, depending on availability of the parent:

Children in Group A (test group) received intensive therapy of one hour per day for five days (Monday to Friday). This included careful instruction to a caregiver or parent on a home exercise programme individually designed for them, which was done in the subsequent weeks.

The home programme was designed using general ball exercises known to the researcher which would focus on postural control and exercises to improve stability. It was also designed to incorporate activities which are performed in the therapy sessions themselves and specific tasks were chosen which would be easy for a parent to administer.

The parents kept as thorough a record as possible of the exercises and extra-murals done using a diary. This was then used in order to measure the degree to which the parents complied with their home programme. The diary was an A5 book, the parents were asked to record the date, which exercises were done and the repetitions of each exercise as well as any extra-murals which the children took part in during the weeks in which the home exercise programme was done. The home exercises were divided into activities directed at improving weight-bearing, strength and control in the abdominal and back extensor musculature as well as in the hip and shoulder girdle. The parent was directed to do two of each exercise under each muscular category and change to do two of the next exercises in the section when the exercises before have become visibly easy for the child. The exercises in the programme were designed to increase with difficulty as they advance in each section. The progression of the difficulty of the exercises was done at the discretion of the parent. The parent was requested to do the exercise programme for the equivalent of at least 45 minutes per week.

These children were then re-assessed within one week post-intervention on the BOT-2 (Bruininks-Oseretsky Test of Motor Proficiency *second edition*) to assess for any treatment gains. They then continued to participate in their daily extra mural activities as well as followed a home exercise programme for a subsequent five weeks with no other physiotherapy intervention. They were then re-assessed again on the BOT-2 after this five week period where one of two possibilities occurred. If the child's scores had dropped from his baseline score, he/she received further intensive therapy for one hour per day for five days (Monday to Friday). The child was re-assessed again post-intervention and the home exercise programme was revised in order for it to be followed for a further five weeks with no other therapy intervention given during this time. If however the child had maintained or improved on his previous BOT-2 scores, he continued with the same exercise programme for a further six weeks. They were then assessed again on the BOT-2, after the full period of 12 weeks (please refer to Appendix 1 for outline of procedure).

The home exercise programme was given to the parents in the form of a booklet (please refer to Appendix 4 for the Home Exercise Programme) which was illustrated with digital photographs of each exercise and explained together with a step by step guide. The home exercise programme was taught to the parents of the children in group A during the last 15 minutes of each session, each day in the five day intervention. The booklets were designed as a photographic aid to refer to as well as to facilitate compliance. In order to aid in measuring compliance the parents were also given a log-book to chart their progress in carrying out the home programme with their children as well as to record their children's extramural activities within the period of the study.

The children in Group B received physiotherapy for 45 minutes once a week for a total of three months (12 weeks). This is the standard management which is currently being given at these schools. They were then re-assessed on the BOT-2 after six weeks and again after the 12 week intervention period and the scores between the two groups were compared to establish the treatment effects. The study took place over a full 12 weeks for each of the children in both groups.

The type of activities done in therapy sessions in both groups included activities which improved weight-bearing through shoulder girdle such as somersault and back-flips over apparatus and exercises 12-16 and 25 in HEP, such as exercise weight shift such as hopping and tasks involving balancing on one leg, bilateral integration and dissociation such as star jumps and stride jumps on a big ball and such as exercises 6 and 8 in HEP. Tasks involving abdominal activation such as exercises 12-16, 18-20, 23 and 24 in HEP, tasks involving abdominal activation and rotation such as exercise 11, 17 and 21 in HEP, as well as back extensor activation such as exercises 1-5 in HEP, depending on the child's specific needs.

The therapist who assessed the child on the BOT-2 was not the same therapist who treated the child. This ensured blinding of the therapists treating the child to the scores obtained on the BOT-2, in order to prevent treating the specific tasks that the child found difficult. Both therapists treating the children were certified NDT therapists with many years of experience. Reliability was ensured through consistent assessment and analysis of scores by one researcher who had been trained on the usage of the BOT-2. The validity of the study was ensured through the use of the BOT-2 which is both a valid and reliable standardised assessment tool.

The Scale Scores of the eight subtests, Fine Motor Composite Standard Scores (made up of Fine Manual Control and Manual Co-ordination separately), Gross Motor Composite Standard Scores (made up of Body Co-ordination and Strength and Agility separately), and the Total Motor Composite of the data sets were obtained and the data was then analysed and compared pre, during and post intervention and after the period of home exercise programme.

Children's extra-mural activities were recorded to determine whether these may have affected improvement. To eliminate the possibility that any improvement found after the intervention was due to normal development (or there would have been an equal improvement in the scores), and to see whether treatment effects were maintained in the

short term, the home exercise programme period given to Group A (the test group), with no additional therapy during that time period, and was used as a control.

4.7 STATISTICAL ANALYSIS

Data was recorded at baseline, at six weeks and at 12 weeks in both groups (A and B) and also after five days of intervention in group B. Groups were compared over time with respect to motor area composite parameters using a repeated measures analysis of variance (ANOVA). The treatment group was the between subject factor and time was the within subject factor (interaction terms were not significant and hence the main effects treatment group and time was interpreted). When time was significant contrasts were assessed, using regression methods, to determine where differences are. Of interest was also to compare treatment groups with respect to change from baseline at six weeks. Here an analysis of co-variance (ANCOVA) was employed with baseline value as covariate.

From an exploratory point of view it was of interest to consider a within group analysis for the intervention group comparing day five, week six and week 12 results with baseline. These comparisons were done using random effects General Least Squares (GLS) regression. The group of children who were receiving occupational therapy (OT) and the group of those who were not, were compared using repeated measures analysis of variance (ANOVA). Testing was done at the 0.05 level of significance.

4.8 ETHICAL CONSIDERATIONS

Ethical clearance was received from the Committee for Research on Human Subjects at the University of the Witwatersrand to conduct this study. The protocol number is M080950 (See Appendix 4).

The physiotherapy practices are run on the school premises. The usual protocol is that the teachers refer any children whose physical development they are concerned about for a

physiotherapy assessment. The teachers inform the parents of the practice on the school premises and give the parents numbers for other practices in the area. The parents who like the convenience of the practice on the school premises call the practice to arrange a physiotherapy assessment. These parents whose children were then assessed were then asked if they would like to participate in the study. The school was not asked to look for children to refer as this would be considered as canvassing.

Participation was voluntary. Refusal to participate involved no penalty or loss of benefits to which the participant was otherwise entitled. Subjects were allowed to withdraw from the study at any time without penalty.

Informed consent was obtained from the parents for the participation of their children in this study and verbal assent was obtained from the children themselves for their own participation in this study.

Parents were charged for the treatment during the study as they would have been charged for the treatment regardless of whether they were participating in the study or not.

No additional costs were incurred by the parents for assessment of their children on the BOT-2 (Bruininks-Oseretsky Test of Motor Proficiency *second edition*) as this required additional time from the parent and would not have been part of the usual protocol had they not participated in the study.

Receiving no treatment was included as withholding necessary treatment, and was deemed unethical. There was therefore no group that did not receive the necessary physiotherapy. Anonymity of the children in the study was maintained by assigning numbers to them. Their identity and personal information is known only to the researcher.

CHAPTER 5

RESULTS

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

5.1 Demographic Data

Thirty four subjects who had minor motor difficulties, participated in this study. There were twenty seven children in Group A (children who received physiotherapy based on a Neurodevelopmental therapy approach, once a week for 45 minutes) and seven children in Group B (children who received intervention for one hour per day for five days together with a prescribed home exercise programme).

The above-mentioned sample size was settled upon instead of the 28 children in each group, as stipulated in the sample size calculation, due to unforeseen circumstances of sampling issues which will be discussed further in chapter six.

Of these subjects 12 were girls and 22 were boys, therefore a boy to girl ratio of 1.83:1. The mean age of the children in Group A, at the initial baseline assessment was 5.59 (± 0.85) and age range of 4.25 to 7.67 months. The mean age of the children in Group B, at the initial baseline assessment was 6.57 (± 1.81) and age range of 4.75 (four years and nine months) to 10.08 (10 years and one month).

5.2 Gross and Fine Motor Improvement for Group A and B:

5.2.1 Mean Scores for each Group

The mean total point scores, scale scores and standard scores for the four motor area composites; Fine Manual Control (FMC), Manual Co-ordination (MC), Body Co-ordination (BC), Strength and Agility (StrA), together with the scores for the Total Motor Composite (TMC) of the Bruininks-Oseretsky Test of Motor Proficiency *second edition* (BOT-2), are reported for Group A (once a week therapy) and Group B (five days of therapy with a home exercise programme for the subsequent 12 weeks) separately.

In Group A these scores are compared to each other for three assessments i.e. the baseline assessment (pre-treatment), the assessment at six weeks and the assessment at 12 weeks.

In Group B these scores are compared to each other for four assessments i.e. the baseline assessment (pre-treatment), the assessment five days later (post-treatment), the assessment at six weeks and the assessment at 12 weeks.

The mean scores and standard deviations are presented in Table 5.1 for Group A, and Table 5.2 for Group B.

