AN EVALUATION OF TEACHERS' ABILITY TO IDENTIFY CHILDREN WITH MOTOR DIFFICULTIES

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ABSTRACT

Background: Children with Developmental Coordination Disorder present with motor difficulties that affect their activities of daily living, academic and social function, with both short- and long-term consequences. Referrals for therapy are often made by class teachers, which is necessary for further assessment and initiating intervention.

Objective: To evaluate whether teachers are able to identify motor difficulties among the children in their class.

Methods: Sixteen teachers at seven schools were approached. Several children were randomly chosen from each class. Once parental consent had been obtained, children were tested on the Movement Assessment Battery for Children Second Edition (MABC-2). The results were compared to a brief teacher questionnaire on each child's motor ability.

Results: Overall the teachers' sensitivity was 0.33 and specificity was 0.75, which is below the recommended level for a screening tool. Teachers had a tendency to over-score (over-estimate) a child's ability for Manual Dexterity, but under-score (under-estimate) for Aiming and Catching and Balance. No significant difference ($p<0.05$) was found relating to teacher education level, or a teacher's confidence in her ability to identify children with motor difficulties. Overall prevalence, at 20 percent, was found to be higher than the APA (2000) reported statistic of six percent. Information regarding teachers' opinions of what constituted motor difficulties was obtained, but a detailed analysis of why this was so was not in the scope of this research.

Conclusion: Teachers are not adequately able to identify children with motor difficulties from their class. They were unable to distinguish between those presenting with difficulties and those without. An alternative system to identify children with motor difficulties should be investigated.

Key words: Developmental Coordination Disorder (DCD); motor difficulties; Movement Assessment Battery for Children Second Edition (MABC-2); teachers.

DECLARATION OF ORIGINALITY

I declare that this research report is my own unaided work, except to the extent indicated in the reference citation and acknowledgements. It is being submitted in partial fulfilment of the requirements of the degree of Master of Science (Physiotherapy) at the University of the Witwatersrand. It has not been submitted before for any other degree or examination in any other University.

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LIST OF ABBREVIATIONS

DCD – Developmental Coordination Disorder

MABC – Movement Assessment Battery for Children

MABC-2 – Movement Assessment Battery for Children Second Edition

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CHAPTER 1: INTRODUCTION

1.1 Problem Statement

For most of the last century, poor motor coordination has been identified as a developmental disorder (Coleman, Piek and Livesey, 2001). Over that time it has gone by many names including "clumsy", "motorically awkward", "motor impaired", "physically awkward", "developmental apraxia", and "perceptual motor difficulties" (Barnhart et al, 2003). The most accepted name currently is that of Developmental Coordination Disorder. According to the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (2000), Developmental Coordination Disorder (DCD) is defined as: (A) significant motor impairment below the age-expected norms; (B) motor problems must result in significant impairment to activities of daily living and/or academic achievement/performance; (C) condition cannot be due to other known physical conditions (e.g., cerebral palsy, muscular dystrophy) or pervasive developmental delay; and finally (D) if mental retardation is present, motor impairments must be below the norm (age appropriate) expected for these children. According to criterion (C), DCD is essentially diagnosis by exclusion. Given the difficulties of establishing this diagnosis without a full neurological examination, for the purposes of this study this condition will be referred to as 'motor difficulties'. However, where the literature specifies DCD, it will be called such.

Literature on the incidence of DCD in South Africa is scarce. In their study of children in KwaZulu Natal, Dawson and Puckree (2006) found 25% to have what they term 'benign congenital hypotonia.' However, the study was of poor quality and firm conclusions cannot be drawn from their findings. Internationally, the accepted prevalence according to the American Psychiatric Association Diagnostic and Statistical Manual Fourth Edition (1994) is reported to be around six percent of children at the age of five to 11 years old. However, in a recent study done in the United Kingdom, Lingam and colleagues (2009) found that 18 of 1000 (1.8 %) seven year-olds have DCD according to strict DSM-IV criteria and that 49 of 1000 (4.9 %) seven year-olds have DCD or probable DCD.

Identifying children with DCD has received more attention in recent years. Crawford, Wilson and Dewey (2001) reviewed three tests of motor coordination, and concluded that there is currently no ‘gold standard’ to identify children with motor coordination difficulties, but several tests are available. The Movement Assessment Battery for Children was originally published by Henderson and Sugden in 1992. A revised version, the MABC-II was published in 2007 by Henderson, Sugden and Barnett, and it is this version that will be used in this study. Several studies have used it as the gold standard for identifying children with the movement difficulties typical of children with DCD. It has been used with increasing frequency in recent years to identify children with movement difficulties from at risk populations, including extremely low birthweight children (Burns et al, 2009), acute lymphoblastic leukemia survivors (Hartman et al, 2006), children with language impairments (Cheng et al, 2009) and children with Attention Deficit Hyperactivity Disorder (Fliers et al, 2009), among others. It has been shown to be a reliable measure for pre-school children (Van Waelvelde, Peersman et al, 2006), including those in developing nations (Chow and Henderson, 2003). The MABC was chosen over other tests as it has been shown to be more sensitive than the Bruininks-Oseretsky Test of Motor Proficiency, previously used as the standard measure for identifying children with motor impairments (Dewey and Wilson, 2001).

While the M-ABC is currently the best test we have to assess motor impairment in children, the areas it evaluates are not those that teachers usually note, and are not the common reasons for referral to physiotherapy. Piek and Barrett (2008) found that inaccurate drawing on the manual dexterity section of the M-ABC was due to postural instability. In another study on children categorised as having DCD based on the M-ABC, Johnston, Burns and Brauer (2002) found that altered postural muscle activity may contribute to poor proximal stability and poor arm movement control when aiming for specific targets.

Among paediatric physiotherapists in private practice in Johannesburg, South Africa, many referrals for children with mild motor, coordination or postural deficits, come from teachers. This study aims to assess whether Grade 0 teachers are able to identify children with motor difficulties in order that they be properly evaluated and receive treatment. The information obtained in this study may later be used to compile an education program for teachers.

1.2 Aim of the Study

To establish whether Grade 0 teachers in an area of Johannesburg, South Africa, are able to identify children with movement difficulties.

1.3 Objectives

- To establish the relationship between the number of children with motor difficulties identified by a teacher questionnaire with those identified by a validated test of motor proficiency.
- To obtain preliminary data on the prevalence of motor impairment in an area of Johannesburg, South Africa.
- To obtain information on why Grade 0 teachers are or are not able to identify children with movement difficulties.

CHAPTER 2: LITERATURE REVIEW

2.1 Background

2.1.1Definition of DCD

According to the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM IV–TR) (2000), Developmental Coordination Disorder (DCD) is defined as a marked impairment in the development of motor coordination. The diagnostic criteria are:

A. Performance in daily activities that require motor coordination is substantially below the expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g., walking, crawling, sitting), dropping things, "clumsiness," poor performance in sports, or poor handwriting.

B. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living.

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

D. If mental retardation is present, the motor difficulties are in excess of those usually associated with it.

It is to be noted that each of these four criteria is within the scope of a different health care practitioner, making a conclusive diagnosis according to these criteria somewhat difficult. As per the strict definition, the DSM IV criteria would imply a systematic procedure for diagnosing children with DCD. As a result, in research studies that investigate children with DCD one or more criteria are often applied implicitly, without being thoroughly investigated. Consequently much of the research uses the motor aspect only to establish a study population, and therefore uses the diagnosis of 'probable DCD'. Wherever the literature has used the DSM IV-TR criteria with a confirmed diagnosis of DCD it has been noted.

2.1.2 Prevalence of DCD

According to the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM IV–TR) (2000) the prevalence of DCD is around six percent of the United States population. Many authors agree with this statistic and indeed quote it, including Magalhães et al (2011); Martin et al (2010); Cairney et al (2009); Missiuna et al (2008); Spironello et al (2008); Barnhart et al (2003); and Dewey and Wilson (2001). Other authors have quoted a range of between five and fifteen percent, including Martin et al (2010); Wu et al (2010); Missiuna et al (2006); Wilson (2005); and Gwynne and Blick (2004). The discrepancy appears to be due some authors reporting a statistic of only those with DCD (that is, with motor scores at the fifth centile or below) while others also include those at risk of DCD (that is, with motor scores at the fifteenth centile or below) (Wu et al, 2009).

In the course of the Avon Longitudinal Study of Parents and Children in the United Kingdom, Lingam et al (2009) established the prevalence of severe motor coordination difficulties at 1.8% of the population at age seven to eight years. Using three subtests derived from the MABC to include Criterion A, a handwriting test or ADL questionnaire to include Criterion B, and data previously collected in the longitudinal study to exclude Criteria C and D, it was found that 123 of 6990 children met the criteria for DCD. It is noteworthy that the fifth centile was used for the MABC subtests and the 10^{th} centile for the handwriting test or ADL questionnaire as cut-off points, resulting in only those with severe motor coordination difficulties being classified as DCD. An additional 223 children scored between the fifth and 15^{th} centiles indicating 'probable DCD'. This results in a total of 346 children scoring below the 15^{th} centile and therefore being classified as 'DCD or probably DCD', a prevalence of 4.9% of the population. The strength of this data is that it was obtained from coordination tests performed on a very large cohort based on the general population, rather than on a subset that failed a screening test.

The prevalence in South Africa is unknown. In a study conducted in Kwazulu-Natal, Dawson and Puckree (2006) found the prevalence of Hypotonia, as defined by performance on the Standardised Motor Test Battery (SMTB), to be 25% in six- to seven-year olds. The range was 14% to 32% depending on the area of origin, with a higher prevalence in rural areas. The sampling from the population of KwaZulu Natal was comprehensive. However, the condition they claim to test for, Hypotonia, was poorly defined. The tool used, the SMTB, is not well known as a motor test for children. The SMTB identifies motor deficits, rather than Hypotonia. The authors cite evidence that in children with the condition Benign Congenital Hypotonia (BCH), the low tone affects gross and fine motor skills. The authors note that BCH is a condition which is not directly equated to Hypotonia, which is a symptom. Due to the confusion between the condition as defined (BCH), the motor characteristics that are being tested for by the SMTB (motor deficits), and the symptom being used as diagnostic (Hypotonia), the results cannot be considered conclusive. Another study conducted in the Western Cape investigating the effects of different interventions on children with DCD (Peens et al, 2008) did not report prevalence in their school-based population.

2.1.3 Other Definitions of Motor Dysfunction

In the past many terms have been suggested for motor dysfunction in children, including minimal cerebral palsy, minimal brain dysfunction, clumsy child syndrome, developmental dyspraxia, sensory integrative dysfunction, perceptual motor dysfunction, motor weakness, psychomotor syndrome, low tone and mild motor problems (Dewey and Wilson, 2001; Missuina et al, 2006; Barnhart et al, 2003). The terminology is generally based on the perspective of the professional describing it, commonly physiotherapists, occupational therapists, psychologists and neurologists (Missuina et al, 2006). In South Africa the term ‘low tone’ is commonly used; Dawson and Puckree (2006) investigated ‘hypotonia’ in their study based in KwaZulu Natal. At the International Consensus Conference on Children and Clumsiness in Canada in 1994 it was decided to use the term ‘Developmental Coordination Disorder (DCD)’ to describe this condition, based on the DSM IV definition (APA, 1994).

2.2 Pathology

2.2.1Subtypes of DCD

As noted above, much of the available research does not use strict DSM IV-TR criteria for inclusion, instead using 'probable DCD' based on motor performance. Visser (2003) notes that the research is unclear as to what the range of 'normal motor skills' is, and what is abnormal and therefore constitutes DCD. Vaivre-Douret et al (2011) summarises the difficulties in subtyping DCD by stating that the lack of diagnostic specificity prevents our full understanding of the mechanisms causing DCD and their resulting clinical picture.

Green et al (2008) quotes the work of several other authors when discussing subtyping. Wright and Sugden (1996), note that many children with DCD will perform at an age appropriate level on some measures, but below it on other measures. There are also a number or comorbidities associated with DCD, which are discussed separately below. Overall, there seem to be two groups of thought, namely extent of movement difficulty; and sensory or perceptual components of movement.

In a review of the research on subtypes of DCD Visser (2003) noted that researchers were beginning to use cluster analyses, and that different authors were reporting different subtypes. All authors described a subtype presenting with generalised sensori-motor deficits, with other subtypes presenting with specific deficits, such as in fine motor skills or balance. The literature reviewed below points to the same conclusion: a severe group with global impairments, with several other groups showing more specific impairments. Visser (2003) also points out that subtypes differ depending on the comorbidities (see below).

Hoare (1994) and Macnab et al (2001) have identified five patterns of perceptual-motor dysfunction among children with DCD: (1) poor dynamic balance and kinaesthetic acuity; (2) visual perceptual competencies with poor kinaesthetic acuity; (3) visual-motor deficits; (4) poor static balance and visual perceptual/visual-motor functions, and (5) poor static and dynamic balance. Others, in particular Wright and Sugden (1996) and Piek et al (2006) have suggested that there should be differentiation by ability of fine-motor, gross-motor and complex motor skills, in the context of the child's interaction with their environment.

It is unclear whether these subtypes, alone or in combination with the co-morbidities associated with DCD (see below), have an impact on the outcome of intervention. In their study, Green et al (2008) divided the subjects into those with 'pure' DCD, and those with co-morbidities that may have influenced their motor development. They further divided these groups according to their score on the MABC, namely those in the borderline category between the sixth and the 15^{th} percentile, those in the definite DCD category between the second and the fifth percentile, and those in the severe category below the second percentile. Based on a variety of motor and perceptual standardized tests, the authors ascertained that there are five clusters, specifically: 1) relative strength across perceptual and motor items (37%); 2) relative strength in perceptual and fine motor skills (14%); 3) poor static and dynamic balance (11%); 4) poor perceptual and fine motor tasks (25%); and 5) poor across all items (12%). Their finding was that the cluster groups had no impact on the effectiveness of the intervention. However, the severity of impairment did, with the children most severely affected benefiting most. The authors do note that the intervention was general, and suggest that perhaps a more specific intervention for each cluster would produce a different result.

Finally, in an excellent recent study using a multitude of investigative tools to diagnose DCD based on the DSM IV (APA, 2000) criteria, Vaivre-Douret et al (2011) identified different subtypes based on the analysis of extensive standardised evaluations. They evaluated children on a battery of neuro-psychological tests (full Weschler Intelligence Scale for Children; visual-perceptual-motor tests and visual-spatial tests; mental executive functions; a handwriting scale was used to detect dysgraphy; and a language screening battery); neuro-psychomotor tests (a French standardised functional development assessment); and a neurovisual examination (a set of electro-physiological visual tests). They also performed Magnetic Resonance Imaging studies on each participant. The authors noted that a limitation of the motor portion of their assessment is that they did not use an internationally standardised instrument, but they defend their position by citing the correlations between the test used and other tests. They identified the following subtypes, with two 'pure' forms and one mixed:

Ideomotor dyspraxia (IM). The primary difficulties in this group were with crawling, digital praxis, praxic slowness, imitation of gestures, dynamic balance (with 60% having postural control), body spatial integration, handwriting (but not dysgraphia), hypotonia

(60%), abnormalities in standing tone and homogeneous tonic laterality (60% for each), and visual pursuits (vertical 60% and horizontal 40%). No impairment in visual-perceptual-motor tasks was found.