<u>Table 5.1:</u> Group A Mean (SD) of point, scale and composite standard scores			
Parameters: Scores	Baseline	Six weeks	12 weeks
FMC Point Score	45.7 (±15.9)	53.2 (±13.1)	56.4 (±12.0)
Scale Score	31.6 (±7.1)	36.0 (±6.8)	37.0 (±6.2)
Composite Standard Score	51.1 (±8.2)	57.3 (±8.5)	58.0 (±7.8)
MC Point Score	32.4 (±11.0)	41.5 (±12.0)	47.0 (±11.8)
Scale Score	30.4 (±4.7)	38.1 (±6.8)	40.8 (±7.8)
Composite Standard Score	50.4 (±5.8)	60.0 (±8.4)	62.8 (±9.4)
BC Point Score	41.9 (±7.8)	49.3 (±5.3)	52.1 (±4.2)
Scale Score	32.6 (±4.8)	39.2 (±5.9)	41.9 (±3.8)
Composite Standard Score	52.7 (±6.0)	60.9 (±7.1)	64.0 (±4.2)
StrA Point Score	34.0 (±8.7)	45.8 (±7.7)	50.1 (±7.1)
Scale Score	30.3 (±5.0)	39.5 (±4.6)	42.0 (±4.4)
Composite Standard Score	50.2 (±6.2)	61.2 (±5.9)	64.0 (±5.4)
TMC Sum of Standard Scores	204.3 (±15.6)	239.4 (±21.8)	248.8 (±16.1)
Composite Standard Score	51.0 (±5.2)	63.5 (±7.8)	67.5 (±6.3)

Mean scores with SD in brackets for children in Group A (once per week therapy)

Table 5.2: Group B Mean (SD) of point, scale and composite standard scores				
Parameters: Scores	Baseline	Post five days	Six weeks	12 weeks
FMC Point Score	59.7 (±22.2)	65.3 (±14.7)	64.6 (±15.2)	62.9 (±20.2)
Scale Score	38.0 (±9.2)	41.0 (±5.9)	39.7 (±7.0)	36.3 (±10.2)
Composite Standard Score	59.7 (±11.7)	62.7 (±7.8)	61.3 (±9.3)	56.7 (±12.1)
MC Point Score	44.0 (±20.3)	54.9 (±16.7)	54.7 (±16.6)	55.1 (±17.5)
Scale Score	33.6 (±9.8)	44.7 (±6.7)	43.0 (±6.4)	43.0 (±7.6)
Composite Standard Score	54.1 (±12.3)	67.7 (±8.0)	65.6 (±7.7)	65.4 (±9.5)
BC Point Score	47.9 (±7.1)	54.4 (±3.6)	54.4 (±4.5)	55.1 (±3.8)
Scale Score	34.6 (±5.4)	41.9 (±5.2)	40.9 (±8.2)	41.4 (±4.3)
Composite Standard Score	55.1 (±6.9)	65.3 (±7.7)	64.0 (±10.7)	64.3 (±5.6)
StrA Point Score	45.1 (±13.5)	54.4 (±11.8)	54.9 (±12.7)	56.0 (±12.1)
Scale Score	33.9 (±8.1)	41.9 (±4.7)	41.1 (±7.5)	42.1 (±6.0)
Composite Standard Score	54.1 (±9.8)	63.7 (±5.5)	62.7 (±9.2)	63.7 (±7.3)
TMC Sum of Standard Scores	223.1 (±27.7)	259.4 (±16.0)	253.6 (±27.5)	250.1 (±22.9)
Composite Standard Score	57.9 (±10.4)	71.9 (±6.5)	68.7 (±9.6)	68.3 (±9.1)

Mean scores with SD in brackets for children in Group B (5 day intervention with HEP)

From the tables above results showed that for Group A (physiotherapy intervention once weekly) (See Table 5.1), the mean point scores, scale scores and standard scores for each of the four motor composites as well as for the total motor composite increased from baseline at all subsequent assessments (i.e. at six weeks and 12 weeks).

However for Group B (five days of physiotherapy intervention with a home exercise programme) (See Table 5.2) the mean point scores, scale scores and standard scores for each of the four motor composites as well as the total motor composite, increased after the five days of one-on-one intervention with a trained NDT physiotherapist, however at six weeks and 12 weeks the deterioration of the motor composite scores was negligible compared with the five day scores but these scores never dropped below the baseline scores.

5.2.2 Comparison between groups over time

The first objective in this study was to compare the study groups (Group A and Group B) at six and 12 weeks. Groups were compared over time with respect to motor area composite parameters using a repeated measures analysis of variance (ANOVA). The treatment group was the between subject factor and time was the within subject factor (interaction terms were not significant and hence the main effects treatment group and time was interpreted).

For all of the p-values below, the values are significant if $p \leq 0.05$, marginally significant if $0.05 < p \leq 0.1$ and not significant if $p > 0.1$.

In Table 5.3 the p-values for group comparison, are reported from a repeated measures Analysis of Variance (ANOVA) with group (A and B) as between subject factor and time (Baseline, six weeks and 12 weeks) as within subject factor.

<u>Table 5.3:</u> p-values for comparison between Group A and B for scale and composite standard scores		
Parameter	Scale score (p-value)	Composite Standard Score (p-value)
FMC	0.2244	0.225
MC	0.2123	0.235
BC	0.5572	0.3835
StrA	0.3584	0.4645
TMC	-	0.1163

***=significant**

From the information provided in Table 5.3, in neither scale score nor composite standard score did groups differ significantly, at $p > 0.1$, with respect to all the motor area composites (FMC, MC, BC, StrA and TMC).

5.2.3 Change in scores over time

In Table 5.4 the scale scores and composite standard scores are reported for both Group A and Group B, as the coefficient of change (with p-values) from baseline at six weeks and 12 weeks.

<u>Table 5.4:</u> Change from Baseline at six weeks and 12 weeks Co-efficient (p-value)		
Parameter	Six weeks	12 weeks
Scale Scores		
FMC	4.48 (0.005*)	5.41 (0.001*)
MC	7.78 (0.000*)	10.44 (0.000*)
BC	6.67 (0.000*)	9.30 (0.000*)
StrA	9.19 (0.000*)	11.67 (0.000*)
Composite Standard Scores		
FMC	6.19 (0.002*)	6.93 (0.000*)
MC	9.59 (0.000*)	12.37 (0.000*)
BC	8.26 (0.000*)	11.37 (0.000*)
StrA	11 (0.000*)	13.78 (0.000*)
TMC	12.52 (0.000*)	16.56 (0.000*)

***=significant**

It can be seen from the Table 5.4. that at both six weeks and 12 weeks, the scale scores and standard scores for each motor area composite i.e. FMC, MC, BC and StrA as well as the Total Motor Composite were significantly higher than at baseline ($p < 0.005$) (See

Table 5.4.), but six week and 12 week scores differed significantly for only some of the parameters (See Table 5.6). Note that there was no interaction between group and time. When time was significant contrasts in results were assessed to determine where differences are, using regression methods.

Table 5.5 below represents the results found for the individuals in Group B, who received physiotherapy from a trained NDT physiotherapist for five days and who then followed a prescribed home exercise programme with their caregivers for the subsequent 12 weeks.

<u>Table 5.5:</u> Group B: Mean change from Baseline: Co-efficient (p-value)			
Parameter	Post five days	Six weeks	12 weeks
Scale Scores			
FMC	3 (0.335)	1.71 (0.657)	-1.71 (0.603)
MC	11.14 (0.000*)	9.43 (0.000*)	9.43 (0.000*)
BC	7.29 (0.002*)	6.29 (0.041*)	6.86 (0.000*)
StrA	8 (0.000*)	7.29 (0.000*)	8.29 (0.000*)
Standard Score			
FMC	3 (0.478)	1.57 (0.761)	-3 (0.472)
MC	13.57 (0.000*)	11.43 (0.000*)	11.29 (0.000*)
BC	10.14 (0.003*)	8.86 (0.033*)	9.14 (0.000*)
StrA	9.57 (0.000*)	8.57 (0.000*)	9.57 (0.000*)
TMC	14 (0.000*)	10.86 (0.001*)	10.43 (0.000*)

***=significant**

The results (See Table 5.5) showed that the scale scores and standard scores for three of the four motor area composites i.e. MC, BC and StrA as well as the Total Motor Composite (TMC) were significantly different from baseline at five days (post-intervention), six weeks and 12 weeks, at $p < 0.05$. With the exception of the Fine Manual Control scale and composite standard scores which were not significantly different from baseline ($p > 0.1$).

This statistical analysis was made from the General Least Squares regression model using the specific formulae: $(\text{Coef (time12)} - \text{Coef (time6)})$ divided by the Standard Error = z-score, if $z > 1.96$ results are significant and the p-values are significant at $p < 0.05$ (See Table 5.6).

Table 5.6 below represents the results for the change in scores from six weeks to 12 weeks with respect to motor area composites FMC, MC, BC, StrA and TMC in both groups.

<u>Table 5.6:</u> Change from six weeks to 12 weeks with respect to motor area composites			
Parameter	Change from six weeks to 12 weeks		
	Change	z-score	p-value
Scale Scores			
FMC	0.93	0.574	> 0.05
MC	2.67	2.03	< 0.05*
BC	2.63	2.27	< 0.05*
StrA	2.48	2.07	< 0.05*
Standard Score			
FMC	0.74	0.37	> 0.05
MC	2.78	1.72	> 0.05
BC	3.11	2.13	< 0.05*
StrA	2.78	1.90	> 0.05
TMC	4.04	2.51	< 0.05*

***=significant**

Results (See Table 5.6) showed that the change in scale scores and standard scores between six weeks and 12 weeks for the Fine Manual Control motor composite was not significant. In general the six week and 12 week scores differed significantly for only some of the parameters (See Table 5.6) i.e. Bilateral Co-ordination (BC) consistently, with disagreement between the scale and standard scores for the other parameters. This said, it can however still be noted that the change between six weeks and 12 weeks, in the total motor composite standard score (which is the sum of the four motor composites) was significant ($p < 0.05$), indicating that a change in their overall function is still noted between six weeks and 12 weeks in these children.

A non-parametric analysis of co-variance was thus conducted to compare Group A and Group B with respect to change from baseline at six weeks (6-0) (See Table 5.7 below). In Table 5.7, the groups were compared with respect to change from baseline at six weeks (6-0) using analysis of co-variance with baseline as the covariate. However since standard deviations were often large and also quite different for the two groups, the groups were subsequently compared using non-parametric analysis of co-variance i.e.: analysis of ranks.

<u>Table 5.7:</u> Group Comparison with respect to change from Baseline at six weeks (Mean (SD) and p-value)			
Parameter	Group A (once/wk)	Group B (5day&HEP)	p-value
Scale Scores			
FMC	4.48 (± 7.19)	1.71 (± 10.23)	0.788
MC	7.78 (± 4.26)	9.43 (± 4.72)	0.395
BC	6.67 (± 5.36)	6.29 (± 8.12)	0.617
StrA	9.19 (± 4.59)	7.29 (± 4.46)	0.784
Standard Score			
FMC	6.19 (± 9.00)	1.57 (± 13.70)	0.653
MC	9.59 (± 5.15)	11.43 (± 5.56)	0.399
BC	8.26 (± 6.54)	8.86 (± 10.96)	0.552
StrA	11 (± 5.62)	8.57 (± 5.38)	0.574
TMC	12.52 (± 6.65)	10.86 (± 8.73)	0.937

***=significant**

Results (See Table 5.7) showed that for the scale scores and standard scores for each motor area composite i.e. FMC, MC, BC and StrA as well as the Total Motor Composite the groups were found to be not significantly different at $p > 0.1$ at six weeks.

5.3 Comparison between children receiving simultaneous Occupational Therapy and children who were receiving only Physiotherapy

Six out of the thirty four subjects were receiving occupational therapy (O.T) simultaneously. These six children were in Group A (the individuals receiving physiotherapy based on a Neurodevelopmental therapy approach once weekly). There were no children in Group B who were receiving Occupational Therapy.

Table 5.8 below represents the results found when a repeated measures analysis of variance was used to assess whether the scores were any different in those individuals receiving occupational therapy to those who were not.

<u>Table 5.8:</u> Group comparison of scale and composite standard scores for those receiving OT and those not receiving OT		
Parameter	Scale score (p-value)	Composite Standard Score (p-value)
FMC	0.4316	0.4883
MC	0.6527	0.607
BC	0.7466	0.7842
StrA	0.634	0.482
TMC		0.590

***=significant**

From the information provided in Table 5.8, in neither scale score nor composite standard score did groups differ significantly, at $p > 0.1$, with respect to all the motor area composites (FMC, MC, BC, StrA and TMC).

5.4 Conclusion:

Results showed that the greatest changes in score took place within the first six weeks of intervention. Although the change between six weeks and 12 weeks were smaller than the changes between baseline and six weeks, the changes from baseline in overall motor function were still present. Results also showed that the home exercise programme was effective in maintaining the results gained from the five day intervention. The fine motor function of those children in Group A improved. However the fine motor function of those in Group B did not improve after five days of treatment or after the 12 weeks of complying with the home exercise programme.

CHAPTER 6

DISCUSSION

In this chapter, the results obtained in this study are discussed. These results will be compared with those recorded in previous studies. The implications and limitations of this study are mentioned, and recommendations are made.

6.1 Demographic Data

Thirty four subjects who had minor motor difficulties, participated in this study. There were twenty seven children in Group A (children who received physiotherapy based on a Neurodevelopmental therapy approach, once a week for 45 minutes) and seven children in Group B (children who received physiotherapy intervention for one hour for five days together with a prescribed home exercise programme). Of these subjects 12 were girls and 22 were boys, therefore a boy to girl ratio of 1.83:1 which is just below the ratio of 2:1 which is reported for children with DCD (Zoia et al, 2006; Barnhart et al, 2003).

DCD is usually identified between six and 12 years of age (Barnhart *et al.*, 2003). The age range of the children in Group A was 4.25 to 7.67 months and in Group B was 4.75 (four years and nine months) to 10.08 (10 years and one month). The age range used in the current study had more children who were younger and less children who were older, as did the study by Stevens (2002) who used children between the age range of four years two months and seven years old. Brenner (2007) however, used a wider age range of 7.33 (seven years and four months) to 13.5 (13 years and six months) with more children who were older and no children under the age of seven years old. In the current study children were referred to physiotherapy at younger ages.

6.2 Sample Selection

Waternberg *et al.*, (2007) as well as Schreiber (2004) previously noted that it is essential to individualise intervention given to a child with developmental delay and the therapist must consider the needs of each family and child before making decisions about the frequency and intensity of treatment for children with developmental delays. This is because for many different reasons not all children and families will be able to replace one-on-one intervention from a therapist with an intensive therapy regime and a home exercise programme.

Schreiber (2004) also noted that one of the factors involved in determining the dosage of physical therapy for a child is the willingness, interest and ability of the parent to take part in the different intervention. Not all families will be able to take part in an intervention that involves an increased frequency or intensity of treatment or their own involvement in implementing a home exercise programme; as this requires more time and energy than the usual protocol of once a week therapy (Schreiber, 2004). It is important to remember that parents have other responsibilities such as the care of other family members, job commitments or limited resources (Schreiber, 2004). It was important to take all this into account when allocating the children to the weekly protocol or to the intensive protocol with a home exercise programme. The study was therefore non-randomised and parents chose in which group they wanted to take part.

6.3 Sample Size

This study was undertaken as an exploratory study to determine whether an intensive physiotherapy regime might be an alternative for once per week therapy for children with minor motor difficulties. This was due to the fact that many parents were unable to afford the expenses of weekly physiotherapy because of the recession and poor economic climate in South Africa at the time. However because of this there are more households where both parents are working longer hours to support their family and to maintain their standard of living. They could therefore also not commit to doing a home programme

with their child as they had very little time because of their job commitments as well as their commitment to the care of other family members.

The sample size in Group B was therefore smaller than expected for the above reasons. In order to meet the objectives for this study, the original sample size was calculated at 23 children in each group which would have then had 90% power to detect a difference in change from baseline, of one standard deviation (six points), when utilising a two group t-test at the 0.05 level of significance.

There were only seven children in Group B, which drops the power to 63%. Therefore when stating that something was found not to be significant it may be for two reasons either that there really is no difference or that the sample size may be inadequate to detect the difference. It is rather more likely to be that the sample size was inadequate to detect the change as the power was reduced from 90% to 63%.

6.4 The Bruininks-Oseretsky test of motor proficiency- second edition

Not all children who are referred to occupational and physical therapy have DCD. The functional problems which these children experience may not always be motor based and may be due to components such as attention, memory and behaviour (Crawford *et al.*, 2001). Any child with motor difficulties requires a comprehensive assessment. This assessment should include a standardised test which can give a valid and reliable measure of the child's fine and gross motor skills as well as other clinical observations (Crawford *et al.*, 2001).

Missiuna & Pollock (1995) demonstrated the importance of using other clinical observations in children with a mild delay in motor skill development. They noted that the norm-referenced tests demonstrated a mild motor delay in a small percentage of children. It was noted that clinical judgments and decisions should not be made on the basis of one or two test scores or on an isolated observation; rather clinical reasoning based on many sources of information should be used. They suggested that therapists

should evaluate their data from different sources for consistency. The different sources of data which should come from clinical observations of the child interacting with their natural environment, the teacher report on observations of the child in the classroom and on the playground, historical and anecdotal information and analysis of the child's quality of movement which characterise children with DCD or general motor delay, is of great importance (Missiuna & Pollock, 1995).

As noted, standardised tests may be limited in their ability to identify children with DCD as they do not evaluate the quality of a child's movement; thus making place for informal and judgment-based measures in the assessment of children with DCD (Missiuna & Pollock, 1995). In the absence of a gold standard (Crawford *et al.*, 2001) or no one test that can be used alone to consistently identify or evaluate the motor functioning of children with DCD or those with mild motor problems (Crawford *et al.*, 2001), the revised second edition of the Bruininks-Oseretsky test of Motor Proficiency (BOT-2) was used to assess the children in the current study, together with separate observations on their quality of movement as they are performing the tasks on the test.

In the Bruininks-Oseretsky Test of Motor Proficiency-*second edition*, the child can not score points unless the tasks are done in the manner stipulated in the manual. The test was chosen as it included many of the tasks assessed in the non-standardised test used by the physiotherapy practice. The test does make space for the assessor to write on the child's quality of movement during performance of the activities however it does not specifically measure impairment in terms of the quality of how the movement and tasks are done, it is said to measure only the ability to perform an activity (Missiuna *et al.*, 2006).

Missiuna & Pollock (1995) demonstrated that children with DCD may achieve the performance criteria on activities tested in standardised tests; however they will still have poor quality of movement, far below that of their peers, so much so that their performance is no longer functional and efficient. They did not recommend the use of a score below a certain standard deviation on a norm-reference measure in order to

determine the eligibility of children with DCD for services. They emphasised the importance of analysing the quality of their movement and of evaluating different sources of data and the consistency between them i.e. ensuring consistency between data obtained from standardised tests and clinical observation of the therapists and other information and observations from teachers (Missiuna & Pollock, 1995).

This was also observed in the current study. Children achieved the maximum score for a certain activity by being able to perform it according to the criteria stipulated by the BOT-2 manual. However it did not take into account quality of movement (even though a point can only be given if the task is carried out in a certain manner) thus making their total score and competence level seem higher than it actually was. This made the child's abilities appear to be better than they would have been if quality of movement from clinical observation would have been taken into account.

Thus although improvements in score from baseline were reported for both Group A and B, these children may have achieved these results using certain methods of compensation not necessarily detected by the BOT-2. They therefore may have still needed further therapy to improve on their posture whilst sitting at their desk and quality of movement while performing their gross motor skills.

The Bruininks-Oseretsky Test of Motor Proficiency-*second edition* was however the most appropriate test to use in order to determine the aims of this present study.

6.5 Gross Motor Improvement

The Bobath technique or Neurodevelopmental therapy (Mayston, 2008; Raine, 2006) was used in the physiotherapy intervention in both groups in the current study to treat children with minor motor difficulties / 'low muscle tone' / DCD. Gross motor activities in the treatment sessions involved active participation of the child with hands-on guidance when necessary to promote correct form and the feeling of normal movement. It also involved trunk (core) strengthening, shoulder strengthening, hip stability tasks to improve balance and hopping, activities involving bilateral co-ordination and integration such as star jumps, stride jumps, galloping and skipping and throwing and catching activities to improve hand-eye co-ordination and ball skills.