Visual spatial and visual constructional dyspraxia (VSC). The primary difficulties in this group were with puzzles, visual motor integration and visual spatial structuring, arithmetic (89%), visual spatial constructional tasks (84%), handwriting, vertical pursuit (68%), and anomalies in visual refraction (53%).

Mixed dyspraxia (MD). (including ideomotor and visual spatial and/or visual constructional with motor coordination and neuropsychological co-morbidities). This group had difficulty with all tasks, with the most significant impairments being coordination between upper and lower limbs (84%), bimanual dexterity (84%), synkinesis (89%), manual dexterity (79%), dysdiadochokinesis (74%), oro-facial praxia (58%), and executive function (37%). This group is represented in the majority of research on DCD.

Contrary to some of the theories regarding DCD, they suggest that there is a confusion between visual-motor and visual-perceptual skills. The primary impairments are visual-spatial-motor and eye pursuit disorders, as few perceptual deficits are found. The authors cite other examples in the literature to substantiate this view. The great strength of this study is the variety of different measuring instruments used, and the grouping of the results into functionally useful clusters for subtyping DCD.

2.2.2Theories on Underlying Pathology

Recent advances in imaging technologies have allowed more detailed analysis of neurological structures in children with DCD, with functional MRI studies shedding further light on brain activation during function.

Zwicker et al (2010) examined the patterns of brain activity in children with and without DCD during a motor task. The task used was a drawing trail from the MABC. Interestingly, performance between the two groups on the task was similar. However, patterns of brain activation were different. They found that the following areas were significantly more active in children with DCD than the controls: left inferior parietal lobule, right middle frontal gyrus, right supramarginal gyrus, right lingual gyrus, right parahippocampal gyrus, right posterior cingulate gyrus, right precentral gyrus, right superior temporal gyrus, and right cerebellar lobule VI. These areas are involved in visuospatial processing, indicating that this was the strategy that children with DCD used to complete the task. The control group demonstrated significantly more activation in the following areas: left precuneus, left superior frontal gyrus, right superior temporal gyrus/insula, left inferior frontal gyrus, and left postcentral gyrus. These areas have been associated with spatial processing, motor control and learning, and error processing, indicating that these are the strategies used by typically developing children to complete the task.

Kashiwagi et al (2009) also investigated the differences between children with DCD and typically developing controls using a functional MRI. They used a visuomotor task, tracking a horizontally moving target by manipulating a joystick. They found that, compared to the controls, children with DCD showed lower brain activity in the left posterior parietal cortex and left postcentral gyrus. The posterior parietal cortex is an association cortex, which integrates multimodal information relevant to motor control. The left postcentral gyrus is associated with proprioceptive control of movement. Querne et al (2008) found that, in a fMRI study on children with DCD with attentional and executive functional difficulties, there was abnormal brain hemispheric specialization during development.

In a review of the literature concerning cerebellar involvement clumsiness and other developmental disorders, Ivry (2003) comments that problems with motor coordination are a common feature of adult neurological disorders. The same standards cannot be applied to children due to immaturity and subsequent maturation of the system, and possible delays in this process (Ivry, 2003). The cerebellum is a significant structure to be considered when discussing coordination. The cerebellum is an interval timing system, with involvement in functions such as coordination between different muscle groups, motor and perceptual timing, and coordination of rapid shifts of attention. A number of developmental disorders have been shown to have cerebellar pathology, including autism, ADHD, developmental dyslexia and schizophrenia (Ivry, 2003). Given the perceptual components of DCD described above under the discussion of subtypes, the link between delayed cerebellar maturity or cerebellar dysfunction can be inferred. Two studies, unfortunately both old (Lundy-Ekman et al (1991) and Williams et al (1992), both in Ivry (2003)), discussed how children classified as 'clumsy' on commonly used clinical instruments displayed impairment on tasks that required precise timing, indicating cerebellar involvement.

In a discussion on whether clumsy motor behaviour is caused by a lesion of the brain, Hadders-Algra (2003) defines minor neurological dysfunction as signs that can be detected during a standardised and age-specific neurological examination. Minor Neurological Dysfunction (MND) is classified into simple and complex. The two types are described as follows: At school age children with simple MND present with two or less dysfunctional clusters of MND, while complex MND present with three or more. Clusters include dysfunctional muscle tone regulation, reflex abnormalities, gross motor difficulties, fine motor difficulties and miscellaneous disorders. Prevalence is age specific, being low in the preschool years, peaking at puberty, and then declining into adolescence. Hadders-Algra noted that the incidence of MND declines at puberty, possibly attributable to the increase in hormones, specifically thyroxine and oestrogens. The author cites previous research by authors including Garcia-Segura et al (2001), Hampson (2000) and Timiras (1972 in Hadders-Algra, 2003) to support the belief that pubertal hormones promote neurological development. In discussing DCD, Hadders-Algra (2003) notes the dearth of data investigating the relationship between MND and DCD, and found evidence to support the fact that the neurological dysfunction described as MND relate to the functional difficulties described as DCD (Jongmans et al, 1997; Hadders-Algra et al, 1988). Simple MND was found to have minimal clinical significance as compared with the definite clinical significance of complex MND, which is equated to DCD by Hadders-Algra et al (1988a).

In their discussion on the subtypes of DCD, Vaivre-Douret et al (2011) summarise the currently suggested and identified areas of the brain associated with the dysfunction seen in DCD. Specifically, the factors suggested to be involved are: prematurity; impairment of dominant cerebral hemisphere; sensory integration disorder; perinatal factors consecutive to anoxia or to hypoxia. Other proposed causes include: inter or intra hemispheric connection disorders; cortex, cerebellar or basal ganglia dysfunction; parietal dysfunction. Other non-specific cerebral abnormalities have been seen in positron emission tomography (PET) or in magnetic resonance imagery (MRI): cortical atrophy or demyelinization; thinning of the corpus callosum; moderate ventricular dilatation. Finally, the visual system has been shown to be involved: oculo-motor or gaze disorders; neuro-visual abnormalities. The visual system links with the deficits in activity noted in the parietal lobe, as the posterior parietal and superior temporal lobe regions are involved in smooth pursuit movement and have different maturational ages. Their analysis points to soft signs linked to cerebellar control (synkinesis, abnormalities in muscle tone), or basal ganglia and cerebellum (motor disorders involving impairment of planning and programming of movement). Axial hypotonia with resulting postural control problems appears to compromise dynamic balance in ideomotor dyspraxia. They also propose that the thalamus, as the relay for all sensory pathways and an integrator of motor function in the two main loops of extra-pyramidal control, might be involved. Their findings on MRI pointed to abnormalities being more due to co-morbid learning disabilities than dyspraxia. The lengthy discussion of their findings and the literature could be summarised into the following diagram (Vaivre-Douret et al, 2011, *Developmental Neuropsychology* 36 (5): 637):

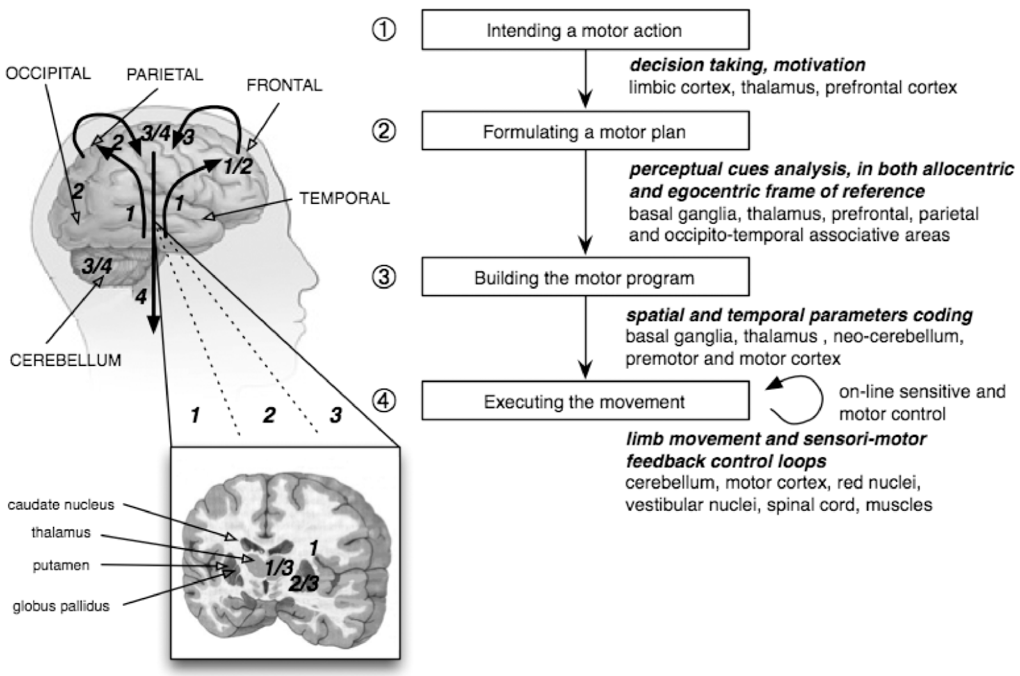

Figure 1: Anatomo-functional model. (Vaivre-Douret et al, 2011)

In a very interesting discussion on the subject Pearsall-Jones et al (2010) suggest that DCD and cerebral palsy are in fact two ends of a continuum rather than discrete disorders. The authors note that both are associated with neurological impairment, and that a number of predisposing factors are associated with both DCD and cerebral palsy primarily relating to premature birth. These factors are discussed below.

2.2.3 Factors predisposing to DCD

In her discussion of simple MND, Hadders-Algra (2003) cites two major causes: a genetic predisposition, or stress early in life, including preterm birth, severe intrauterine growth retardation, and mild to moderate degrees of perinatal asphyxia. A link has been established between DCD and premature birth and/or low birth weight (Lingam et al, 2009). Hadders-Algra also notes that simple MND could be considered to be the lower end of non-pathological brain function. Her conclusion regarding complex MND is that it is as a result of an early neurological lesion. This conclusion is drawn from the work of several authors including Ley et al (1996 in Hadders Algra, 2003), Soorani-Lunsing et al (1993 in Hadders Algra, 2003), and Hadders-Algra et al (1988). The author notes the similarities in the causal pathways between complex MND and cerebral palsy as discussed by Stanley et al. (2000 in Hadders-Algra, 2003), which suggests that complex MND may in fact be a mild form of cerebral palsy. This view is substantiated in a review by Pearsall-Jones et al (2010). Hadders-Algra (2003), summarising the work of several authors, noted that there is an increased rate of development of the cerebellum, corpus colossum, and peri-ventricular regions including central white matter and internal capsule during the last trimester of pregnancy, leading to increased vulnerability of these structures at that time. The dysfunctions in fine manipulation and coordination that are typical of MND suggest a dysfunction of the cortico-striato-thalamo-cortical and cerebello-thalamo-cortical pathways. It is noteworthy that these pathways play a role in several sensori-motor aspects of motor programming, including movement planning, program selection, and motor memory; as well as in cognitive tasks involved in learning and in regulating attention.

While the terminology is not commonly used in the general literature regarding motor coordination deficits, the pathological and anatomical basis of Hadders-Algra's (2003) discussion of MND is certainly relevant to our understanding of the pathological basis of motor dysfunction. Further studies are required to establish whether the neurological signs she discusses as being diagnostic of complex MND have a relationship to DCD. However, it should not be forgotten that DCD is a classification based on functional difficulties; more studies are needed to define the relationship between these two terms and to describe any clinically useful correlations.

Pearsall-Jones et al (2010) discuss how the same environmental factors are associated with DCD as with cerebral palsy (CP), leading to their position that these disorders both fall on either the continuum of neurological deficits in childhood. Multiple births, premature birth, and low birth weight have all been associated with both CP and DCD. Cytokine release from perinatal infection or inflammation, perinatal hypoxic episodes and perinatal haemodynamic instability have all been implicated in the mild or severe neurological damage associated with premature birth. The immaturity and vulnerability of the premature brain has been linked to both disorders. Maternal pre-eclampsia, with or without premature birth, has also been associated with DCD and CP. These authors imply that there is neurological damage causing sensory and motor deficits, which results in a limitation in activity and function in both DCD and CP. The difference is in the degree and extent of the damage and functional limitations.

2.2.4 Co-morbidities

In the literature the comorbidities of DCD are well established. In a review of the comorbidities associated with DCD, Visser (2003) cites a substantial body of literature associating DCD with Attention Deficit Disorder (ADD), Attention Deficit Hyperactivity Disorder (ADHD), Reading Disability (RD) and Specific Language Impairment (SLI). The author discusses three theories linking these comorbidities to DCD:

1. The *Atypical Brain Development (ABD) Hypothesis*, which suggests that where DCD is present with it's comorbidities, it is the result of a diffuse abnormality in brain development;

2. The *Deficits in Attention, Motor Control and Perception (DAMP) Hypothesis*, which suggests that these deficits are linked but remains unclear on what this generalised disorder is; and

3. The *Automatization Deficit Hypothesis*, which states that when dual-task performance is required, performance of the primary task deteriorates with the addition of a secondary task as the first task had not yet been automatised.

In an overview of DCD Polatajko and Cantin (2005) discuss the association between DCD and ADHD, learning disabilities and communication disorders. They also note that while a motor deficit component is noted in many conditions such as mental retardation, autism, acquired brain injury, mild cerebral palsy, Tourette syndrome, muscular dystrophies, and seizure disorders, DCD cannot be considered as comorbid as such a diagnosis is by definition one of the exclusion criteria for DCD.

In their very detailed study identifying subtypes within a population of children with DCD as diagnosed by strict DSM-IV criteria, (Vaivre-Douret L, 2011) found co-morbid impairments to be most common with the 'mixed' ideomotor and visual spatial and/or visual constructional deficits. These included learning difficulties in areas such as language, writing, executive function, cognitive-auditory memory, kinaesthetic memory, and auditory attention.

In a population-based study conducted as part of the Avon Longitudinal Study of Parents and Children (ALSPC) conducted in the United Kingdom, Lingam et al (2010) investigated the association between DCD and other developmental traits. The analysis for this study was conducted when the children were aged seven to eight. Children were classified as 'probably DCD' if they met all four criteria outlined in the DSM-IV. Motor testing was done using subtests derived from the MABC (Henderson and Sugden, 1992). In addition, children were assessed based on four major areas of development: 1) attention and hyperactivity; 2) language skills and short-term memory; 3) social skills; and 4) academic ability. Children performing in the bottom five percent on each test were considered to be impaired. They found that probable DCD was associated with difficulties in attention, non-word repetition, social communication, reading and spelling. The strength of this study is that it was population based, with an initial sample of 6902 children of whom 346 children met the criteria for DCD.

A study undertaken in Australia aimed to explore the links between Developmental Coordination Disorder (DCD), Attention-Deficit/Hyperactivity Disorder (ADHD), Reading

Disorder (RD), Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD) from a genetic basis. Martin et al (2010) used the population of the Australian Twin ADHD Project consisting of 1304 families, of whom they obtained a final sample of 3148 individuals. They developed a questionnaire to establish the presence of each of the ADHD, ODD and CD based on the DSM-IV diagnostic criteria. They also used the Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson et al, 2000) to establish the presence of DCD, and the Reading Disability Questionnaire (RDQ) (Willcutt et al., 2011) to establish the presence of DCD and RD. They found an association between all of the above-mentioned disorders, with the exception of CD. They identified seven latent classes, ranging from 'unaffected' to 'severely affected': 1) unaffected; 2) inattentive, impulsive, and oppositional defiant symptomatology (ADHD and ODD); 3) severe symptoms of reading disorder, and moderate fine motor ability (RD and fine motor of DCD); 4) motor deficits ('pure' DCD); 5) multiple comorbidites (symptoms of ADHD, ODD, RD, and DCD); 6) ADHD and ODD as in class two but with more severe symptoms; and 7) ADHD, ODD, RD and DCD as in class five but with more severe symptoms. This study adds to the understanding of the comorbidities of DCD by not only linking these disorders but by identifying classes by which they might be associated.

Finally, physical activity and fitness have been found to be decreased in children with DCD (Hay et al, 2004; Wu et al, 2010; Cantell et al, 2008; Schott et al, 2007). In a recent systematic review on the subject, Rivilis et al (2011) found a significant body of literature on the subject. Children with DCD, when compared with their peers, have sub-optimal body composition; cardio-respiratory fitness; muscle strength, endurance and flexibility; anaerobic capacity; and physical activity. This is significant because these factors raise the risk for cardiovascular disease, due to higher percentage of body fat, decreased aerobic capacity, and generally decreased participation in physical activity. In general physical activity minimises the risk of chronic disease and maximises wellbeing (Rivilis et al, 2011).

2.3 Impairments

At the 'Body Structure and Function' level of the International Classification of Function, Disability and Health (ICF: WHO, 2001), there are many proposed mechanisms for the impaired function seen in children with DCD. As the concept of 'motor coordination' is complex, so are the mechanisms needed to achieve it.

Geuze (2005) discusses the deficits in postural control, and balance, experienced by children with DCD. The author notes that for infants to develop an upright posture they need: 1) the strength to do so; and 2) the sensory experience of vision and being up against gravity. He lists the visual, kinaesthetic, and vestibular systems, and pressure receptors of the somatosensory system as the sensory systems involved in balance. The author summarises the impairments in children with DCD as follows: 1) poor postural control (moderate hypotonia or hypertonia, poor distal control, static and dynamic balance); 2) difficulty in motor learning (learning new skills, planning of movement, adaptation to change, automatization); and 3) poor sensorimotor coordination (coordination within/ between limbs, sequencing of movement, use of feedback, timing, anticipation, and strategic planning).

Barnhart et al (2003) wrote a review on the subject for the general physiotherapist population. They suggest that the primary movement impairments of these children are: slowness of both reaction time and movement time; reliance on vision more heavily than other senses to control movement; difficulty selecting the best motor response for a task; repeating motor tasks in the same way regardless of their success with that task; and decreased strength and power.

The recent discussion on the subtyping of DCD brings to the fore all the impairments recognised in children with DCD in order to group and structure them. (Vaivre-Douret L, 2011) list the following impairments found to varying degrees among their three subtypes: coordination between upper and lower limbs, bimanual dexterity, synkinesis, manual dexterity, dysdiadochokinesis, oro-facial praxia, executive function, digital praxis, praxic slowness, imitation of gestures, digital gnosis, dynamic balance, body spatial integration, handwriting, hypotonia, abnormalities in standing tone and homogeneous tonic laterality, visual pursuits, visual motor integration, visual spatial structuring, visual spatial constructional tasks, handwriting, and anomalies in visual refraction.

2.4 Functional Problems

By definition, the motor coordination deficits of DCD interfere with the activities of daily living and academic function of children (APA, 2000). Therefore the significance of the impairments listed in 2.3 above is not in their presence, per se, but in their effect on function.

In a systematic review of the recent literature regarding activities and participation in children with DCD based on the conceptual framework of the International Classification of Function, Disability and Health (ICF: WHO 2001), Magalhães et al (2011) found that commonly identified themes were limitations in: performance of classroom tasks; play and/or sports; activities of daily living; and social skills. The most frequently cited issues were regarding play-related activities, including difficulties riding a bicycle or tricycle, rollerblading, using playground equipment, jumping rope and participating in free play. Participation in organised sport was limited by difficulty with running, jumping, and swimming. Classroom tasks were the second major issue, with poor handwriting and limitations in using hands to perform classroom tasks (such as crafts) being the limiting factors. Difficulty with self-care was also noted, specifically dressing and feeding using cutlery. Other factors limiting a child's participation included language and speech; poor social skills and a tendency for loneliness and exclusion by peers; feelings of inadequacy; and or poor quality of life related to motor awkwardness.

Dewey and Wilson (2001) reviewed the literature regarding DCD and function in their article giving an overview on DCD. They cite several authors who note the link between DCD and learning difficulties, such as those discussed under comorbidities above. They also discuss the relationship between DCD and academic performance. Common areas of difficulty are in reading, spelling and mathematics, as well as writing speed. They noted that not all children with motor difficulties present with poor academic performance, and that the motor deficits of DCD may interfere with the activities of daily living rather than academic performance. The authors note a limitation in the amount of information relating to self-care activities, such as doing buttons and tying shoelaces. Other areas of functional limitation include: leisure, such as sports; social-emotional problems, such as lack of confidence; and classroom difficulties, such as arts and crafts or handling equipment in science class.

In the parent interview portion of their study describing children with DCD identified by physicians, Missiuna et al (2008) found the following to be common problems:

Self-Care: difficulty dressing, messy feeding, poor hygiene, dependant with self-care routines.

School problems: printing/writing, cutting/crafts, task completion, homework.

Leisure activities: poor ball skills, difficulty learning to ride a bicycle, preference for sedentary activity.

In addition, parents identified the following additional health issues: frequent falls and resulting fractures, endurance, strength, overweight, poor organisation, poor attention, difficulty with peers/social issues.

DCD also affects children in the emotional and social domains. These include the development of a poor self-concept, a poor physical self-perception, socialisation problems and anxiety to participate in motor tasks (Peens et al, 2008). In a well-designed study conducted in the Potchefstroom district of the North-West province, Peens et al (2008) found that the self concept of a group of seven- to nine-year-olds was below average. They conducted an eight week intervention consisting of a psychological intervention program, a motor-based intervention, both or neither. The author found that the two groups who received a psychological intervention improved in their self-concept and showed decreased anxiety. The two groups who received the motor-based intervention improved in their scores on the MABC. These findings indicate that while poor self-concept is present in a population with DCD, it requires separate intervention and cannot be assumed to improve with motor intervention. The study was well designed in that it sampled a range of schools in a particular district, and used both teachers to identify children with motor difficulties and the MABC (Henderson and Sigden, 1992) to confirm the presence of motor difficulties. The intervention groups were well designed, with enough groups to isolate the effects of each treatment (motor intervention, self concept enhancing intervention or both) as well as maturation (control group).

In their study on teachers' perceptions of children with DCD, Rivard et al (2007) quoted several studies on the long term sequelae of DCD, certain of which have also been reviewed here. They found that children with DCD are more likely to exhibit psycho-social difficulties, including poor perceived social and physical competence, social isolation, academic and behavioural problems, poor self-esteem and even a higher rate of psychiatric problems.

2.4.1 Long Term Implications for Function

Based on previous research, Piek and Edwards (1997) noted that there are differing opinions in the literature as to whether DCD is a delay in the maturation of motor skills, or a life-long disability with various social, emotional and academic problems associated into adolescence and adulthood. In a more recent study Cantell et al (2003) also commented on the existing literature, noting that methodological inconsistencies make it inappropriate to draw firm conclusions. The same concern was noted by Magalhães et al (2011). The general understanding up to when Piek and Edwards published in 1997 that point was that children with more severe coordination deficits would to continue to have difficulties, while those with milder problems would grow out of it. As part of a larger, longitudinal study they followed up children who were screened at five-years-old. They concluded that although a screening at that age was not predictive of the degree of motor impairment at age 17, half the individuals who presented with perceptual motor difficulties at five still displayed difficulties at 17.

Recently more attention has been given to the progress of children with DCD from childhood through adolescence to young adulthood. Kirby et al (2011), using the The Adult DCD/Dyspraxia Checklist (ADC), a tool first reported in 2010 by the first author, 19 young adults were asked to complete a questionnaire relating to past and current motor function. The authors quote previous studies detailing the lack of socialization in children with DCD, leading to an increased risk of anxiety and depression, as well as increased loneliness, greater alienation, and lowered self-esteem. Most participants reported that difficulties with coordination persisted, but had improved from childhood. Major areas of persisting motor difficulty were speed and neatness of handwriting, speed of self-care tasks such as doing up buttons and zippers, and parking a car. Of bigger concern to the participants was difficulty with executive functioning, including managing money, difficulties planning ahead and organising, and finding things in their room. Finally, social difficulties were reported, with participants making social choices to avoid activities requiring coordination, including team games, going to clubs or dancing. A parent questionnaire of the same population showed similar concerns.

Cousins and Smyth (2003) also recruited 19 participants who had received a diagnosis of DCD or dyspraxia in childhood. They found that participants performed poorly compared to controls on all motor tasks. A particular problem was slowness of execution, with unusual strategies used for task completion. Performance was also more variable across all tasks, which was explained by deficits in timing, consistent with literature on childhood DCD.

These studies indicate that the deficits in function of children with DCD persist in different forms into adulthood.

2.5 Identifying DCD

The potential for improving quality of life and participation justifies efforts to screen for and diagnose DCD (Faught BE, 2008).

As stated above, the DSM IV-TR (APA, 2000) has strict, comprehensive criteria for the diagnosis of DCD. Specifically, it is a marked impairment in motor function that impairs with the academic function and activities of daily living not due to a general medical condition or mental retardation. As a result, aside for identifying the impairment in motor function, deficits in function must be identified, and other medical or genetic diagnoses and mental retardation must be excluded. Therefore a battery of tests conducted by a variety of professionals is necessary to make a conclusive diagnosis of DCD. A further factor that complicates the diagnosis of DCD is the frequent co-occurrence of other developmental disorders (Missiuna C, 2008).

Criterion A of the DSM-IV is an impairment in motor function. Various instruments are available to identify motor impairment in children, none of which has been established as the 'gold standard' (Venetsanou et al, 2011). Two of the more frequently used instruments are the Movement Assessment Battery for Children – Second Edition (MABC-2) (Henderson, Sugden and Barnett, 2007) and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks, 1978). A detailed discussion of these two tools is included in CHAPTER 3: Measuring Instruments page 33**.** Briefly, the MABC-2 identifies impairments in manual dexterity; aiming and catching; and balance (Henderson, et al, 2007). The BOTMP identifies impairments in fine manual control; manual coordination;

body coordination; and strength and agility (Deitz et al, 2007). These are standardised motor tests commonly used to identify children with motor impairment.

Criterion B of the DSM-IV is that the motor impairment interferes with academic performance and activities of daily living. This is the area where teachers and parents often see the deficits in function leading to referral to medical professionals and more formal diagnosis. Tools available for use by teachers and parents are most commonly questionnaires, such as the Movement Assessment Battery for Children Checklist currently on its second edition (Henderson et al, 2007); the Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, et al 2000); Children Activity Scales for Parents (ChAS-P) and for Teachers (ChAS-T) (Rosenblum, 2006); and the Motor Observation Questionnaire for Teachers (MOQ-T) (Schoemaker et al, 2008). A child-reported scale is available for older children, the Children's Self-perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA) (Hay, 1992).

The final two criteria are commonly not addressed, but are necessary to make a strict diagnosis of DCD. Criterion C is that the motor impairment is not due to a general medical condition. This requires a full assessment by a paediatrician, neurologist or other medical professional with relevant skills. Criterion D is that if mental retardation is present, the motor difficulties are in excess of those usually associated with it. This requires a full test of intellectual function, such as the Wechsler Intelligence Scale for Children-Fourth Edition (Wechsler, 2004).

2.6 Teachers and DCD

The essential significance of DCD is that it affects functional performance. In their study on the functional performance of children with DCD at home and school, Wang et al (2009) define functional performance as the ability to proficiently perform a variety of activities, and the ability to use these activities to participate in a way that is socially relevant and developmentally appropriate, in order to live a meaningful life.

Children with DCD experience many difficulties in the academic realm including awkward handwriting, immature cutting ability, poor manipulation skills and poor organisational ability. Due to the increased effort and energy expenditure in paper-based activities, such as writing and cutting, these children are often fatigued. Physical awkwardness also leads to decreased participation in playground and other physical activities (Wang et al, 2009; Rivard et al, 2007). These are certainly areas where a classroom teacher is intimately involved in a child's daily life. As teachers have the opportunity to observe children both at play, in outdoor and free-play activities, and with scholastic activities, such as desk-based work, they have an advantage over other professionals in terms of observation over time and in different activities (Faught BE, 2008).

Wang et al (2009) found that children with DCD or suspected DCD performed poorly on the School Function Assessment in comparison to their peers. It is notable that in the same study no significant correlation was found between scores on the School Function Assessment (Coster et al, 1998) and the Vineland Adaptive Behaviour Scale (Sparrow, Balla, and Cicchetti, 1984), a measure of activity limitation and participation. The authors propose two reasons for this: that children's performance is dependant on context and is more likely to deteriorate with time pressure; and that parents' and teachers' perceptions of a child's functional status may differ.

In their study on teachers' perceptions of children with DCD, Rivard et al (2007) quoted several studies on the long term sequelae of DCD, certain of which have also been reviewed here. They found that children with DCD are more likely to exhibit psycho-social difficulties, including poor perceived social and physical competence, social isolation, academic and behavioural problems, poor self-esteem, and even a higher rate of psychiatric problems (Miller LT, 2001). With these as the potential long-term consequences of DCD, the current interest and attention is certainly indicated.

In a clear and necessary study on teachers' perceptions of children with DCD, Rivard et al (2007) summarise the current situation regarding teachers and their ability to identify children with DCD. Children with DCD are often only identified once academic failings occur, even though difficulties are often apparent in the classroom and playground from an earlier stage. Both classroom and special education teachers, refer when poor skills development interferes with overall performance. However, many children are not identified by teachers in spite of displaying motor difficulties. Schoemaker et al (2008) noted that teachers' training generally does not include formal training on the observation and rating of motor behaviour. In addition, some teachers may be more accurate in detecting deviant motor behaviour than others.