Results showed that all the scores for Group A (those children receiving weekly physiotherapy) increased from baseline at all subsequent assessments (i.e. at six weeks and 12 weeks). However for Group B (five days of physiotherapy intervention with a home exercise programme) all the scores increased after the five days of one-on-one intervention with a trained NDT physiotherapist, however at six weeks and 12 weeks which relied on the home exercise programme, the deterioration of the motor composite scores were negligible compared to the five day scores but these scores never dropped below the baseline scores.

It must be noted that Niemeijer *et al.*, (2007) have found that it is rare for spontaneous development to occur within a three to four month period in children with DCD. The current study took place over a three month period; it thus must have been the intervention programme that was responsible for the improvement in motor proficiency.

These results of Group A and of Group B found directly post-intervention are similar to the results of a study done in Johannesburg, South Africa by Brenner (2007) who found that the group gross motor point scores and composite scores for the children who took part in a group gross motor intervention programme once a week for eight weeks, increased post intervention. When measured on the Bruininks-Oseretsky test of Motor Proficiency, a mean group improvement in motor proficiency in comparison to their baseline scores was found (Brenner, 2007).

Peens *et al.*, (2008) who conducted a study in Potchefstroom, South Africa set out to determine if a motor-based intervention, a psychological intervention programme or an integrated psycho-motor intervention programme is the most effective intervention to treat children with DCD's motor problems and self-concept. They found evidence to support the results of Brenner (2007) in that those children who took part in the groups with the motor-based intervention which consisted of task-specific, kinaesthetic and sensory integration methods showed the most sustainable improvement and enhancement in all aspects of their motor proficiency (Peens *et al.*, 2008).

The results from Brenner (2007) and Peens *et al.*, (2008) also concur with results found by Schoemaker *et al.*, (1994) who studied the effectiveness of a physiotherapy programme based on an eclectic approach using sensori-motor training (which is comparable to perceptual motor training) and to an extent the Bobath or NDT technique as an intervention for clumsy children (i.e. children with DCD). They found that after three months of physiotherapy intervention twice a week for 45 minutes, the study group of clumsy children improved their performance on the TOMI meaning that their movement skills and motor proficiency improved (Schoemaker *et al.*, 1994).

All these studies have shown an improvement in gross motor skills after a motor-based or physiotherapy programme, which supports the results of the current study. However in all the studies above mentioned studies different frequencies and types of treatment were provided; therefore results cannot be directly compared.

Raynor (2001) noted that children with DCD have less strength and power than their typically developing peers which may be due to increased levels of muscular co-activation also known as “fixing” (Missiuna *et al.*, 2003). Increased levels of muscular co-activation may also be due to lack of movement experience or motor planning problems (Raynor, 2001). Movements appear awkward and stiff due to “fixing” of the joints and the time it takes for children with DCD to adapt to changes in their environment is increased thus causing their muscles to fatigue easily (Missiuna *et al.*, 2003).

The gross motor skills of the children with DCD in the current study may therefore have improved due to the improvement in strength and power through strengthening exercises which were part of the intervention programme received by Group A and Group B in the current study. This increase in strength and power together with ensuring opportunity to experience various movements with the use of an obstacle course, for example, in the intervention used in the current study, may have contributed to the refinement of the muscular activation of the children with DCD leading to less ‘fixation’ and greater efficiency and fluency of movement. This was noted by Kaufman & Schilling (2007) in their case study of a five year old boy who found that after a 12 week strength training

programme placing emphasis on correct form of movement, the subject showed improvements in his strength, proprioception and general function (Kaufman & Schilling, 2007).

6.6 Fine Motor Improvement

The Fine Motor Control component may have improved in Group A but not in Group B because in once a week therapy (which Group A received) there is a greater period of time in which to be able to not only work on activities that will improve gross motor function but to add desktop and fine motor activities, into the 45 minutes of therapy.

It is common knowledge that postural control of the trunk and centre of the body has an influence on fine manual dexterity skills (Shumway-Cook & Woollacott, 1995). The development of trunk stability is thought to be an important pre-requisite for upper limb and hand function. It has been hypothesised that proximal stability allows the arm and hands to be used independently for tasks involving manipulative dexterity. This assumption has lead to clinicians intervening at the level of postural control in order to enhance the performance of a child's hands (Rosenblum & Josman, 2003).

In Group A the scale scores and standard scores of the fine manual control aspect (which includes fine motor integration and fine motor precision components) of their fine motor function may have improved due to generalisation and carry over from desktop activities performed during the weekly intervention. This was noted as the tasks that were tested in the BOT-2 were not at all similar to the fine motor activities that are performed during the physiotherapy intervention. Many studies have found results supporting the notion that the improvement in fine motor function may have also been due to the improvement in trunk and shoulder strength and stability proximally (i.e. postural control) which leads to greater distal mobility and control which is usually noted in activities such as drawing, writing and cutting in fine motor function (Miyahara *et al.*, 2008; Brenner, 2007; Stevens, 2002; Johnston *et al.*, 2002).

Brenner (2007) found a statistically significant improvement in the fine motor composite standard scores post-intervention which are similar results to those found in Group A in the current study. Brenner (2007) noted that this improvement may have also been due to the gross motor intervention which included strengthening and improving the stability of the postural muscles (shoulder girdle and trunk) leading to a transfer of skills and thus the improvement of distal hand function and upper limb co-ordination (Brenner, 2007).

The results found in Group A in whom the fine motor function improved, are also similar to those found in a study by Stevens (2002) whose aim was to evaluate the effect of physiotherapy involving NDT principles and postural exercises, on the fine motor function of children with DCD, with and without the inclusion of a home exercise programme. One group acted as the control and received three months (12 sessions) of physiotherapy (once a week for 45 minutes) only whereas the experimental group received three months (12 sessions) of physiotherapy (once a week for 45 minutes) together with a home exercise programme to be done three times a week. On comparison of the fine motor ages of each group using the BOTMP, it was found that 75% of the children who received the more intensive regime with a home exercise programme reached their fine motor chronological age in comparison to only 25% of the children who received physiotherapy alone. This indicates that postural exercises to improve postural control, such as those performed in the study by Stevens (2002) may assist in impacting positively on the fine motor function of children with DCD, especially when they are provided in a more intensive regime (Stevens, 2002).

In addition a study by Smits-Engelsman *et al.*, (2001), also investigated the effectiveness of an individualised child-specific physiotherapy regimen on those children found to have poor handwriting and other fine motor deficits. Twelve children were referred for physiotherapy (eight boys and four girls with a mean age of eight years and four months). They were treated by one of two therapists 18 times over a period of three months. Results showed that at three months after their initial assessments the children who received the intervention, had higher quality handwriting and their writing speed improved. Children were also able to increase their copying speed without reducing the

quality of their handwriting. This study did not use a gross motor programme as in the current study, other activities which improved execution, grading and activation of appropriate muscles were practised. Handwriting itself was not practised and results still showed carry-over or a transfer of skills to handwriting skills.

However, this strong correlation has not consistently been found to be true which was noted in a study by Rosenblum & Josman (2003) who recommended that studies with larger samples and longitudinal designs should be conducted further to ascertain this relationship.

Pehoski's (2006) theory has also noted that the child's degree of distal dexterity may not necessarily be directly linked or determined by the degree of postural control due to their particular muscle groups being governed by different neurological pathways (Exner in Case-Smith & O'Brien, 2010).

The above theories may be one of the reasons why the correlation between postural control and fine motor function was not found to be true for the individuals in Group B of the current study; who received the intensive regime of five days of intervention together with the home exercise programme. The changes in scale and standard scores for the Fine Manual Control motor area composite were not significant at $p > 0.1$, at five days post-intervention. This may be due to the fact that desktop activities and fine motor function was not the focus of the intervention as much as the gross motor aspects of co-ordination, pelvic girdle-, shoulder girdle- and core strengthening were; therefore fine motor skills were not practiced. This is because there is so much for the therapist to achieve with the child in a limited amount of time and physiotherapists usually concentrate on improvement of gross motor skills and refer to occupational therapists for the treatment of fine motor skills.

It may also show that a five day intervention (i.e. five intervention sessions) may not be enough time to strengthen the postural and shoulder girdle musculature sufficiently for a transfer of skills to occur; whereas six sessions, as in Group A, may influence the shoulder strength enough for a transfer of skills to occur.

Stevens (2002) noted that postural exercises with a home exercise programme (a more intensive regime) was more effective in improving the fine motor function of children with DCD than physiotherapy alone was after 12 weeks (i.e. three months) of intervention. In contrast to these results, the current study found that the change in scale and standard scores in Fine Manual Control at six weeks and at 12 weeks from baseline was not significant in Group B who received the more intensive regime (i.e. five days of treatment with a home exercise programme). Carry over or generalisation and improvement of distal function due to improvement in proximal shoulder girdle strength may only be found if the home exercise programme was indeed adhered to as often as the log-books which were given to the parents report, and if the exercises were performed effectively.

Another reason for this may be because the home exercise programme included only exercises focusing on improving postural control and gross motor function and did not specifically include any activities involving fine motor function itself. It has been shown previously that the muscles of the hand and postural muscles are innervated by different neurological pathways (Pehoski, 2006) therefore improving postural control may have an effect on fine motor function but is not necessarily a precursor to it.

Six out of the thirty four subjects were receiving occupational therapy simultaneously. These six children were in Group A (the individuals receiving physiotherapy based on Neurodevelopmental therapy once weekly). There were no children in Group B who were receiving occupational therapy. To assess whether the scores were any different in those individuals receiving occupational therapy to those who were not a repeated measures analysis of variance was used. It must be noted that the fine motor skills of those children in Group A which included children receiving occupational therapy improved; whereas the fine motor skills of those children in Group B in which there were no children receiving occupational therapy, did not improve.