One way that has been suggested to compensate (Schoemaker et al, 2008) for this is teacher checklists. In recent years several screening instruments have been suggested for teachers to identify children with DCD. These include the Motor Observation Scale for Teachers (MOQ-T) developed in the Netherlands (van Dellen et al, 1990); the Childrens Activity Scale for Teachers (ChAS-T) developed in Israel (Rosenblum 2006); the Teacher Estimation of Activity Form (TEAF) (Hay & Donnelly, 1996); and the Movement Assessment Battery for Children Checklist (Henderson and Sugden, 1992). Teacher observations and checklists have been not conclusively been shown to be either accurate or inaccurate (Schoemaker et al, 2008). The variety of instruments available and the lack of validation between measures have made comparisons difficult. Faught et al (2008) noted, based on previous studies, that teacher checklists in general and the MABC checklist in particular has shown only modest correlations and poor sensitivity. They also noted that the length of the MABC checklist makes it impractical in a regular classroom setting. Schoemaker et al (2008) noted that for none of the instruments had adequate sensitivity and specificity yet been achieved.

In an older study, Piek and Edwards (1997) used the MABC and the MABC Checklist to establish whether class and physical education teachers were able to identify children with motor difficulties. The sample was 191 children aged between nine and eleven. Using the MABC Checklist, class teachers identified 50 percent of cases defined as severe by the MABC, and only six percent of those defined as moderate. In addition they identified 12 percent of children who the MABC defined as normal, as being impaired. Physical education teachers identified 36 percent of the severely impaired children but 54 percent of the moderately impaired children. In addition, 14 percent of normal children were identified as impaired. The authors noted that, using a comprehensive analysis of the MABC Checklist broken down into sections, classroom teachers were better able to identify children with difficulties in a stationary environment, i.e. at a desk, while physical education teachers were better able to identify those with difficulty in a moving environment, i.e. on the sports field. If it was assumed that poor performance on one section of the test indicated movement difficulties, then the percentage of children correctly identified by classroom teachers rose to 34 percent and that by physical education teachers rose to 71 percent.

In a study conducted in Canada, Junaid et al (2000) also compared the results of the MABC Checklist, as administered by teachers, with the results of the MABC Test as administered by physical therapists. The study population consisted of 103 children aged seven and eight. The correlation between teachers' scores on the MABC Checklist and physical therapists' scores on the MABC Test were moderate. However, the sensitivity of the MABC Checklist was so poor, at 14%, that the authors do not recommend its use to identify children with motor difficulties.

Faught et al (2008) correlated the results of the Teacher Estimation of Activity Form (TEAF), a 10-item scale developed for the study, with the Short Form of the Bruininks–Oseretsky Test of Motor Profficiency (BOTMP-SF) and the Children's Self Perceptions of Adequacy in and Predilection Toward Physical Activity (CSAPPA). The TEAF rates each child's aptitude for and general enjoyment of physical activity. They found that teachers had an accurate perception of their students' physical activity behaviour and potential. The perceptions of the teacher also correlated well with the child's self-report. While their study found teachers to be good judges of physical ability, given their constant exposure to and observation of their students, they noted that other studies done in developed countries show differing results. This study was done in Niagara, Canada.

Other studies have noted teacher's referral patterns for DCD. In Ontario, Canada the majority of children with motor problems who were referred to occupational therapy by teachers had been identified by Grade Three (Miller et al, 2001).

2.7 Treatment of DCD

The underlying motivation behind early identification and treatment of children with DCD is to address the physical, emotional and social consequences of DCD, and prevent the associated negative experiences (Faught et al, 2008). The approaches discussed below are those used by either physiotherapists, or occupational therapists, or both.

In a systematic review of interventions to improve motor performance in preschool children, Riethmuller et al (2009) found that most interventions were efficacious. The majority of the studies were eight weeks or longer. However, the interventions were of differing structure and content making it difficult to apply the results widely. In addition, the authors considered many of the studies to be of poor quality, which reduces the strength of the results.

In a practitioner review Wilson (2005) summarises the current approaches to treating children with DCD, based on different theoretical constructs. He identifies the following five categories:

1. *Normative Functional Skill Approach*. This approach is based on early normative models of child development in the motor, sensory and cognitive domains (Gesell (1925) and McGraw (1945), as well as Piaget's (1952) cited in Wilson (2005)). The treatment approach is *Cognitive Orientation to Daily Occupational Performance (CO-OP)* (Missiuna et al, 2001). It is essentially a general task approach, targeting age-relevant functional skills.

2. *General Abilities Approach*. This approach asserts that sensory-integrative and sensori-motor functions are necessary for later physical and intellectual development. *Sensory Integration (SI)* theory underlies this approach. Treatment is aimed at activating and integrating these faulty sensory systems to enable development (Ayres (1979, 1989) as cited in Wilson (2005)) .

3. *Neurodevelopmental Theory*. The author discusses this section with few references cited. This approach focuses on neuromaturation and the acquisition of motor milestones. Neurological soft signs are used as markers of dysfunction in this approach. This approach has not established a clear theoretical basis for understanding DCD. Treatment is aimed at achieving age appropriate motor milestones with reference to previous developmental stages.

4. *Dynamical Systems Approach*. This approach focuses on the interaction between multiple systems (for example motor and perceptual) and how this interaction translated into coordination of movement between limbs (Newell and

Vaillancourt, 2001). In this approach observational analysis of movement patterns is primary. Treatment according to this approach is task specific with adjustments made based on the movement analysis (Revie and Larkin, 1993).

5. *Cognitive Neuroscience Approach*. In this approach brain-behaviour interactions are viewed in light of their effect on motor development. The key term of this approach is motor imagery, the internal model of intended movement that has not yet been initiated (Crammond, 1997). In this approach a deficit of motor imagery is noted, as well as deficits in motor timing and how it links to the cerebellum. Treatment according to this approach is kinaesthetic training or motor imagery training (Wilson et al, 2002).

Barnhart et al (2003) in an overview article on DCD, summarise the current approaches into two streams.

1. *Bottom-up.* In these approaches the focus is on addressing the underlying deficits through the transmittal of sensory information, which the central nervous system then interprets and organizes in order to develop an appropriate movement strategy. Examples are: Sensory Integration Therapy, Process-Oriented Treatment, and Perceptual Motor Training.

2. *Top-down.* In these approaches the emphasis is on cognitive or problem-solving skills. Intervention teaches the child to select and implement the most appropriate strategies for successful task performance. Examples are: Task-Specific Intervention, Cognitive Orientation to daily Occupational Performance (CO-OP).

In another overview, Polatajko and Cantin (2005) summarise the approaches in the same way, but refer to 'bottom-up' as deficit oriented to reduce impairments, and 'top-down' as task oriented to increase activities and participation. Their understanding is in keeping with the ICF framework (WHO, 2001).

In a review of the literature on treatment of DCD, Mandich et al (2001) investigated the evidence supporting both the 'bottom-up' and the 'top-down' approaches, viewing each approach individually. They note that because the aetiology of DCD is poorly understood there are competing theories and therefore widely varying treatment approaches. No one approach has been shown to be more effective than any other. More of the recent research has focused on a 'top-down' approach as these approaches are congruent with current motor learning theories, and the authors recommend the use of one of these approaches. They conclude that as there is not strong evidence for any particular approach, clinical reasoning is necessary to develop an individualised therapy plan for each child.

Peens et al (2008) conducted a well-designed study assessing the effect of psychological and motor-based interventions on self-concept and motor proficiency (see above regarding the results and implications for self-concept). The four groups were a psychological intervention group, a motor-based intervention group, a psycho-motor intervention group and a control group. Testing was done immediately before the intervention, immediately after the intervention, eight weeks after the intervention, and a year after the initial assessment. Both the groups that received a motor intervention improved their scores on the MABC after the eight week intervention. The psychological intervention group maintained the same level of motor proficiency, while the control group deteriorated slightly. However, only the pure motor intervention group continued to improve after the intervention was completed. The other groups maintained their level of motor proficiency but did not improve. The study was well designed in that it sampled a range of schools in a particular district, and used both teachers to identify children with motor difficulties and the MABC (Henderson and Sugden, 1992) to confirm the presence of motor difficulties. The intervention groups were well designed, with enough groups to isolate the effects of each treatment (motor intervention, self concept enhancing intervention or both) as well as maturation (control group). The most useful aspect of this study is that it was done in South Africa, and therefore their approach to the motor intervention was in line with other South African therapists. Specifically, the intervention included an integration of task-specific, kinaesthetic and sensory integration treatment methods. This approach is not unique to South African therapists. In a randomised trial on physical therapy interventions in children with ADHD and DCD, Watemberg et al (2007) used a combination of perceptual motor training, sensory integration therapy, kinaesthetic training, and neurodevelopmental treatment. They found than an intensive physical therapy intervention resulted in a significant improvement in the motor performance of these children.

2.8 Developmental Surveillance and Screening

Developmental surveillance is an ongoing process whereby individuals skilled in observation continually assess children during the provision of healthcare. In general paediatric practice this includes parental interviews, direct observation, obtaining developmental histories and consultation with other relevant professionals, including preschool teachers (Dworkin, 1993; Thomas et al, 2011). Developmental screening refers to testing a population with a standardised screening tool, and is intended to identify children who require more in depth assessment (Thomas et al, 2011).

According to Marks et al (2011) developmental surveillance is a longitudinal, ongoing process which may include administering a screening tool as part of the process. The authors found that by using a psychometrically sound screening tool, as opposed to unreliable milestone checklists, developmental delays are more likely to be detected. The American Academy of Pediatrics (2006) recommends developmental screening at every well-child preventative care visit, which currently occur up to 24-months of age. DCD is only identified once children reach school-going age, including pre-school, with a tendency to diagnose DCD only after age five (Rhitman et al, 2011). The earliest age for screening by questionnaire is three-years-old, using the Little Developmental Coordination Disorder Questionnaire (Little DCDQ) (Rihtman et al, 2011), an adaptation of the earlier Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, et al, 2000). The earliest age for screening using a standardised motor test is three-years-old, using the MABC-2 (Henderson, Sugden and Barnett, 2007; see below). Therefore, as children have moved out of the stage of regular well-child visits by the time DCD is diagnosed, screening is more appropriate than surveillance.

2.8.1 Acceptable properties of screening tools

Sensitivity, specificity, positive predictive values and negative predictive values are used to assess the validity of a screening test, as compared to a test which is taken as the 'gold standard' (Glascoe, 1997). Akobeng (2007) discusses the importance of understanding these concepts, and their relevance in understanding the usefulness of clinical tests. The author defines these concepts as follows:

‘*Sensitivity*: proportion of people with disease who will have a positive result.

Specificity: the proportion of people without the disease who will have a negative result.

Positive predictive value: the proportion of people with a positive test result who actually have the disease.

Negative predictive value: the proportion of people with a negative test result who do not have disease.’

(Akobeng AK 2007 Understanding Diagnostic Tests 1: Sensitivity, Specificity and Predictive Values. *Acta Paediatrica* 96 (3) : 338-41).

The American Psychiatric Association (1985) recommends a sensitivity of 80% or above, meaning that at least 80% of those with the disease will test positive. The clinical usefulness of the sensitivity is that if the sensitivity is high, then almost all of those who have the disease will test positive. Therefore a *negative* test result means that there is almost certainly no disease. However, the sensitivity does not give an indication of how many false positives there may be (Akobeng, 2007).

For specificity, the recommended value is 90%, meaning that 90% of those without the disease will test negative (American Psychiatric Association, 1985). The clinical usefulness of specificity is that when this value is high, almost all of those who do not have the disease will test negative. Therefore a *positive* result means that there is almost certainly disease present. However, the specificity does not give an indication of how many false negatives there may be (Akobeng, 2007).

Predictive values use a patient’s test results to describe the probability of the disease being present. These figures therefore combine the information obtained from both the true positives and the false positives, giving a figure describing how likely it is that a patient with a positive result would actually have the disease. Combining the information on true and false negatives will give a figure describing how likely it is that a patient with a negative result would not have the disease (Akobeng, 2007).

A screening tool with high sensitivity and high specificity would therefore exclude all of those without the disease and include all of those with the disease. A screening test should have higher sensitivity than specificity, to include all those with the disease, rather than to exclude all those without the disease. Netelenbos (2005) describes a two-step process used when screening large numbers of children for DCD, such as by that used by Wang et al (2009), Peens et al (2008), Wilson et al (2001), and Wright and Sugden (1996). In the first step the teacher is asked to assess the general motor ability of their pupils using a global checklist or observations. The children identified by teachers are then screened using a standardised test as the second step. The assumption is that teachers' daily contact with children will put them in a good position to identify those with difficulties (Netelenbos, 2005). No information was given on the sensitivity of this method in any of the above-mentioned studies, as only the children identified in the first step were tested in the second. The same method has been used in developmental screening before preschool age. With younger children, Glascoe (1997) used parents' concerns to identify children requiring further screening. The author found that this method had a high level of sensitivity, with 79% of children identified as having disabilities by concurrent standardised tests being identified by parental concerns. In delineating an updated algorithm for developmental-behavioural surveillance and screening, Marks et al (2011) also recommend a process of 'pre-screening' followed by screening using standardised tools as indicated. Cairney at al (2007), when describing a screening process for school-age children for DCD, note that in a two-step process an initial test with high sensitivity and low or moderate specificity is desirable. This will identify almost all true cases but will be accompanied by a relatively high number of false positives, a situation which is acceptable in a two-step process (Cairney et al, 2007) where a 'pre-screen' is followed by a more detailed screening, which is followed by further assessment and intervention as necessary.

2.8.2 Available Screening Tools

Several tools are currently available to screen for DCD. Some of these tools, with their reported sensitivity and specificity, include:

- Movement Assessment Battery for Children Checklist currently on its second edition (Henderson et al, 2007), with a reported sensitivity of 62% and a specificity of 66% (Schoemaker et al, 2003). There are 48 items, 12 each in the following four sections: (a) child stationary- environment stable, (b) child moving-environment stable, (c) child stationary-environment changing, and (d) child moving-environment changing. It is designed for children aged five to 12. The tool was developed in the United Kingdom.

- Children Activity Scales for Teachers (ChAS-T) (Rosenblum, 2006) with a reported sensitivity of 67% and a specificity of 93%. The tool consists of 21 items reflecting ADL skills, motor performance, and organization in time and space. The tool was designed for children four- to eight-years-old. This tool was developed in Israel.

- The Motor Observation Questionnaire for Teachers (MOQ-T) (Schoemaker et al, 2008) has a reported sensitivity of 80.5% and a specificity of 62%. It has 18 items in the fine and gross motor domains. The tool is designed for children ages five to 11. This tool was developed in the Netherlands.

- The Teacher Estimation of Activity Form (TEAF) (Faught et al, 2008), with a reported sensitivity of 74% and a specificity of 62%. It has ten items. The tool is designed for children primary school. It was developed in Canada.

- A tool currently used in studies involving children with DCD is parent questionnaire The Revised Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, et al 2009). It has with a reported sensitivity of 85% and a specificity of 71%. There are 15 items divided among the following scales: fine motor and gross motor ability, controlled movement, and general motor coordination. The tool was designed for children aged five- to 14.5-years-old, but has been adapted for three- and four-year-olds by Rihtman et al (2011) in Israel. This tool was developed in Canada.

CHAPTER 3: MEASURING INSTRUMENTS

1.1 Introduction

Objective assessment of motor impairment was done using the Movement Assessment Battery for Children – Second Edition (MABC-2) (Henderson, Sugden and Barnett, 2007). The background to the MABC-2 and the reasoning for the use of the MABC-2 in this study is discussed below.

3.1 Background to the MABC-2

Development of the performance component of the test now known as the MABC-2 began as the Test of Motor Impairment (TOMI), developed by Stott, Moyes and Henderson and first published in 1972. The objective of the TOMI was to provide a sensitive, objective and reliable measure of motor impairment. Initially Keogh and subsequently Sugden (1972) developed the teacher checklist to assist teachers in identifying children with movement difficulties in order to evaluate the educational significance of those difficulties. These two components, the performance Test aimed at motor competence and the Checklist aimed at teachers, were merged in 1992 into the Movement Assessment Battery for Children (Henderson and Sugden, 1992). This was revised and published as the Movement Assessment Battery for Children Second Edition (Henderson et al, 2007). The revised test was administered to 1172 children in the UK to obtain norms. It is notable, in light of the discussion below regarding the choice of the MABC-2 rather than the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks, 1978), that the original format of the TOMI and MABC were derived from the original Oseretsky test (Oseretsky, 1923), as was the BOTMP (Henderson et al, 2007).

The primary aim of the MABC is to identify children with movement difficulties and describe the characteristics of those difficulties. The authors of the MABC-2 Examiners Manual discuss how different areas of motor development impact one another, including balance, postural control and hand-eye coordination. They used this as the basis for a broad test including both fine and gross motor components. The three areas the test focuses on are: manual dexterity; aiming and catching; and balance.

***Manual Dexterity**:* The basis of inclusion of this section in the test is that much of a young child's learning occurs through use of their hands. Adult life is full of activities requiring good fine motor function, skills which are established in early childhood. The tasks in the MABC focus on three aspects of function: speed and confidence of movement of each hand; coordination of the two hands in a single task; and hand-eye coordination to use a pen (Henderson et al, 2007). There are three items in this section.

***Aiming and Catching**:* The authors note that these skills have evolutionary links, such as grabbing a nearby object to prevent oneself from falling. However they also note that development of these skills in the complex forms of today are often dependent on formal tuition, therefore they used the most basic form of each task. The two aspects of this function that the tasks focus on are: ability to catch a moving object; and ability to aim accurately at a target (Henderson et al, 2007). There are two items in this section.

***Balance**:* The authors cite several points from previous literature to establish that the ability to stabilise the body is essential for the successful execution of movement. Balance is divided into two areas. Static balance is the ability to maintain the centre of gravity over the base of support with an upright posture. Dynamic balance involves maintaining equilibrium when moving from point to point (Gallahue and Ozmun, 2006). There is much discussion in the literature as to how these two aspects of balance interact. The test focuses on three aspects of balance: static balance to maintain a specific position for as long as possible; dynamic balance in slow movement; and dynamic balance in fast movement (Henderson et al, 2007). There are three items in this section (Henderson et al, 2007).

In addition to the quantitative aspect of each task that is recorded, there is space for qualitative observations. Several are offered for each task through the use of check boxes. A space is also given for other observations. This follows the view that a lack of motor competence is the result of a combination of many factors, and therefore the inability to perform a certain task can have many possible causes. The qualitative observations are also intended to facilitate the development of an intervention program relevant to the child.

The original MABC covered children from four to 12 years of age in four age bands, while the MABC-2 covers children aged three to 16 in three age bands. The age bands were adjusted so each set of tasks covered a span of four years to ensure consistent evaluation during an intervention program over two or more years. Norms are provided on a six month basis for three- and four-year-olds, and on a year-by-year basis thereafter.

3.2 Reasoning for Using the MABC-2

There is currently no ‘gold standard’ for the measurement of motor coordination (Engel-Yeger et al 2010, Spironello et al 2010, Cairney et al 2009, Mackenzie et al 2008). The literature on DCD primarily used two tools in identifying children with DCD: the Movement Assessment Battery for Children (MABC; Henderson and Sugden, 1992) and the The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks, 1978).

Numerous studies have used the MABC to evaluate the efficacy of other instruments, specifically screening questionnaires (Junaid et al, 2006; Lingam et al, 2009; Rosenblum, 2006 and Schoemaker et al, 2008). In addition, many other studies used the MABC to establish motor ability in comparison to some other factor such as cardiovascular fitness or language, or to establish prevalence of DCD in a particular population (Missiuna et al, 2011; Zwicker et al, 2010; Cheng et al, 2009; Wu et al, 2009; Cantell et al, 2008; de Castelnau et al, 2008; Green et al, 2008; Mackenzie et al, 2008; Missiuna et al, 2008; Peens et al, 2008; Poulsen, 2008; Watemberg et al, 2007; Dawson and Puckree, 2006; De Kleine et al, 2006; Fisher et al, 2005; Rodger et al, 2003; Sugden and Chambers, 2003; Johnston, 2002; Coleman et al, 2001; Skinner and Piek, 2001).

However, others used the The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks, 1978). This test was based on an adaptation of the Oseretsky tests of motor proficiency from the United States with regards to content and structure. Studies using the BOTMP included Cairney et al (2010), Faught et al (2008), Gwynne and Blick (2004), Hay et al (2004), Inder and Sullivan (2005), Ivry (2003). A second edition of the BOTMP had been published as the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2; Bruininks & Bruininks, 2005).

Other literature used both tools, either in comparison to one another or in combination, including Chen et al (2009), Crawford et al (2001), de Kieviet et al (2009), Polatajko and Cantin (2005), Wang et al (2009), Wiart and Darrah (2001).

There are several studies where the MABC and the BOTMP are discussed together or compared directly (Chen et al, 2009; Crawford et al, 2001; de Kieviet et al, 2009; Polatajko and Cantin, 2005; Wang et al, 2009; Wiart and Darrah, 2001). In the examiners manual of the MABC-2, Henderson et al (2007) correlated the total impairment scores on the two tests, resulting in a coefficient of 0.53. At the outset of this discussion it is important to note that all authors who discussed both tests commented on the differences in administration and structure of the two tests (Chen et al, 2009; Crawford et al, 2001; de Kieviet et al, 2009; Polatajko and Cantin, 2005; Wang et al, 2009; Wiart and Darrah, 2001). The BOTMP has more verbal promptings and chances for correction, whereas the MABC is administered with more detailed instructions and strict scoring criteria without prompting during the testing.

Wiart and Darrah (2001) reviewed four tests of gross motor development, including: the Bruininks–Oseretsky Test of Motor Proficiency (BOTMP); the Movement Assessment Battery for Children (MABC); the Peabody Developmental Motor Scales (PDMS);and the Test of Gross Motor Development (TGMD). They note that different tests have been designed for different purposes, such as classification, diagnosis, intervention planning, assessment, measurement of achievement and program evaluation. Therefore the purpose of a test must be clear before it is used. They conclude that the BOTMP should be used primarily in a physical education setting. There are items in the test that may be difficult for a child with cognitive impairment to understand, and therefore the test should not be used in that population. They also note that reliability, validity and clinical utility has not been established for some items, which includes the short form. The complete battery consists of 46 items and takes 45-60 minutes to administer. The short form consists of 14 items and takes 15-20 minutes to administer. The MABC is praised for its organized structure, and the use of age appropriate but similar skill sets across the different age bands. They note that the psychometric properties of the performance tests and the checklist have not been fully established.

Crawford, Wilson and Dewey (2001) examined the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), the Movement Assessment Battery for Children (M-ABC) and the Developmental Coordination Disorder Questionnaire (DCDQ) for consistency between the tests. They emphasise that there is no ‘gold standard’ for identifying children with DCD. Regarding the BOTMP, they note its popularity in North America. Quoting previous literature they comment that there were concerns with: the grouping of subtests; sex differences on some items; low item consistency; variable test-retest reliability; large confidence intervals; and high percentage of disagreement between testers. They conclude that the test should not be used as it is unreliable. Regarding the MABC: they state that the test is useful for screening, planning intervention and research. Reliability and validity of the TOMI-H has been established, but not for the MABC. They conclude that since the content of both tests is largely identical the usefulness of the TOMI-H in identifying children with motor problems can be extended to the MABC. Concerning the consistency of the BOTMP and the MABC in identifying the same children, the authors quote overall agreement of the two tests as between 40% and 88% based on the literature. More children were identified as impaired by the MABC, and these children tended to have additional difficulties such as attention deficits. In their own study the authors found that the overall agreement between the BOTMP and the MABC was 67%, less than the 80% agreement considered sufficient for satisfactory concurrent validity. They concluded that the BOTMP under-identified children with DCD while the MABC was prejudiced against children with attention difficulties due to the way it is administered. There is no conclusive test to identify children with DCD, and clinical judgement is therefore required.

In their substantial discussion on DCD, including definitions, diagnosis, identification, associated problems and intervention, Dewey and Wilson (2001) include their own data comparing the MABC to the BOTMP. They found scores on the two tests to have an overall agreement of 82%. They noted that since the two tests do not consistently identify the same children, factors such as attention and memory may be influencing performance, resulting in different children being identified by each test.

Chen et al (2009) used the DCDQ to screen a large population for DCD, then used the BOTMP and the MABC to confirm the diagnosis. They found that 14.6% were indentified as having DCD on both the MABC and the BOTMP, whereas 27.8% were identified on only one of the measures. The kappa statistic (k) was 0.43 between these two tests, which is lower than the level of 0.75 that this study considered as acceptable (Landis and Koch, 1977). Their study also looked at psychosocial characteristics, which further substantiated the growing consensus that the two tests identified different subsets of the population with DCD due to the differences in their structure and administration. These authors suggest that the MABC is better equipped to provide a general index of motor impairment, while the BOTMP measures the ability to perform a given activity.

Unlike other authors, Spironello et al (2010) began with the assumption that the MABC was designed to identify significant motor impairment while the BOTMP aimed to measure a wide range of motor ability. Therefore only a moderate correlation was expected, which was exactly what they found ($r = 0.50$, $P < 0.01$).

The difference between the MABC and the BOTMP was summarised by Wilson (2005), saying that the MABC is primarily used as a screening tool to establish criterion groups for research purposes, while the BOTMP is primarily used as a diagnostic test used to provide information about movement competencies of a particular child.

Taking the information obtained from the literature it was decided to use the Movement Assessment Battery for Children as the research tool. The decision was based on the aim of the research, namely to establish whether Grade 0 teachers in an area of Johannesburg, South Africa, are able to identify children with movement difficulties. As an absolute answer from the teachers was required ('yes the child has motor impairment' or 'no the child does not have a motor impairment') the stricter, more defined cut-off of the MABC was appropriate. Overall the literature, particularly from before 2009 when this research was proposed, was more favourable toward the MABC than to the BOTMP. In addition, the time it took to administer the MABC was shorter, which was more practical for a study involving many children. When the tool was purchased the MABC-2 had replaced the MABC, and was therefore used.

3.3 Psychometric Properties of the MABC and the MABC-2

Venetsanou et al (2011) recently published a study discussing whether the MABC can be used as the 'gold standard' for assessing children with motor impairments. Their study is a review of 19 other studies on the technical adequacy of the MABC. The studies quoted have been accessed and discussed.

3.3.1 Reliability

When discussing reliability studies the authors considered the content of the MABC and the MABC-2 to be similar enough that the reliability studies on the MABC are still relevant (Henderson et al 2007). They therefore only quote studies published subsequent to the publication of the original MABC manual. These studies have been accessed and discussed in Table 3.1 below.

Venetsanou et al (2011) conducted a critical review of the psychometric properties of the MABC. Based on the studies they found, which have been accessed and discussed in Table 3.1 Reliability of the MABC below, the authors concluded that inter-rater reliability is considered to be good. Test-retest reliability of the total score is considered to be good, section scores are considered to be moderate, and individual item scores are considered to be poor. Further research is required in both areas of reliability before firm conclusions can be drawn.

Table 3.1 Reliability of the MABC		
Study	Form of Reliability	Results and Comments
Chow and Henderson (2003)	Inter-rater reliability Test-retest reliability	Mean intraclass correlation of 0.96 across items. Applicable to present study as testers had been trained to use the MABC but had no previous formal testing experience with MABC. Good at 0.77
Smits-Engelsman et al (2008)	Inter-rater reliability	High agreement between therapists, kappa coefficients between .95 and 1.00. Test administration was videotaped, 131 paediatric physical therapists asked to score the video.
Croce, Horvat, and McCarthy (2001) in Henderson et al (2007)	Test-retest reliability	High ICC of 0.95. Sample of 106 children aged five to 12
Van Waelvelde et al (2007)	Test-retest reliability SEM	High ICC of 0.88 Good agreement expressed as kappa coefficient of 0.72. Substantial SEM of total score of 2.4 Sample of 37 four- and five-year-olds described by teachers as 'the worse motor skills in their class.'
Leemrijse et al (1999)	SEM	SEM of 3.13 (scale range 0 to 40) Total score of the MABC sensitive enough to detect individual change Subscores for each section only have moderate sensitivity Individual items have poor sensitivity

ICC – Intra-Class Coefficient; SEM - standard error of measurement

Information regarding reliability of the MABC-2 is limited given its recent publication. In a review and critique of the MABC-2, Brown and Lalor (2009) discuss the results of several other studies involved in the development of the MABC-2. The studies primarily involving the added age bands, namely three-year olds and 11- to 16-year olds, are not relevant to this study and have therefore not been accessed or quoted here. The remainder have been accessed and quoted in Table 3.2 below. They conclude that there is reasonable test-retest reliability for the entire test, and the new age bands in particular. An additional study by Ellinoudis et al (2011) examined the reliability and validity of Age Band 1 of the MABC-2, the age band relevant to the current study. Their findings indicate that the test can be relied upon to be consistent.

Table 3.2 Reliability of the MABC-2		
Study	Form of Reliability	Results and Comments
Henderson, Sugden and Barnett (2007)	Test-retest reliability	Reliability coefficient of 0.80 overall, 0.77 for Manual Dexterity, 0.84 for Aiming and Catching, 0.73 for Balance SEM of 1.34 overall SEM of 3 at 95% confidence interval Study conducted with 20 children in each age band as part of UK standardisation study
Ellinoudis et al (2011)	Test-retest reliability Internal consistency	ICCs of .85 overall, .82 for Manual Dexterity, .61 for aiming and catching, .90 for balance Moderate ICC for Drawing Trail (.66) High ICC for all other items (.73 and above) Cronbach's alpha Manual dexterity: .51 Aiming and catching: .66 Balance .70 Indicating rather moderate to poor internal consistency due to small number of items used to calculate Cronbach's alpha

3.3.2 Validity

As with reliability, Henderson et al (2007) discuss validity in the MABC-2 manual using studies of the original MABC. Criterion-related validity of the MABC was assessed by correlating the results with tests covering the same broad range as the MABC, and with tests covering the narrower range of one section of the MABC. Regarding Age Band 1 Ellinoudis et al (2011) found that correlation coefficients among individual item scores were all good, except for the drawing trail task, which was moderate. As with reliability, the studies cited in Venetsanou et al's (2011) critical review of the psychometric properties of the MABC have been accessed, reviewed and discussed with other relevant studies in Table 3.3 below.