However results showed that in neither scale score nor composite standard score did the groups differ significantly, at $p > 0.1$, with respect to all the motor area composites (FMC, MC, BC, StrA and TMC). This indicated that the children who were receiving

both physiotherapy and occupational therapy which involved techniques of the sensory integration approach (SI) and fine motor skill building; did not show superior improvement over those children who only received physiotherapy. This may be expected as occupational therapy with an SI approach and physiotherapy with an NDT approach are two different therapies which influence different skills in children with minor motor difficulties. It was therefore not the occupational therapy which influenced the improvement in fine motor skills of the children in Group A whose fine motor skills improved in contrast to those children in Group B whose fine motor skills did not improve.

6.7 Effects of intervention on psychosocial function

Mandich *et al.*, (2003) explored the impact that DCD has on children and the importance of participation for these children from the parents' perspective, using interviews in a qualitative study. Twelve in-depth interviews were carried out with the parents of children who were receiving a cognitive-based intervention. Results revealed serious negative effects on those children who felt incompetent in everyday activities. It was noted that the intervention not only improved their performance competence but also emphasised enablement at the activity and participation level. This had a significant positive impact on the children's quality of life and boosted their self-confidence, allowing them to try new activities and leading to peer-acceptance (Mandich *et al.*, 2003).

The intervention in the current study also emphasised enablement and included activities of a playful and fun nature. The therapist used a lot of positive feedback whenever a child performed a task correctly, tried to avoid failure and made the child feel confident with their motor skills. The same statement as was made by Schoemaker *et al.*, (1994) can therefore be made with regards to the intervention programme in the current study. It may have been the intervention itself that improved the motor proficiency of the children with DCD in the current study, or it may have been the fact that their confidence had increased and therefore they were more willing to try new movements. It is not possible to know which of these possibilities it was in this study design however it is a consideration when

discussing improvement in the gross motor skills of the children who participated in this study.

6.8 Intensive versus weekly physiotherapy intervention based on the NDT approach

An objective in this study was to compare the study groups (Group A and Group B) at six and 12 weeks. Results showed that in neither scale score nor composite standard score did groups differ significantly, at $p > 0.1$, with respect to all the motor area composites (FMC, MC, BC, StrA and TMC). This indicated that it could not be proven that the five day intervention with the home programme (Group B) was superior to the weekly physiotherapy intervention group (Group A), which is the status quo of treatment used at present. This may have been because the sample size was inadequate to detect the change or because Group B was compromised due to the non-randomisation of subjects into groups.

The scale scores and composite standard scores were compared to baseline at six weeks and at 12 weeks for both groups. Results showed that at both six weeks and 12 weeks, the scale scores and standard scores for each motor area composite i.e. FMC, MC, BC and StrA as well as the Total Motor Composite were significantly higher than at baseline ($p < 0.005$), but six week and 12 week scores differed significantly for only some of the parameters.

These significant results imply that the intervention in both groups improved the fine motor control, manual dexterity, body co-ordination, strength and agility and overall motor performance of the individuals in both groups at six weeks and 12 weeks. However the times may have differed mainly as a result of Group A's (the larger group's) results. Therefore the times for Group B were explored in further detail separately.

The results from the children in Group B showed that the scale scores and standard scores for three of the four motor area composites i.e. MC, BC and StrA as well as the Total Motor Composite (TMC) were significantly different from baseline at five days (post-

intervention) at $p < 0.05$. With the exception of the Fine Manual Control scale and composite standard scores which were not significantly different from baseline ($p > 0.1$).

This indicates that a possible protocol of five days of physiotherapy intervention using an NDT approach may be useful in the treatment of children with minor motor difficulties as the individuals who participated in this programme showed an improvement in their manual dexterity, body co-ordination, strength and agility and overall motor performance after a five day intervention.

The second objective of this study was to assess whether a possible protocol of intensive therapy for five days with a home exercise programme can bring about the same changes at six weeks of treatment; that the current protocol of weekly therapy would at 12 weeks; with regards to positive outcomes achieved in the functional motor abilities of these children. Results for this objective were not able to be found because of the small sample size. However the objective was changed to compare the results achieved by each group, one in which a protocol of intensive therapy for five days with a home exercise programme was used and the other in which the current protocol of weekly therapy was used, with respect to change from baseline at six weeks.

Results showed that for the scale scores and standard scores for each motor area composite i.e. FMC, MC, BC and StrA as well as the Total Motor Composite, the groups were found to be not significantly different at $p > 0.1$ at six weeks.

This implies that it is possible for a five day intervention and a home exercise programme to be used as an additional option to once a week NDT based physiotherapy under certain conditions as results for both groups were found to be not significantly different when groups were compared at six weeks. This said one must take note that there may really not have been a difference between the groups or that the sample size was too small to detect a difference. The power was calculated at 63% which is too low to make concrete recommendations.

Waternberg *et al.*, (2007) and Schreiber (2004) found similar results to those of Group B in the current study in support of the use of a brief course of intensive physical therapy. Waternberg *et al.*, (2007) found that a four week course of physical therapy for one hour per session twice a week together with a home exercise programme was found to be effective in improving the motor performance of children with DCD and ADHD. Schreiber (2004), found that changing the child's therapy programme from one hour of therapy once every two weeks to four times a week for one hour for a full month, followed by the resumption of the normal protocol of therapy (i.e.: in this case once a week every two weeks) may lead to a more cost-effective and valuable implementation of physiotherapy for children with movement difficulties (Schreiber, 2004). Although this report provides support for using an intensive programme of physiotherapy, as this was a case report these results can not be generalised to the population.

Waternberg *et al.*, (2007) noted that the fact that a shorter course of physical therapy is efficacious in children with DCD and ADHD may have important financial implications for the families of these children. The findings in the current study may support this notion, however one must have in mind that the sample size was small and the shorter intensity intervention should not be recommended for every child as was noted by Schreiber (2004).

The results found by Stevens (2002) support the results found in the current study for the use of a more intensive physiotherapy regime as an alternative to the current protocol of practice of weekly intervention. However the results found by Stevens (2002) indicated that a more intensive physiotherapy treatment with the inclusion of a home programme carried out over three months, such as that received by Group B in the current study, would be more beneficial for improving fine motor skills of children with minor motor difficulties. The results in the current study opposed these results as the fine motor function of the children who received the intensive five day treatment with a home programme did not improve but the gross motor function did improve.

In the current study it was noted that although the children's scores on the Bruininks-Oseretsky Test improved, their movement quality and efficiency was not yet sufficient to support discharge from therapy. Thus it was found that the children in the group who received weekly therapy continued with their sessions after cessation of the study. Most of the children in the group who received the intensive intervention and the home programme opted to continue with once a week therapy as the parents saw the benefits, improvements and changes in their children after this short intervention and they wanted their motor skills to improve further but found it difficult to commit to continue to comply with the home exercise programme. This finding was similar to the suggestion made by Schreiber (2004) that an increased intensity of physiotherapy based on the child and family factors, followed by the resumption of the normal protocol of therapy may lead to a more cost-effective and valuable implementation of physiotherapy for children with movement difficulties (Schreiber, 2004).

6.9 The use of a home exercise programme

The sample size in Group B was small because it was difficult for the parents to bring their children for an intensive block of therapy or even commit to having time to do the home exercise programme. This may be due to the fact that they have other children, they were employed or they were busy with other activities. Law *et al.*, (1991) also found this from looking at their pattern of attendances for the group of children in their intensive therapy.

Although Schreiber *et al.*, (1995) recommended that physiotherapists should offer all parents of school-aged children the opportunity to take part in a home exercise programme, it must be noted that compliance with a home exercise programme is difficult for many parents and caregivers because of the demands that may exist in their lives already (Rone-Adams *et al.*, 2004). This said, the participation of parents is an integral part of NDT (Law *et al.*, 1991) and Law *et al.*, (1991) found that those parents who felt comfortable with the home exercise programme and with whom compliance was high made more gains in hand function in their children. Therefore parents were

instrumental in the endorsement of their children's development and function. However parent compliance was an important predictor of change in function (Law *et al.*, 1991).

In Group B in the current study the scale scores and standard scores for three of the four motor area composites i.e. MC, BC and StrA as well as the Total Motor Composite (TMC) were significantly different from baseline at the six week and 12 week assessments at $p < 0.05$. With the exception of the Fine Manual Control Composite scale and standard scores which were not significant ($p > 0.1$). It was noted that at six weeks and 12 weeks of the intervention (following use of the home exercise programme) the change from baseline in the scale scores and composite standard scores was smaller than the change observed at five days, for certain parameters i.e. FMC, MC, BC and TMC and larger in others i.e. StrA. The change in the Strength and Agility parameter from baseline may have been from natural development of strength over time or due to the fact that the home exercise programme contains more activities which work on the child's strength than any of the other motor components.

The scores were still significantly ($p < 0.003$) greater than the baseline scores at six weeks and 12 weeks; and the improvements gained in their manual dexterity, body co-ordination, strength and agility and overall motor performance after an intensive block of five days of physiotherapy intervention with an NDT trained physiotherapist, were maintained with assistance of the home exercise programme. However these positive changes in gross motor function were not as easily improved on, with a home exercise programme alone for the subsequent 12 weeks, after the intensive physiotherapy had ceased.

Even though the changes from baseline at six weeks and at 12 weeks (during performance of the home exercise programme) were not as large as the changes noted after the one-on-one five day intervention with the therapist; the individuals who participated in Group B with the use of the home exercise programme were still able to maintain their scores above their baseline scores in the parameters of manual dexterity, body co-ordination, strength and agility and overall motor performance.

The fact that the parents were able to at least maintain the gross motor function of their children at the level of function post the intensive intervention indicates that some level of compliance was maintained.

It also indicates that the home exercise programme designed may be effective for use by parents or primary caregivers (at termination of physiotherapy or after an intervention) if compliance is high enough, in order to maintain motor function but not necessarily to improve on it, in the treatment of children with minor motor difficulties.