Table 3.3 Validity of the MABC and MABC-2

Study	Form of Validity	Results and Comments
Henderson et al (2007)	Criterion-related validity (BOTMP)	MABC compared to BOTMP Correlation coefficient of 0.53 Part of the standardization of MABC High correlation not expected as purpose of tests are different
Croce, Horvat, and McCarthy (2001) in Henderson et al (2007)	Criterion-related validity (BOTMP)	MABC compared to BOTMP using percentile ranks Long form BOTMP had correlation of 0.76 Short form of BOTMP had correlation of 0.71
Tan, Parker and Larkin (2001)	Criterion-related validity (BOTMP and MAND)	Correlation between BOTMP (short form) and MABC of 0.79 Correlation between MAND (McCarron Assessment of Neuromuscular Development; McCarron, 1982) of 0.86
Van Waelvelde et al (2007)	Criterion-related validity (PDMS-2)	MABC compared to PDMS-2 (Peabody Developmental Motor Scales; Folio and Fewell, 2000) Correlation coefficient of 0.76 4- and 5-year-old children
Smits-Engelsman et al (1998)	Criterion-related validity	MABC compared to KTK (Korperkoordinations Test fur

	(KTK)	Kinder; Kiphard and Schilling, 1974) Correlation coefficient of 0.65 Large sample of 134 children
Ellinoudis et al (2011)	Confirmatory factor analysis Goodness-of-fit	Marginally non-significant chi-square (x2(17) = 22.17, p = .048) for Age Band 1 Satisfactory Data fits the three domain model proposed by Henderson et al (2007)
Schultz et al (2011)	Goodness-of-fit	Acceptable goodness of fit P-value for the test of close fit was very high, p = 0.92
Henderson et al (2007)	Content validity	Content validity derived from consultation with an expert panel. Expert panel discussed possible changes in structure of the test, improvements based on feedback since the initial publication of the MABC, new test items and the results of pilot studies. Different professionals from different disciplines also asked to comment formally and informally.

3.4 Scoring the MABC-2 to establish the presence of motor impairment

The authors of the MABC-2 describe a ‘traffic light system’ to describe where a child’s performance falls relative to their peers. Two cut-off points are used: ‘impaired’ describing children falling on or below the fifth percentile; and ‘at risk’ describing children falling between the sixth and sixteenth percentiles. For those in the ‘impaired’ category further assessment is recommended, while for those in the ‘at risk’ category monitoring is recommended, with further assessment as necessary.

Particularly in population based studies involving the MABC, many authors have used below the 15^{th} percentile as the cut-off point, combining the ‘impaired’ and ‘at risk’ category into one category often called ‘probably DCD’ (Missiuna et al, 2011; Lingam et al 2010; Zwicker et al, 2010; and Wu et al, 2009). More specifically, these studies categorised children into ‘DCD and probable/suspected DCD’ and ‘typically developing’, with all children scoring below the 15^{th} percentile falling out of the ‘typically developing’ category and therefore warranting classification as motor impaired. Clinic based studies where a population that had already been referred was used, such as those conducted by Cheng et al (2009), de Castelnau et al (2008), Green et al (2008), and Pettit et al (2008), tended to discriminate more between the bottom two categories.

3.5 Teacher Questionnaire on Child's Performance used in this study

There was some consideration as to whether to use the MABC Checklist to collect data from the teachers. In a study specifically looking at teacher's use of the MABC Checklist to identify children with DCD, Junaid et al (2000) found sensitivity and specificity of the Checklist compared to the performance test to be low. Sensitivity of the checklist was so low that most children identified as having DCD by the MABC performance test were not identified by the Checklist. They therefore do not recommend its use. Piek and Edwards (1997) found that class teachers were unable to satisfactorily identify children with DCD using the Checklist. They did not discuss whether this was due to the Checklist's poor sensitivity or the teachers' poor ability to identify these children. Schoemaker et al (2003) established construct validity of the Checklist as compared to the performance test. Sensitivity was reported at 70% while specificity was reported at 90%.

After some consideration it was decided that this study wished to ascertain the teacher's discriminative powers without the assistance of any instrument. Checklists are not commonly used in the identification of children with motor difficulties by teachers in this city. It was therefore decided to design a form that simply asked teachers to indicate whether a child's performance was impaired, at risk or normal. These results could then easily be correlated with the scores obtained from the MABC-2. Therefore a questionnaire was compiled specifically for this study. Elements of the questionnaire have been based on the Movement Assessment Battery for Children 2nd Edition, and included sections for:

- Manual dexterity (hand function)
- Aiming and catching
- Balance

It also included the teacher's opinion on whether the child has gross motor problems or fine motor problems, and whether he/she would refer this child for physiotherapy. There was a question on whether the child is currently receiving, or has previously received physiotherapy or occupational therapy as far as the teacher is aware. A copy of the questionnaire is included in Appendix VII page 110.

3.6 Teacher Questionnaire on Previous Knowledge

In addition, each teacher was asked to complete a questionnaire relating to her knowledge relating to motor impairment, including any workshops on motor function she may have attended. This was done to obtain qualitative information on what training teachers had received, and what they would like more information on.

A copy of the questionnaire is included in the addenda (see Appendix VI page 108).

CHAPTER 4: METHODS

As per advice from the statistician, Grade R teachers were the subjects rather than the children in each class. The sample size that this study was aiming for was 20 teachers and therefore 120 children, with a ratio of six children per teacher. The sample size calculation is discussed under *Sample Size.* The procedure for recruiting schools, teachers and children, and for conducting the research is discussed below.

4.1 Subjects

A sample of convenience was used when recruiting schools. Schools that refer to a private paediatric physiotherapy practice in Dunvegan, Johannesburg, were approached, as well as other schools in the area. In addition, schools that other therapists in the practice were associated with were approached. Initially the intention was to include a variety of private and public schools, but logistical issues regarding obtaining permission from the Gauteng Department of Education precluded the use of public schools, therefore only private schools were used. All of the Grade R units were either attached to a nursery school, or on the grounds of a school including both nursery and primary schools. It was therefore possible to include Grade R units that feed both private and public schools, resulting in a more equitable sample. Nevertheless, these schools drew on a population from only the middle and upper income economic strata.

4.1.1Inclusion/Exclusion Criteria:

Included were all Grade R teachers from participating schools. For the random sampling all children in those classes were included. Following the random sampling and return of the consent forms, children with known mental, physical and neurological impairments, such as cerebral palsy or muscular dystrophy were excluded. These criteria are in line with the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), where Developmental Coordination Disorder (DCD) is defined as: (A) significant motor impairment below the age-expected norms; (B) motor problems must result in significant impairment to activities of daily living and/or academic achievement/performance; (C) condition cannot be due to other known physical conditions (e.g., cerebral palsy, muscular dystrophy) or pervasive developmental delay; and finally (D) if mental retardation is present, motor impairments must be below the norm (age appropriate) expected for these children (American Psychiatric Association, APA, 2000). While this study was not specifically assessing for DCD as the diagnostic criteria are difficult to fulfill, these criteria are nevertheless relevant to a discussion on motor difficulties in children.

4.2 Study Design

The experimental design was an unbalanced nested mixed effects model. This was a mixed design because:

- children were nested within teachers =, i.e., different children were assumed to be randomly selected from several (a population of) possible children, so children were a random effect; moreover, different children were assigned to different teachers so that children were nested within teachers.
- there were different numbers of children for each teacher = unbalanced design
- the other factors e.g. teacher, education etc were fixed as the levels of these variables applied to all respondents = mixed model.

4.3 Sample size

Of primary interest in this study was to assess the proportion of children with motor impairment correctly identified by Grade R teachers. A random sample of at least 62 children was required to estimate the proportion of correct identifications with 95% confidence to an accuracy of 10% or better, where the expected proportion of correct identifications was 80%. However, children from the same class can be viewed as a cluster, and for a design effect of two, a sample size of 120 children needed to be be tested. If six children per class are sampled, the total number of teachers will be 20.

4.4 Demographic information

Information on the age and sex of each child was obtained. In addition, brief information on birth history, and medical and surgical history was obtained. This was done using a form that participating parents were asked to complete, which included a section where parents signed consent for their child to participate in the study (see Appendix IX page 112).

4.5 Procedure

Principals at participating schools received a letter (see Appendix III page 105, and Appendix IV page 106) detailing the purpose of the study and requesting their participation. Permission was obtained from the principal of the school prior to the start of data collection (see Appendix II page 101). Once consent was given and signed for by the principal, each Grade R teacher was then approached to request her participation. This was done through an information letter and a questionnaire (see Appendix V page 107, and Appendix VI page 108) regarding her own knowledge of motor impairment. As stated in the information letter, completion of the questionnaire implied consent for the teacher's participation in the study.

Recruiting for individual children proceeded slightly differently at different schools. In all cases names were chosen randomly by either the researcher or the school secretary, by counting every third name off a class list. In no case did the class teacher select the participating children. At the first school only six information sheets and consent forms (see Appendix VIII page 111, and Appendix IX page 112) were sent out per class. Then, depending on how many were returned, more forms were sent out to once again make up a total of six. This proved to be a very time-consuming, laborious way to obtain consent. At subsequent schools up to ten consent forms were sent out initially, again with further consent forms being sent out depending on how many were returned. Teachers were asked to remind parents to return the forms on the day before testing occurred. The researcher's contact details were included on the consent form, but few parents chose to contact the researcher prior to data collection.

The initial wording of the information letter for the parents stated clearly that children participating in the study were chosen randomly. This wording was approved by the researcher's supervisor, head of research in the physiotherapy department, and the ethics committee of the university. Nevertheless, a parent at the first school used for data collection was extremely upset that his child was chosen, feeling that his child had been chosen due to her motor difficulties. He was under the impression that the researcher had screened children in the class without consent. Following this incident the following line was added in bold to the information sheet for parents: **Please note that the selection is random and does not in any way imply that your child has difficulties**.

The time between distribution of consent forms and data collection varied widely due to school holidays, outings and other logistical factors.

On the day of data collection all consent forms were collected first. Children were called from class one at a time, either brought by the school secretary, a teacher or fetched by the researcher, and the MABC II was administered. The room was either private or semi-private, depending on whether only the primary researcher or the researcher and her assistant were present. The MABC-II was then administered by either the primary researcher or the research assistant. During the administration of the test the researcher recorded the raw scores, but did not score or interpret the results. Once the MABC II had been completed, the child was sent back to class with the questionnaire for the teacher (see Appendix VII page 110) requesting information on the child's classroom performance. The primary researcher was responsible for all contact with principals, teachers and parents, including obtaining consent. On the day of data collection the primary researcher was responsible for collecting consent forms, establishing which children were present of those who had given consent, set-up and clean-up, and all other logistical issues. The researcher administering the test, being either the primary researcher or the research assistant, fetched the child to be tested, performed the test and recorded the results on the Record Form. The primary researcher performed all the scoring and interpretation, from her own recording and that of her research assistant.

Data collection was done either in one day or over two or more days, depending on the logistics of how many children were participating at each school and whether the research assistant was available on the day of data collection. In all cases the questionnaires for the teachers were collected subsequent to the day of data collection. This was because the teachers requested time to complete the questionnaires in a quiet, calm environment rather than in the classroom. To ensure blinding on the part of the teachers no discussion on the data collection was entered into.

In order to provide standardised feedback to the parents, a feedback form and standard explanations of percentile scores were devised. These are included in Appendices 9 and 10. Again, the researcher's contact details were included on the form, but few parents chose to follow up.

4.6 Administration of the MABC-2

Researchers were trained in the administration of the test. Preparation for data collection was done by both researchers familiarising themselves with the test, and administering the test several times together to ensure inter-rater reliability. The test was administered as per the guidelines in the Examiners Manual (Henderson et al, 2007).

All equipment for the test, excluding a stopwatch, was included in the test kit. Set-up was done exactly as described in the manual, with all items placed on the table and all distances measured before testing began. Instructions regarding the demonstration of each task and the instructions to be given followed the requirements listed in the manual. Wherever possible the order of the items was followed, but the authors allow for a deviation from the order due to practical considerations. The manual provided good guidance as to the scoring of certain items that could be interpreted in more than one way, which ensured consistency. As the testing population comprised of Grade R students all children fell in the five- or six-year age group, placing them all in Age Band 1. This made testing easier as the same tasks and procedure could be used with all children.

4.7 Scoring of the MABC-2

Scoring was done after all the tests on a particular day had been administered. Scoring was done as per instructions in the manual, with raw scores being converted to standard scores, which were summed and converted to percentile scores.

The MABC-2 manual defines 'impaired' as the fifth percentile and below, 'at risk' as between the sixth and the 15th percentiles, and 'normal' as the 16th percentile and above. However, the standard scores obtained from the test only give the ninth percentile as in the 'at risk range.' It was therefore decided to define 'impaired' as the first, second and fifth percentiles, 'at risk' as the ninth and 16th percentiles, and 'normal' as above the 16th

percentile. As discussed in Measuring Instruments (page 44), the 'impaired' and 'at risk' categories were collapsed into a single category of 'motor difficulties'. Therefore the 16th percentile and below were categorised as having 'motor difficulties' whereas those falling above the 16th percentile were categorised as 'typically developing.'

4.8 Statistical Analysis

The type of analysis used for experimental designs with random effects is variance components analysis. This analysis estimates how much of the variance in teacher ratings can be attributed to random effects, for example, how much of the variance in teacher ratings can be attributed the effect of the children assigned to different teachers (StatSoft, Inc. (2011). STATISTICA (data analysis software system), version 10. www.statsoft.com.)

In order to compare teachers' opinion of motor difficulties with the MABC score percentages of agreement were calculated. Kappa statistics were used to adjust for the percentage agreement that can be expected by chance alone. Due to the high agreement and low kappa another statistical approach was used. True positives, true negatives, false positives and false negatives were calculated. From this sensitivity, specificity, positive predictive values, negative predictive values and prevalence were calculated. A Mann-Whitney U test was used to test for differences between groups where applicable, specifically for 5.3.1 Teacher Education Level (Honours and Bachelors degrees combined as group one, and Nursery School Teachers and Other diplomas combined as group two), and 5.3.2 Teacher Confidence (teachers who reported 'always' feeling confident as group one, and teachers who reported being 'sometimes' or 'usually' confident as group two). Demographic and qualitative information was descriptively analysed using percentages, means and standard deviations.

4.9 Pilot study

The M-ABC was piloted on a group of five children to ensure smoothness and efficiency during testing, as well as inter-rater reliability. A school that was not part of the larger sample was approached. Consent was obtained from the teacher and principal, and the parents. Assent was obtained from each child. The two researchers took turns to give instructions for the test, with both researchers scoring the test independently. Where there was a query as to the scoring of a particular item a consensus was obtained during the testing, and the answer was noted. This ensured both researchers obtained the same scores for each item. The teacher questionnaire was not piloted on the entire group.

4.10 Ethical Considerations

Ethical clearance was obtained from the Human Ethics Research Committee Medical (Clearance number: M091124; see Appendix I page 100). Written permission was obtained from the participating schools (see 7.3Appendix II, page 101), and implied consent was obtained from teachers through completing the teacher questionnaire as outlined in the information sheet (see Appendix V page 107). Signed parental consent and verbal assent, with recorded assent, from each participating child was also obtained.