The HEP uses real life diagrams, is well structured, easy to follow and easy to administer. It includes key points to watch for to avoid compensation and each exercise includes ideas for progression to increase difficulty. There are easier exercises and difficult exercises giving the parent a variety of exercises to choose from to cater to all children at any ability level. It is generic rather than individualised but therapists are able to choose which exercises the child should do in order to individualise the home programme to each child's needs. The exercises are fun and playful for the children and are not time-consuming enhancing adherence to the programme.

The HEP contains jargon which may not be understood by the parents and some of the explanations do not correlate exactly to the pictures. However when the parents were taught the programme they were given time to add in any additional notes they found helpful. It consists of 25 exercises where the literature recommends a maximum of 3 or 4 as it may not be the only home exercise the child may have. This said, the parent is able to choose as many exercises as they would like and do them at any time depending on the amount of time they have in their schedule so that they can be included easily into the family's daily routine. The exercises can be done at a time convenient to the parent when the child is the least resistant to intervention in order to prevent conflict between the parent and child. This also enhances adherence to the programme.

Every effort was made to enhance compliance with the home programme by ensuring that the parents were capable of performing the home programme with the child first as

advised by Schreiber *et al.*, (1995). This said; if the parents' compliance with the home exercise programme was higher, a larger improvement or change in score may have occurred in the subsequent weeks.

Compliance was established through parents noting the date and which exercises were done on that day. Exercises were designed to be used in combination with one another and worked on specific areas of the body. Therefore the specific exercises done were not of concern, but the frequency was. The dates that the parents noted in the logbook cover this.

There was no great difference between adherences to the home programme by different parents. Most parents complied with the home programme doing it for at least 45 min per week, therefore there was no need to analyse this separately, as it would not have affected the results.

Most children took place in physical education, regular school sporting activities and swimming once a week. Therefore there was no need to analyse this separately, as it would not affect the results.

Law & King (1993) advocate that therapists should ask parents to report on their compliance and they should listen to what parents say about their adherence to the home exercise programme. The advice of Law & King (1993) was followed as the parents who took part in Group B of the current study were asked to record their progress with the home programme in a log-book provided to them by the investigator. Law & King (1993) noted however that one disadvantage of using log-books is that they are difficult to retrieve from the parents; this was noted in the current study as two out of seven parents misplaced their log-books and therefore did not return them which also may be indicative of evidence of non-compliance. Schreiber *et al.*, (1995), also noted that the possibility that parents may over-report their compliance which cannot be discarded in the current study either.

Schreiber *et al.*, (1995) found that six weeks was an appropriate amount of time to maintain compliance with their home exercise programme. This may be inferred from the results of this study as the scores did not drop below the baseline or five day scores. It is also interesting to note that in the current study the change between six weeks of assessment and 12 weeks of assessment was not significant for some parameters but significant in others. This implies that the changes in score made between baseline and six weeks were consistently more significant than the changes in score made between six weeks and 12 weeks indicating that the greatest change in score takes place in all parameters in the first six weeks of the intervention, although there is still a change between six weeks and 12 weeks.

6.10 Implications of the study

All the results of the current study have clearly shown that those children with minor motor difficulties who received one-on-one physiotherapy using an NDT approach (Group A) improved significantly in their fine and gross motor function after 12 weeks of intervention.

In addition the results clearly showed that those children with minor motor difficulties who received one-on-one physiotherapy using an NDT approach for five days (Group B) improved significantly in their gross motor function after five days of intervention. When the groups were compared with respect to change from baseline at six weeks, the groups were found to be not significantly different at six weeks. This implies that more intensive physiotherapy i.e. the five day intervention and a home exercise programme may have the potential to be used as an additional option to once a week NDT based physiotherapy for parents who are experiencing financial strain and cannot afford to pay for therapy but are able to commit to doing a home programme with their children (keeping in mind the small sample size and the 63% power).

Results showed that the greatest changes in score took place within the first six weeks of intervention. Even though the changes between six weeks and 12 weeks were smaller

than the changes between baseline and six weeks, the changes from baseline in overall motor function were still present.

The home exercise programme used in this study was shown to be effective in maintaining the results gained from the five day intervention indicating that it may be useful as a tool used by parents or primary caregivers in order to maintain motor function but not necessarily to improve it.

6.11 Limitations of the study

A limitation of this study is the fact that there was no period of time or assessment before the intervention was given, in order to determine spontaneous rate of motor development without treatment. There was also no follow up assessment which should have been done after a period of no intervention, after the intervention, in order to determine the maintenance or the long-term effects of the treatment.

It was not possible to have a control group due to the fact that it is unethical to withhold treatment when children are referred for our services. Therefore in order to measure spontaneous development this study should have included a pre-test assessment which was done six weeks before the intervention began, this was unfortunately not possible.

Another limitation of the study is that although the changes in score of individuals in Group B reached significance, comparison with the individuals in the weekly therapy sample could not be made as it lacked adequate power to compare the two groups due to a small sample size in Group B who received the five day intervention.

6.12 Recommendations for future research

Further studies on the effectiveness of an intensive block of physiotherapy on the fine and gross motor skills of children with DCD should include a period of time before the start of treatment to determine spontaneous rate of motor development without treatment. It should also include a period of time with no intervention, after the intervention, in order to determine the maintenance or long-term effects of the treatment.

Instead of having a long period of doing a home exercise programme which only maintains results but doesn't necessarily improve them, future research should involve block treatment. Further studies should try assessing whether increasing the intensity of treatment by increasing the frequency of treatment sessions to twice a week for four weeks then having two weeks off therapy with the use of a home programme followed by another four weeks of therapy twice a week, then another two weeks off with the use of a home programme; might be as effective as once a week therapy which is the current protocol of practice.

The Bruininks-Oseretsky test of motor proficiency *second edition* was an adequate tool to use to detect changes in motor function over a period of time; however it is recommended further studies use the Movement Assessment Battery for Children (MABC) as a standardised tool as it may be able to facilitate the detection of changes in the quality of movement.

CHAPTER 7

CONCLUSION

The Bobath technique or Neurodevelopmental therapy approach was used in the physiotherapy intervention to treat children with minor motor difficulties / 'low muscle tone' / DCD in both groups in the current study. Those children who received weekly physiotherapy improved in both fine and gross motor function. However those children, who received five days of physiotherapy intervention with a home exercise programme, improved their gross motor function but not their fine motor function.

Parents were able to maintain the gross motor function of their children at the level of function post the intensive intervention. This indicates that if a high enough level of compliance is maintained, the home exercise programme designed may be effective for use by parents or primary caregivers (at termination of physiotherapy or after an intervention), in the treatment of children with minor motor difficulties.

It could not be proven that the five day intervention with the home programme was superior to the weekly physiotherapy intervention group, which is the status quo of treatment used at present. However it was found that a possible protocol of five days of physiotherapy intervention using an NDT approach may be useful in the treatment of children with minor motor difficulties as the individuals who participated in this programme showed an improvement in overall motor performance after a five day intervention.

Therefore 45 minutes of physiotherapy once a week, which is currently being used is effective in improving the fine and gross motor skills of children with minor motor difficulties. However if parents are unable to afford weekly intervention but are willing to comply regularly to a prescribed, individualised home exercise programme, a possible protocol of an intensive block of therapy with a home programme may be advised. This

protocol however cannot be advised for use with all children with minor motor difficulties and the therapists' clinical judgment is imperative in this regard.

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APPENDIX 1

Outline of Procedure

	Group A	Group B
Baseline	Ax (Assessment)	Ax
Week 1	Intensive week	Therapy
Week 2	Ax	Therapy
Week 3	Home ex's	Therapy
Week 4	Home ex's	Therapy
Week 5	Home ex's	Therapy
Week 6	Ax	Ax and Therapy
Week 7	If score has not dropped, cont. with home ex's. If has dropped, intensive week Home ex's/intensive week	Therapy
Week 8	Home ex's	Therapy
Week 9	Home ex's	Therapy
Week 10	Home ex's	Therapy
Week 11	Home ex's	Therapy
Week 12	Ax	Ax

APPENDIX 2

Parent Information letter

My name is Stacey Lisa Edelman. I am currently completing my Masters of Science degree in Physiotherapy at the University of the Witwatersrand.

Physiotherapy has been found to have positive effects in treatment children with motor difficulties. In particular, a period of intensive therapy has been found to be more effective than weekly therapy over a longer period of time. I am therefore studying the effectiveness of two different treatment protocols which may enhance the effectiveness of therapy: An intense intervention (one hour a day for 5 consecutive days) together with a home exercise programme, as compared to weekly 45 minute physiotherapy sessions.

Your child will be assigned to one of the following groups:

Group A: Children will be assessed to obtain baseline scores. They will then receive physiotherapy for a full 5 day week, for one hour per day. During this time either you or a caregiver that is with your child during the day will need to be present. This is in order to be given an exercise programme to be done at home during the period in which no physiotherapy treatment will be given. Your child will then be assessed after their week of therapy, after which you will be responsible for doing the home exercise programme for the subsequent 5 weeks. Your child will then need to be re-assessed again. If at this time their scores have fallen below their original scores, they will be given an additional 5 day week of therapy for one hour per day. Following this, another 5 week break will commence, with the home programme being followed, and an assessment will be done 5 weeks later. You are asked to keep a diary which will document the home programme progress.

Group B: Children will be assessed using the standardized measurement tool in order to obtain baseline scores. They will then receive physiotherapy for 45 minutes once a week for 12 weeks. They will be re-assessed 6 weeks into the treatment period, and at 12 weeks to establish the effectiveness of these treatment sessions.

All children, no matter in which group they are placed will participate in the study for a total of 12 weeks

It is important to note that your child will need to attend all the therapy sessions for the duration of the treatment. If your child was sick every effort will be made to catch up his/her treatment session within that week. Should you know that you are going away for an extended period of time during the duration of the study, please be so kind as to inform me as if this is too long a period that could affect the results of the study, and your child will not be able to be included in the study. You and your child will not be prejudiced in any way should you wish not to participate in the study. You and your child may also withdraw from the study at any time should you wish to do so.