CHAPTER 5: RESULTS

5.1 Demographic Information

5.1.1Children

The demographic and delivery information for the sample of children is presented in Table 3.1 below:

Table 5.1 Demographic and Delivery Information of Children	
Age	6 years, 0 months (± 5.18 months)
Male	42 (52%)
Female	39 (48%)
Mean gestational age	38.46 (± 1.96) weeks
Type of delivery	Natural: 25 (31%) Elective Caesarean Section: 50 (63%) Emergency Caesarean Section: 5 (6%)
Mean birth weight	3.16kg (± 0.57)
NICU admissions	9 (11%)
Number of children requiring ventilation	4 (5%)

All children were between five years zero months (60 months) and six years 11 months (83 months), with a mean of six years zero months (72.01 months) (± 5.18 months). The sample of children consisted of 42 males and 39 females. In addition, information regarding the gestational age at birth, type of delivery, birth weight, Apgar score, admission to a neonatal intensive care unit (NICU) and neonatal ventilation has been summarised in the table above. Many parents did not report the Apgar score or approximated the score, and this was therefore excluded from the final analysis. The gestational age at birth of the sample fell between 31 and 42 weeks, with the mean age being 38.46 weeks (± 1.96). The type of delivery was predominantly Caesarean Section (69%), of which five parents specified it as emergency. The only other reported type of delivery was natural delivery.

Birth-weight ranged between 1.47kg and 4.5kg, with a mean of 3.16kg (± 0.57). Nine children were admitted to NICU. Duration of stay ranged between one day and seven days, with a mean of 3.78 days (± 2.16 days). Four children were ventilated for a minimum of a fewer than 24 hours (zero days) and a maximum of three days, with a mean of 1.5 days (± 1 day).

5.1.2Teachers

One teacher did not respond to the questionnaire on her own teaching background, and was therefore excluded from the analysis regarding teacher education level, experience and confidence, resulting in a sample of 15 for this analysis. The mean number of years teaching ranged between two and 34, with a mean of 19.31 (± 11.56 years). The number of teachers per school ranged between one and five, with a mean of 2.3 (± 1.4). Eight teachers (53.3%) described themselves as 'confident' to identify movement difficulties, while seven (46.7%) described themselves as 'sometimes confident'. Teacher education level is summarised in Table 5.2 below.

Table 5.2 Teacher Education Level

Education Level	**Number of Teachers (n=15)**
Honours level degree	3 (20%)
Bachelors degree	4 (26.7%)

Nursery school teachers diploma	5 (33.3%)
Other diploma	3 (20%)

5.2 Main Findings

As the primary population of interest in this study was the teachers rather than the children, data was analysed for each teacher rather than for each student. Therefore the findings for all the students were considered jointly to obtain a profile for each teacher, for each task and overall. Unless otherwise stated, all results are reported at teacher rather than child level.

The original research question asked whether Grade 0 teachers in an area of Johannesburg, Gauteng, South Africa were able to identify children with motor difficulties. To ascertain this the results of a teacher questionnaire were correlated with the results of the MABC-2. In order to obtain a 'true' indication of the motor ability of each participating child, the Movement Assessment Battery for Children – Second Edition (MABC-2) (Henderson, Sugden and Barnett, 2007) was administered. The teacher questionnaire followed the format of the MABC-2, namely dividing motor ability into three sections (Manual Dexterity, Aiming and Catching, and Balance), with three categories of performance in each (normal, at risk and impaired).

As a low kappa was obtained when correlating teachers' assessment of motor ability with the results of the MABC-2, sensitivity and specificity were calculated as per Feinstein and Cicchetti (1990). For the purposes of this study the teachers themselves were considered to be the screening tool. Using the MABC-2 as the 'gold standard' to establish the presence of motor difficulties, 'true positives', 'true negatives', 'false positives' and 'false negatives' were calculated for each teacher. A total number of 'correct' and 'incorrect' identifications ('n') for each teacher was calculated as a number of instances depending on how many children each teacher had. From these values sensitivity and specificity were calculated for each teacher individually, and for the group of teachers as a whole. A Mann-Whitney U test was used to test for differences between groups where applicable.

5.2.1Main findings for Individual Teachers

Table 5.3 below summarises the scores of the 16 individual teachers on overall performance across the three tasks, with calculations for sensitivity and specificity.

Table 5.3 Performance of Individual Teachers (n=16)

Teacher	**Correct**	**Incorrect**	**Sensitivity**	**Specificity**
A	58.3% (n = 7)	41.7% (n = 5)	0	0.78
B	75% (n = 9)	25% (n = 3)	0.75	0.75
C	50% (n = 9)	50% (n = 9)	0.5	0.5
D	50% (n = 3)	50% (n = 3)	1	0.4
E	91.7% (n = 11)	8.3% (n = 1)	Not valid (0 prevalence)	0.92
F	77.8% (n = 7)	22.2% (n = 2)	Not valid (0 prevalence)	0.78
G	66.6% (n= 12)	33.3% (n = 6)	0.2	0.85
H	75% (n = 9)	25% (n = 3)	0.33	0.89
I	33.3% (n=8)	66.6% (n=13)	0.33	0.39
J	66.6% (n=11)	33.3% (n = 4)	0.67	0.75
K	44.4% (n = 8)	55.6% (n = 10)	0	0.57
L	62.5% (n = 15)	37.5% (n = 9)	0.5	0.67
M	72.2% (n = 13)	27.8% (n = 5)	0	1

N	76.2% (n = 16)	23.8% (n = 5)	0.2	0.94
O	91.7% (n = 11)	8.3% (n = 1)	0	1
P	86.7% (n = 13)	13.3% (n = 2)	0.67	0.92
Total	66.7% (n = 162)	33.3% (n = 81)	0.33	0.75

For Teachers E and F no sensitivity could be calculated due to no prevalence, i.e. no children presenting with motor difficulties in the sample. However, both of these teachers did identify children as having motor difficulties, resulting in false positives, and therefore specificity could be calculated. This table illustrates clearly how applying different statistical assumptions produces a different picture of performance. The proportion of correct identifications appears to be high, but the ability of teachers to identify children with motor difficulties is not necessarily so.

5.2.2 Main findings for MABC-2 sections

Sensitivity, specificity, positive predictive values (PPVs), negative predictive values (NPVs) and prevalence, with their respective confidence intervals for each section of the MABC are listed in Tables 5.4 to 5.7 below. As noted in the literature review above, in order for a ‘screening’ test to be clinically acceptable the sensitivity should be 0.8 and above (American Psychiatric Association, 1985), indicating that 80% of cases who truly have the condition will be identified by the test. Specificity is of less concern for a screening test to be used in a two-step referral process, as the purpose is to exclude a large proportion of true negatives before further assessment rather than to exclude all false positives (Cairney et al, 2007). Nevertheless, the recommended specificity is 0.9 (American Psychiatric Association, 1985). For all sections the sensitivity and specificity were unacceptable low.

5.2.3Manual Dexterity

Table 5.4 presents sensitivity, specificity, positive predictive value, negative predictive value and prevalence for Manual Dexterity.

Table 5.4 Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Prevalence for Manual Dexterity (n=16)		
	Value	**95% Confidence Interval**
Sensitivity	0.36	0.21 to 0.55
Specificity	0.77	0.62 to 0.87
PPV	0.52	0.31 to 0.73
NPV	0.64	0.50 to 0.76
Prevalence	0.41	0.30 to 0.52

For Manual dexterity, neither sensitivity at 0.36, nor specificity at 0.77, reach an acceptable level. The positive predictive value is 0.52, indicating that if a teacher identifies a child as having motor difficulties, there is a 52% chance that the child will have motor difficulties, but there is a 48% chance that the child will not. Conversely, the negative predictive value is 0.64, indicating a 64% chance that the child does not have motor difficulties, but a 36% chance that he or she does. The prevalence indicates that 41% of children in this sample scored in the 'at risk' or 'impaired' categories on the MABC-2. The high prevalence indicated a large proportion of children who displayed motor difficulties, but the teachers were only able to identify these difficulties just over half of the time (12 true positives, versus 11 false positives, with a total of 23).

5.2.4Aiming and Catching

Table 5.5 presents sensitivity, specificity, positive predictive value, negative predictive value and prevalence for Aiming and Catching.

Table 5.5 Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Prevalence for Aiming and Catching (n=16)		
	Value	**95% Confidence Interval**
Sensitivity	0.33	0.02 to 0.87
Specificity	0.79	0.69 to 0.87
PPV	0.21	0.13 to 0.32
NPV	0.79	0.68 to 0.87
Prevalence	0.04	0.01 to 0.11

For Aiming and Catching the sensitivity and specificity were again lower than the recommended levels, at 0.33 and 0.79 respectively. For this section the prevalence was low at 0.04, with only three children displaying motor difficulties on the MABC-2. The positive predictive value is just 0.21, indicating that if a teacher identifies a child as having motor difficulties, there is a 21% chance that the child will have motor difficulties, but there is a 79% chance that the child will not. In total teachers identified 17 children as having motor difficulties, of whom only one was classified as 'at risk' or 'impaired' on the MABC-2.

5.2.5Balance

Table 5.6 presents sensitivity, specificity, positive predictive value, negative predictive value and prevalence for Balance.

Table 5.6 Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Prevalence for Balance (n=16)		
	Value	**95% Confidence Interval**
Sensitivity	0.25	0.07 to 0.57
Specificity	0.68	0.56 to 0.78
PPV	0.12	0.03 to 0.32
NPV	0.84	0.71 to 0.92
Prevalence	0.15	0.08 to 0.25

For Balance, sensitivity was lower still than Manual Dexterity and Aiming and Catching, at 0.25. Interestingly, the specificity was also lower at 0.68, indicating that in this section the teachers were less able to include children with problems, but also less able to exclude those without. The positive predictive value of 0.12 indicates that if a teacher identifies a child as having motor difficulties, there is a only 12% chance that the child will have motor difficulties, with a 88% chance that the child will not. Conversely, the negative predictive value is 0.84, indicating a 84% chance that the child does not have motor difficulties, but a 16% chance that he or she does. The prevalence indicates that 15% of children in this sample scored in the 'at risk' or 'impaired' categories on the MABC-2. The high prevalence indicated that there was a moderate proportion of children who displayed motor difficulties, but the teachers were seldom able to identify these difficulties (three true positives, versus 22 false positives, with a total of 25).

5.2.6Overall results

Table 5.7 presents sensitivity, specificity, positive predictive value, negative predictive value and prevalence for overall results.

Table 5.7 Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Prevalence for Overall Results (n=16)		
	Value	**95% Confidence Interval**
Sensitivity	0.33	0.21 to 0.49
Specificity	0.75	0.68 to 0.81
PPV	0.25	0.15 to 0.37
NPV	0.82	0.75 to 0.87
Prevalence	0.20	0.15 to 0.25

For the entire sample sensitivity and specificity were consistent with Manual Dexterity and Aiming and Catching. Again, neither sensitivity at 0.33, nor specificity at 0.75, reaches an acceptable level. Overall the positive predictive value is poor at 0.25, but the negative predictive value is much better at 0.82. This indicates that only a quarter of those children identified by teachers as having motor difficulties will in fact have motor difficulties, but 82% of those identified as not having motor difficulties by teachers will be correctly identified. The prevalence indicates that 20% of children in this sample scored in the 'at risk' or 'impaired' categories on the MABC-2. The teachers were able to identify 16 children who displayed motor difficulties (true positives), but also identified 49 children who did not (false positives).

5.2.7Overscoring and Underscoring

To identify the overall patterns of teachers' descriptions of their students, the proportion of correct identifications, as well as over- and under-scoring was analysed. Over-scoring referred to a teacher over-estimating a child's ability and considering him or her to be typically developing when in fact the child had motor difficulties. Under-scoring refers to the opposite. Values in Table 5.8 Overscoring and Underscoring of Teachers Compared to the MABC-2 below summarise this analysis. The percentages for over-scoring and under-scoring refer to the percentage of overall incorrect scores.

Table 5.8 Overscoring and Underscoring of Teachers Compared to the MABC-2				
Section on MABC-2	**Total with Motor Difficulties (MABC-2)**	**Correct Identification of total with motor difficulties**	**Over-scoring (False Negative) of total sample**	**Under-scoring (False Positive) of total sample**
Manual Dexterity	n = 33 (41%)	n = 12 (36%)	n = 21 (26%)	n = 11 (14%)
Aiming and Catching	n = 3 (4%)	n = 1 (33%)	n = 2 (2%)	n = 16 (20%)
Balance	n = 12 (15%)	n = 3 (25%)	n = 9 (11%)	n = 22 (27%)
Overall (Combined totals of each individual section)	n = 48 (20%)	n = 16 (33%)	n = 32 (13%)	n = 49 (20%)

Teachers had a tendency to under-score for Aiming and Catching, but to over-score for Manual Dexterity. This indicates that they are over-estimating their student's ability in the realm of Manual Dexterity, and assuming performance is 'typically developing' when it is 'at risk' or 'impaired'. Conversely, they are under-estimating performance for Aiming and Catching and Balance, interpreting skills as 'at risk' or 'impaired' when they are in fact 'typically developing'.

5.3 Teacher Factors

The overall scores for teachers were also analysed based on their education level and their confidence in their ability to detect motor problems. Sensitivity and specificity based on teacher education level for the overall result is summarised in Table 5.9 to Table 5.12 below.

Confidence intervals have not been calculated as the Gaussian approximation used to calculate confidence intervals for sensitivity and specificity is not suitable for small proportions, such as those in the four education groups. Instead, the Mann-Whitney U test, a nonparametric test using rank order data, was used to establish whether one set of data is significantly higher than another (StatSoft, Inc., 2011). The analysis was performed using STATISTICA (data analysis software system), version 10.

5.3.1Teacher Education Level

Sensitivity and specificity based on the four categories of teacher education level are summarised in Table 5.9 below, scored for the overall tasks. As stated above under subheading 5.1.2 Teachers, as one teacher did not respond to the questionnaire on her own teaching background, and was therefore excluded from the analysis regarding teacher education level, experience and confidence, resulting in a sample of 15 for this analysis.

Table 5.9 Sensitivity and Specificity Related to Teacher Education Level with 95% Confidence Interval (CI) for Overall Results (n=15)

Education Level	n	Sensitivity	Specificity
Honours level degree	3 (%)	0.09	0.67
Bachelors degree	4(%)	0.33	0.79
Nursery school teachers diploma	5(%)	0.54	0.66
Other diploma	3(%)	0.33	0.92

For the overall results, sensitivity and specificity appear to be lowest for those teachers with an Honours level degree, and highest for the teachers with a Nursery school teachers diploma. A Mann-Whitney U test was used to establish whether these differences were significant. The small sample sizes (three to five teachers per education level) necessitated combining the teacher education levels into the following groups: Honours and Bachelors degrees were combined to one level, and Nursery School Teachers and Other diplomas were combined into another single level. The u and p values were calculated to assess for differences between the two groups for sensitivity and specificity, and have been presented in Table 5.10 below.