Your child's identity will also be kept confidential and only I, 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 Stacey Lisa Edelman at 072-225-1655.

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

You are welcome to contact me at the end of the year if you are interested in the results of the study.

Thanking you in advance for your time and co-operation,

Stacey Lisa Edelman
BSc Physiotherapy (WITS)

APPENDIX 3

Informed consent and assent form

If you agree to your child participating in this study, please sign the following letter of consent.

I, _____, hereby give my permission for my
child, _____, to participate in the proposed
study by Stacey Lisa Edelman, for the purpose of her research report.

To my knowledge, I am able / unable to meet the requirements stipulated in her study.

I have also explained the proceedings to my child whose permission I have also received.
I understand that I may withdraw from the study at any point without it affecting the
treatment of my child in any way.

Signed: _____

Date: _____

Time: _____

Place: _____

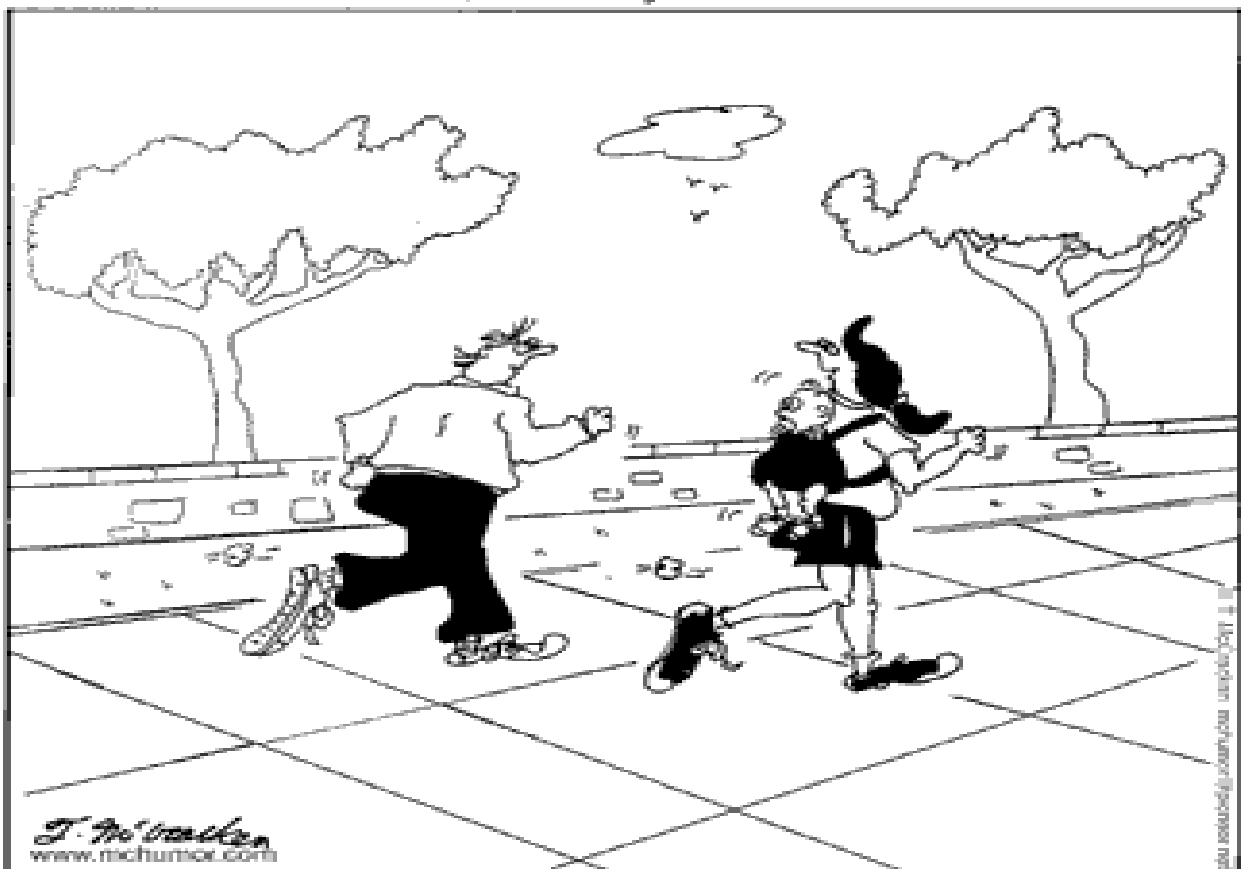
APPENDIX 4

Home Exercise Programme

HOME EXERCISE PROGRAMME

Stacey Lisa Edelman
BSc Physiotherapy WITS

MCHUMOR.COM by T. McCracken



"You can't start them exercising too early."

Index:

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Exercise 1: "Bash and Clap"

Starting Position:

Lying on the floor with one pillow under chest and one pillow below shins.

Tuck head in so that forehead is resting on the floor.

Arms above head, elbows straight.



Bash hands to the floor 10 times.

Then bash hands to the floor above head and clap them together above head alternately.



Bash hands out to the side

Then clap them together above head. Alternate, Repeat 10 times.



Key points:

- Ensure that shoulder blades remain flat alongside spine (Do not lift or hunch shoulders).
- Ensure that eyes remain looking at the floor i.e. head remains in a neutral position (Do not allow head to extend up towards ceiling)
- Ensure that legs do not elevate off the floor

Progression:

- Increase the number of repetitions performed, as this exercise gets easier

Exercise 2:

Starting Position:



Lying on the floor with one pillow under chest and one pillow below shins. Tuck head in so that forehead is resting on floor. Place arms out to the side, elbows straight. Make a fist with hands and turn thumbs up towards the ceiling.



Elevate extended arms off the floor and lower them back down without touching the floor. Keep forehead on the floor throughout the exercise. Pulse 20 times then hold for 10 seconds.

Progression:

- Increase the number of repetitions performed, as this exercise gets easier

Key Points:

- Ensure that thumbs remain pointing towards the ceiling
- Ensure that shoulders remain depressed and away from the ears

Exercise 3: "Superman arms"



Starting Position:

Lying on the floor with one pillow under chest and one pillow below shins. Tuck head in so that forehead is resting on floor. Place arms above head, elbows straight.



Elevate head and extended arms off the floor, maintain head and arms in this position (called: 'superman arms') for 10 seconds minimum but preferably 20 seconds or more.

Key points:

- Ensure that shoulder blades remain flat alongside spine (Do not lift or hunch shoulders).
- Ensure that eyes remain looking at the floor i.e. head remains in a neutral position (Do not allow head to extend up towards ceiling)
- Ensure that legs do not elevate off the floor

Progression:

- Increase the amount of time the position is held



Exercise 4:

Starting Position:

Lying on the floor with one pillow under chest and one pillow below shins.

Tuck head in so that forehead is resting on the back of hands. Arms flexed at elbows.

Elevate head and upper body off the floor with head resting on the back of hands.

Hold this position for 5 seconds.

Bring flexed arms out from under forehead and move them SLOWLY towards body, maintaining head in an elevated position.

Move hands back to their position under forehead, Hold this position for 3 seconds, relax head again down towards the floor.

Repeat process 10 times.

Key points:

- Ensure that shoulder blades remain flat alongside spine.
- Ensure that eyes remain looking at the floor i.e. head remains in a neutral position (Do not allow head to extend up towards ceiling).

Progression: Increase the number of repetitions performed, as this exercise gets easier



Exercise 5: "Arrows"

Starting Position:

Lying on the floor with one pillow under chest and one pillow below shins.

Tuck head in so that forehead is resting on the floor.

Arms by sides, elbows straight.



Elevate head and extended arms off the floor, squeezing shoulders back towards each other. Maintain head and arms in this position for 10 seconds. Then relax back down to starting position.

Repeat this exercise 10 times.

Key points:

- Ensure that shoulder blades remain flat alongside spine. (Do not lift or hunch shoulders).
- Ensure that eyes remain looking at the floor i.e. head remains in a neutral position (Do not allow head to extend up towards ceiling).

Progression: Increase the number of repetitions performed, as this exercise gets easier.

Exercise 6: "Dinosaurs"



Starting position:

Lying on the side extend bottom leg.

Flex other leg placing foot on opposite side at the level of the extended knee.

Place hands in front of body, putting equal weight through extended arms.



Elevate buttocks off floor towards ceiling, extending flexed knee, then lower SLOWLY back down to the floor, back into the starting position.



Repeat procedure on opposite side.

Repeat exercise 10 times on each side.

Key Points:

- Ensure that the foot of the flexed knee remains flat on the floor, without the heel elevating.
- Ensure that the hands remain in front of body and do not move out to the side.
- Ensure that extended knee does not flex.

Progression:

Increase the number of repetitions performed, as this exercise gets easier.



Exercise 7: "Ball Bashes"

Starting Position:

Lying on back, head on 2 pillows, knees bent and feet together.

Extend and elevate arms up above head at the level of the ears. Link fingers or place hands one on top of the other.



Caregiver to throw the ball so that he/she can bash it back.

Repeat 20 times.

Then catch the ball, without the ball touching face, tummy, or knees, lift it slightly back and throw it back. Repeat 20 times.

Key Points:

- Ensure that feet remain on the floor and knees remain upright and together.

Progression:

- Increase the number of repetitions performed, as this exercise gets easier



Exercise 8: "Ball Kicks"

Starting Position:

Lying on back on the floor, pillow under your head. Arms extended by sides and knees bent with feet on the floor.



Bend one leg up towards tummy, with foot flexed.



Kick the ball by extending leg
Alternate sides.
Repeat exercise, kicking the ball 10 times with each leg.

SIDE VIEWS

Progression:

- Kick the ball with buttocks elevated up off floor.
- Increase the number of repetitions performed, as this exercise gets easier.

Key Point:

- ensure that arms do not elevate off the floor when kicking.

Exercise 9:



Starting position:

Lying on back on the floor, pillow under head. Arms extended by sides and knees bent with feet on the floor. Elevate buttocks off the floor. Hold this position.



While maintaining the above position elevate one leg off the floor and maintain this position. Alternate Legs.

Maintain the above positions for 5 seconds each side. Repeat exercise 5 times on each side.



Key Points:

- Ensure that buttocks does not lower to the floor

Progression:

- Increase the amount of time the position is held



Exercise 10:

Starting Position:

Lie on back with the bottoms of feet on the ball, knees bent, arms extended beside thighs, shoulders down and relaxed.

Elevate pelvis (buttocks) off the floor.



Roll ball in, by using the bottoms of the feet and bending the knees towards buttocks.



Roll ball out, by using the bottoms of the feet and straightening the knees away from buttocks (maintaining pelvis in an elevated position).



Roll the ball in and out 10 times.

Progression:

- Increase the number of repetitions performed, as this exercise gets easier.



Exercise 11:

Starting Position:

Lying on back on the floor, pillow under head. Arms extended by sides and knees bent with feet on the floor.

Elevate head off the floor, bringing chin to chest. Elevate shoulders off the floor. Catch the ball which is thrown by a caregiver to one side of body.



Relax head back down resting it on the pillow. Lift the ball slightly back behind head and throw it back to the caregiver.

Repeat the above process again towards the opposite side.

Repeat exercise 5 times on each side.



SIDE VIEW

Key Points:

- Ensure that head, shoulders and arms elevate off the floor adequately.
- Ensure that head is held perpendicular to the floor
- Ensure that feet remain on the floor and knees remain upright and glued together.

Progression: Increase the number of repetitions performed, as this exercise gets easier



Exercise 12: "Motorbikes"

Starting position:

Stand behind the ball, feet flat on the floor, knees bent, and hands resting on the ball.



Slowly go over the ball, land on strong, straight arms and stop. Hold for 5 seconds. Repeat 5 times.

Progression and Key points for exercises 12 and 13:

***Progression:**

- Increase the amount of time the position is held or/as well as the number of repetitions performed, as these exercises get easier
- Walk the hands one step forward and maintain the position, take another step and maintain until ball is under feet.

Key Points:

- Look down towards the ball
- Keep arms straight
- Lift the tummy up (preventing sagging at the lumbar spine)
- Maintain the ball under the knees



Exercise 13:
"Motorbikes with knees"

Starting position as for exercise 12.



Slowly go over the ball, land on strong, straight arms and stop.



Pull ball towards hands using knees.

(He/she may need assistance at his/her ankles at first, which can be removed once the exercise gets easier to perform)



Then straighten out.
Repeat 10 times, then go back to the starting position.



Exercise 14:

Starting Position:

Slowly go over the ball, land on strong, straight arms and stop. Once on the knees, pull ball towards hands.

(He/she will need assistance at his/her ankles at first, which can be removed once the exercise gets easier to perform)



Slowly drop the hips down to the side and back up again.



Repeat to the other side,

Repeat exercise 5 times to each side.



Straighten out and return to starting position

Key Points:

- Look down towards the ball
- Keep arms straight
- Lift the tummy up
- Maintain the ball under the knees



Exercise 15 : "Push Ups"

Starting position:

Stand behind the ball, feet flat on the floor, knees bent, and hands resting on the ball.



Walk hands out, keeping hands just wider than the shoulders and fingers parallel to body, until the ball is right in front of the knees.



Bend arms so that upper body moves towards floor doing push ups. Then straighten arms to move back up again.

Repeat the exercise 10 times.

Key points:

- Do not let your elbows jar into place when straightening the arms.
- Prevent sway back (a sagging tummy), squeeze abdominals.
- Do not let the head drop: keep it in line with the spine.

Progression:

- Increase the number of repetitions performed, as this exercise gets easier. Or move the ball under the shins or closer to the ankles.



Exercise 16: "Wheelbarrows"

Wheelbarrows around the house, up and down stairs.

Key points:

- Caregiver to hold child at the level of the knees not by the ankles
- Caregiver to bend his/her own knees in order to prevent excessive pressure on his/her back
- Ensure that the child avoids sagging his/her tummy (sway back), squeeze abdominals.
- Do not let your elbows jar into place when straightening the arms.
- Do not let the head drop: keep it in line with the spine.



Exercise 17: "Spider-bridge"

Starting position:

"spider position"

Sit on floor, elevate buttocks with tummy towards the ceiling.

Toes and fingers should be parallel to the body.

Neck should be flexed with chin on chest.

Knees should be at 90 degrees.

Body in table top position.

One can remain in this position moving sideways or forward and backward.

Or one can perform the "spider-bridge sequence" moving from the spider position into the bridge position, alternately and repetitively.

One turns over into a "bridge position" by elevating left arm over body if moving towards the right. Then moves back into the "spider position" by elevating right arm over body again moving towards the right. Keep buttocks lifted.



Exercise 18:

Sit on the centre of the ball, knees aligned with ankles, legs hip distance apart and parallel. Arms elevated away from body in order to help stabilise.

Imagine a long string going through the top of the head, down through the centre of the ears, through the centre of the spine to the buttocks.

Now think of being pulled up towards the ceiling by this string. One can also think of pulling the navel up and into the back of the spine, in order to sit straight.



Stabilise and then lift one leg slightly off the floor and hold for 5 seconds then alternate to the other side.

Repeat exercise 5 times on either side.



Exercise 19:

Starting Position:

Sitting on the ball, feet together, knees bent, arm folded across chest.



Slowly roll down, keeping neck flexed, until the ball is under upper back.



Keep knees bent and hips lifted up, Hold for 5 seconds.



Slowly roll back up, walking little steps back (reversing the process above) until in the starting position (sitting on the ball) again



Exercise 20:

Starting Position:

Sit on the centre of the ball, knees aligned with ankles, legs hip distance apart and parallel. Arms folded across chest.

*This exercise can also be done with hands behind head.



Slowly roll down, one vertebra (bone in spine) at a time, keeping neck flexed, until the ball is under the upper back.



Do small abdominal 'crunches' / 'sit ups' lifting head and shoulders up.



Then relax head and shoulders back down to rest on ball again. Repeat this exercise 10times.

Progression: Increase the number of repetitions performed, as this exercise gets easier



Exercise 21:

Starting Position

Sitting on the ball, feet together, knees bent, hands behind head.



Slowly roll down, keeping head flexed, until the ball is under back.



Do small sit ups, coming across the body, left arm to the right knee area.



Alternate sides, coming across the body, right arm to the left knee area.
Repeat 5 times to each side.

Key Point - Caregiver may have to stabilise the ball slightly, to make this exercise easier.



Exercise 22:

Starting Position:

Place the ball against the wall.
Place the ball at the small curve in the back and press your weight back into the ball.



Stand with feet parallel, hip width apart, knees aligned with feet. Slowly bend knees in order to attain a 90-90 degree angle at the hips and knees.



Maintain this position for 15 seconds before straightening knees and returning to starting position.

Key points:

- Ensure that knees do not move too far forward over feet. Hips and knees are to maintain 90 degree angles.
- Be careful that your tailbone does not wrap around the ball.

Progression:

- Increase the amount of time the position is held for maximum of 60 seconds.



Exercise 23:

Starting Position:

Lie on the floor on back with your legs extended straight along the mat and arms extended by the side.



Elevate head off the floor, bringing chin to chest. Elevate shoulders off the floor, curling forwards one vertebra at a time.



Arms remain extended forward as you elevate body from floor. As you sit up into a long sitting position, reach forwards towards toes. Slowly roll back down, reversing the process, vertebra by vertebra, until head reaches the mat. Keep arms extended and in line with eyes.

Key Points:

- Make sure the arch of the lower back is as flat against the floor as possible
- Your child may need to be given assistance at first with a pillow placed under his/her head and shoulders (even as far as his/her lumbar spine at first).

Progression:

- If a pillow was used: move it from lower back to shoulders, to removing it completely.
- Increase the number of repetitions performed, as this exercise gets easier.

Optional exercises:



Exercise 24:

Starting Position:

Lie in supine on the floor.
Caregiver sits at the level of the head.

Elevate extended legs straight up towards caregiver.

Or elevate extended legs towards the caregiver's left shoulder then lower them towards the floor keeping legs extended.

Then elevate extended legs towards right shoulder then lower them towards the floor keeping legs extended.

Caregiver may guide his/her legs towards either shoulder by placing hands at ankles or by guiding the pelvis.

Repeat exercise 10 times to either side

Key points:

- ensure that he/she does not arch the lower back when lowering legs to the floor.



Exercise 25:

Starting Position:

Lying on the ball extend arms over head so that they reach down to the floor. Extend wrists so that hands are flat on the floor, with arms held close to ears.

Flex legs at hips keeping legs straight at knees. Bring legs over head, landing on feet.

Ensure that arms remain extended throughout the exercise. So that the child brings legs over their head on 'strong arms'.

Caregiver assists child by holding ball steady so he/she feels as secure as possible.

Caregiver places hand on the child's tummy, keeping it in this position until the child's legs are on the floor.

Repeat exercise 5 times.

Key points:

- Ensure that remain extended throughout the exercise.
- Hold the ball as steady as possible so as to ensure that the child feels as safe as possible.

Progression: Increase the number of repetitions performed, as it gets easier.

APPENDIX 5

Ethical Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

R14/49 Edelman

CLEARANCE CERTIFICATE

PROTOCOL NUMBER M080950

PROJECT

Intensive versus Weekly Physiotherapy
as a Treatment of children with Minor
Motor Difficulties -A Randomised
Clinical Trial

INVESTIGATORS

Miss SL Edelman

DEPARTMENT

Physiotherapy Department

DATE CONSIDERED

08.09.26

DECISION OF THE COMMITTEE*

Approved unconditionally

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

DATE 08.11.12

CHAIRPERSON


(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : N Baillieu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 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...