Table 5.10 U and P Values for Sensitivity and Specificity for Two Composite Teacher Education Levels

	Sensitivity	Specificity
U Value	17	23.5
P Value	0.617075	0.64342

The Mann-Whitney U test was applied to the teacher values in these composite education levels. The Mann-Whitney U test revealed no significant differences ($p>0.05$) between sensitivity and specificity scores of teachers in these two composite education levels.

5.3.2Teacher Confidence

Sensitivity and specificity based on the teachers' self-reported confidence in their ability to identify motor difficulties is summarised in Table 5.12 below, scored for the overall tasks. As stated above under subheading 5.1.2 Teachers, as one teacher did not respond to the questionnaire on her own teaching background, and was therefore excluded from the analysis regarding teacher education level, experience and confidence, resulting in a sample of 15 for this analysis.

Table 5.12 Sensitivity and Specificity Related to Teacher Confidence with 95% Confidence Interval (CI) for Overall Results (n=15)			
Confidence level	n	Sensitivity	Specificity
Always confident	8 (53.3%)	0.43	0.70
Sometimes confident	7 (46.7%)	0.25	0.80

Teachers who reported ‘always’ feeling confident did have a higher sensitivity than those who reported being ‘sometimes’ or ‘usually’ confident. This supports their belief in their own abilities. However, their sensitivity and specificity did not reach the acceptable level of 0.8 and 0.9 respectively recommended by the APA. The u and p values were calculated to assess for differences between the two groups for sensitivity and specificity, and have been presented in Table 5.12 below.

Table 5.12 U and P Values for Sensitivity and Specificity for Teacher Confidence		
	Sensitivity	Specificity
U Value	19	19.5
P Value	0.94	0.49

The Mann-Whitney U test was again used to investigate a difference or lack thereof between teachers who reported always feeling confident in their ability to identify motor difficulty, and those who usually felt confident. The Mann-Whitney U test revealed no significant differences ($p>0.05$) between sensitivity and specificity scores of teachers in these two confidence levels.

5.4 Analysis of Variance

The variance components mixed model revealed no significant variance in teacher response accuracy due to different teachers, and due to the gender of the children assigned to the teachers.

5.5 Qualitative Information From Teachers

The following is a summary of information obtained from the questionnaires teachers completed regarding their own knowledge of motor impairment. The first question teachers were asked was '**What is motor impairment?'** Table 5.14 to Table 5.17 below indicate some of the points raised, as well as the number of teachers who included each point in their answer.

Table 5.14 below indicates teacher responses to the question 'What is motor impairment' relating to Manual Dexterity.

Table 5.14 Teacher Responses to the Question 'What Is Motor Impairment' Relating to Manual Dexterity (n=15)

Answer	**n**
Fine motor	4 (27%)
Pencil grip	3 (20%)

Certain responses corresponded to the sections of the MABC-2 discussed above. There were four responses specifically stating 'fine motor', and three stating 'pencil grip', for a total of seven responses. This can be related to Manual Dexterity, where sensitivity was 0.36 and the specificity was 0.77. The sensitivity was highest in this section, and specificity was marginally lower than the other sections.

No responses referred to Aiming and Catching specifically, where the sensitivity was 0.33 and specificity was 0.79. Sensitivity for this section was the middle of the three, but specificity was marginally the highest.

Table 5.14 below indicates teacher responses to the question 'What is motor impairment' relating to Balance.

Table 5.14 Teacher Responses to the Question 'What Is Motor Impairment' Relating to Balance (n=15)

Answer	**n**
Balance	3 (20%)
Control	1 (7%)
Stability	1 (7%)
Core muscles	1 (7%)

Three responses referred to 'balance' specifically, with another one each referring to 'control, 'stability' and 'core muscles' for a total of six responses. This can be related to Balance, where the sensitivity was 0.25 and the specificity was 0.78. Sensitivity was lowest for this section, and specificity was the middle of the three sections.

Table 5.15 below indicates teacher responses to the question 'What is motor impairment' relating to general motor performance.

Table 5.15 Teacher Responses to the Question 'What Is Motor Impairment?' (n=15)	
Answer	**Number of Teachers**
Experiences difficulty with motor function and coordination	7 (47%)
Inability to move fluidly, efficiently	2 (13%)
Difficulty getting body to work appropriately to complete a task	1 (7%)
Muscle tone	1 (7%)
Can affect concentration	1 (7%)
Includes perceptual, visual and sensory	2 (13%)
Includes Bilateral movements	1 (7%)
Includes planning	1 (7%)
Reaching motor milestones at a particular age	3 (20%)
Unable to perform given tasks	1 (7%)
Could be due to developmental disorders (genetic/neurological conditions)	1 (7%)
When a child is having difficulty with functioning	5 (33%)

There were a variety of more general responses relating to overall motor performance, of which the most common were 'difficulty with motor function and coordination', 'difficulty with everyday functioning'. These responses relate to Criteria A and B of the APA (2000) definition for DCD: Performance in daily activities that require motor coordination is below the expected, and interferes with academic achievement or activities of daily living. Sensitivity and specificity were 0.22 and 0.75 respectively, below the APA recommended levels for a screening instrument.

When asked ‘**Have you attended any talks or workshops?’**, three teachers (20%) replied ‘no’ and nine (60%) replied ‘yes’. Those who replied ‘yes’ listed various talks, including general in- service training by a physiotherapist in the area, conferences, other workshops, read books, and correspondence courses. Two attended a ‘Back to Basics’ workshop, while three had pursued the subject as part of education-related further tertiary education.

When asked **‘Do you feel confident? Why?’**, referring to the ability to identify motor difficulties, eight teachers (53.3%) reported feeling ‘always confident’, while seven (46.6%) reported feeling ‘usually confident’ (see Table 5.12 and Table 5.12 above for further analysis). Table 5.17 below indicates some of the answers, as well as the number of teachers who included each point in their answer.

Table 5.17Table … Teacher Responses to the Question ‘Do You Feel Confident? Why?’ (n=15)

Answer	**Number of Teachers**
I hope so!	1 (7%)
Confident if problems are obvious	3 (20%)
Yes, because of information received over the last few years	1 (7%)
Do constant assessment	3 (20%)
Watch children playing on outdoor equipment	2 (13%)
Easier fine motor than gross motor	1 (7%)
Look to see if children are copying	2 (13%)

Call parents in to discuss if necessary	1 (7%)
Lots of experience with these kind of children	2 (13%)
Used to only have occupational therapists, now confused as to what is occupational therapy and what is physiotherapy	1 (7%)
Often talk to occupational therapists and physiotherapists	1 (7%)
Sometimes confused because specific motor skills are inconsistent in the child	1 (7%)
Could be behavioural	1 (7%)
Not sure if it is developmental or immaturity	3 (20%)

For this question (**'Do you feel confident? Why?'**) responses were divided between those that were generally confident and those that were generally not confident. Confident responses included 'if problems are obvious' (n = 3), 'received information over the last few years' (n = 1), 'do constant assessment' (n = 3), 'watch children outdoors and in class' (n = 4), and 'lots of experience' (n = 2). Unsure responses included 'not sure what is occupational therapy and what is physiotherapy' (n = 1), 'sometimes confused because specific motor skills are inconsistent in the child ' (n = 1), 'could be behavioural' (n = 1), and 'not sure if it is developmental or immaturity' (n = 3). Finally, a group of responses indicated consultation with parents (n = 1) or therapists (n = 1). The difference between the two groups was not statistically significant, with p values for sensitivity and specificity at 0.94 and 0.48 respectively ($p>0.05$).

5.6 Summary of Results

For Manual Dexterity, Aiming and Catching, and Balance, as well as for the results overall, sensitivity and specificity did not reach the acceptable levels set by the APA (1985) indicating that teachers are not adequately able to identify children with motor difficulties. No significant differences ($p>0.05$) were found relating to either teacher education level or teacher confidence. No significant variance was found in teacher response accuracy due to different teachers.

CHAPTER 6: DISCUSSION

In this chapter the results obtained from this study are discussed, and analysed in context of previous research. The implications and recommendations for further research are also discussed.

6.1 Demographic Information

6.1.1Children

The population of children was selected randomly from each Grade 0 class of the participating schools. In total 81 children participated. The population was considered to be representative of an average Grade 0 sample in an Independent school. The sample was drawn from Independent schools, rather than Gauteng Department of Education schools, as the procedure required to obtain permission was simpler. A variety of pre-schools were used, including those whose pupils typically proceed to Gauteng Department of Education schools, and those who proceed to Independent schools.

As parental consent was required a bias may be present in the final sample. Some parents declined to participate, saying that their children had received therapy and therefore been assessed for motor skills several times. Other parents requested more specific feedback on their children's results, considering the results of the MABC-2 as confirming or otherwise the presence of motor difficulties.

6.1.2Teachers

A total of sixteen teachers participated in the study, from seven schools. Their years of teaching experience varied widely (two and 34, with a mean of 19.31, ± 11.56 years), as did their level of education (post-graduate degree to diploma).

6.2 Teachers' Ability to Identify Motor Difficulties using Agreement Between Teachers and the MABC-2

6.2.1Analysis Using Kappa

As noted above in Results (page 57), the percentage agreement between the MABC-2 and the teachers' description of the children was high, but the kappa score was low. Cicchetti and Feinstein (1990) note that a kappa coefficient is used to correct for the level of agreement that is expected from chance alone. Therefore in a situation where a high level of agreement is expected, the kappa score has limited relevance. In this case, as the majority of children were expected to be normal by both the MABC-2 and the teachers, the agreement was expected to be high, resulting in a high agreement due to chance. For no section was the kappa above 0.1, which is interpreted as 'poor agreement' by Landis and Koch (1977). In fact, for Balance the kappa was -0.04, indicating that the agreement between the teachers and the MABC-2 was worse than expected by chance, i.e. had the teachers been guessing.

6.2.2Analysis Using Sensitivity and Specificity

In a pair of articles discussing the problem of high agreement but low kappa scores, Feinstein and Cicchetti (1990) and Cicchetti and Feinstein (1990) note that a kappa coefficient is useful to correct for the level of agreement that is expected from chance alone. In this case the expected agreement due to chance was high due to the large number of normal children. The authors suggest using p_{pos} *define* and p_{neg} define instead, and using these values to calculate sensitivity and specificity. They define these concepts as follows: '*Sensitivity* is the proportionate accuracy of the diagnostic test in identifying positive cases of disease; and *specificity* is the corresponding proportionate accuracy in identifying the negative control group.' (Cicchetti DV, Feinstein AR 1990 High Agreement But Low Kappa: II. Resolving The Paradoxes. *Journal of Clinical Epidemiology* 43 (6) : 551-2).

6.2.3Analysis using the Mann-Whitney U Test

Due to the small sample size of 16 teachers, the data was evaluated on an ordinal (rank ordered) scale. Therefore a non-parametric test to evaluate for differences between groups was required, specifically the Mann-Whitney U test. This test was applied to teacher education level and teacher confidence.

6.2.4Analysis of Variance

As the study design was an unbalanced nested mixed effects model an ANOVA was performed to assess for variance between teachers.

6.3 Overall Results

The overall score was calculated by summing the three sections. Sensitivity was low at 0.33, as was specificity at 0.75. The specificity score was closer to the level recommended by the American Psychiatric Association (APA) (1985) of 0.9. The sensitivity score was far below the APA recommended level of 0.8. The purpose of developmental screening is to test a population with a standardised screening tool, and thereby to identify children who require more in depth assessment (Thomas et al, 2011). However, it is costly and time consuming to administer standardised tests to every child (Netelenbos, 2005). Therefore a two-step procedure is commonly used. Netelenbos (2005) describes how in the first step a teacher is asked to generally assess motor ability and identify children below average for their age. In the second step these children are screened on a standardised motor assessment. This approach has been used by many authors, including Wang et al (2009), Peens et al (2008), Wilson et al (2000), and Wright and Sugden (1996). Essentially, this study is assessing the validity of the first step of this process. In this initial step a high sensitivity is desired to include all of those with motor difficulties, not to exclude all of those without motor difficulties (Netelenbos, 2005).

The common path of referral for children with motor difficulties to paediatric physiotherapy private practices in Johannesburg is by class teachers. Given the extremely low sensitivity of teachers' identifications, this is not a valid method of referral. An alternative, namely standardised questionnaires, is discussed below .

In the literature no other studies were found that essentially used teachers' own observation skills, without the aid of a tool, to obtain a description of motor ability. Nevertheless, several other studies did assess teacher's ability to identify motor difficulties. It must be noted that as different tools were used, the results may be a reflection of the tool rather than the teacher. It was not clear from the studies whether the prevalent referral practice was using standardised tools or teacher identifications without the aid of a tool.

Piek and Edwards (1997) found that class teachers could only identify 25% of children with probable DCD using the MABC Checklist (Henderson and Sugden, 1992) as the tool for teachers to identify children with motor difficulties. However, the literature regarding the reliability and validity of the MABC Checklist is conflicting. Junaid et al (2006) reported a sensitivity of 0.14 and a specificity of 0.97, while Schoemacher et al (2003) reported a sensitivity of 0.62 and a specificity of 0.66.

6.3.1Manual Dexterity

One of the frequently cited activity limitations in children with DCD is slow or messy handwriting, and difficulty with other classroom tasks, such as crafts (Magalhães et al, 2011). Missiuna et al (2008), discussing the concerns of parents of children with DCD, found that printing/writing, cutting/crafts, task completion, and eating with cutlery were all challenges to these children. Kirby et al (2011) found that difficulty with the speed and neatness of handwriting persists into adulthood.

For Manual Dexterity sensitivity was 0.36 and the specificity was 0.77. This is far below the 0.8 and 0.9 respectively recommended by the APA (1985). This result indicates that the teachers were identifying too few of the children with difficulties in the area of Manual Dexterity, but identifying as impaired too many of those without difficulties. The PPV was 0.52, indicating that a child who was identified as having motor difficulties by the teacher was only slightly more likely to have difficulties as not. When asked 'what is motor impairment', four responses specifically stated 'fine motor', and three stating 'pencil grip', for a total of seven responses, which is less than half the sample. In their answers teachers did not identify any specific fine motor skills, such as drawing, writing, cutting or doing buttons and zips.

Using case studies to obtain teachers' perceptions of children with motor difficulties, Rivard et al (2007) found that teachers showed more concern about gross motor difficulties, and were more likely to refer. This was not the case with this study, with teachers showing more concern and identifying more children with difficulties in Manual Dexterity (fine motor) than Aiming and Catching and Balance (gross motor). A possible reason for this is that teachers are more familiar with the development of fine motor skills. Grade 0 is the first year of more formal, desk-based education, so teachers may be more aware of difficulties with these new tasks than with more gross motor, outdoor play-based activities.

Of the three sections, teachers' sensitivity was best for Manual Dexterity. The tasks in this section of the MABC-2 included posting coins in a box, threading beads, and a drawing trail. These are tasks frequently performed in the average classroom, and therefore would have been frequently observed by the teachers. This is consistent with the opinion of Faught et al (2008) that teachers have the opportunity to observe children over time more than other professionals.

Chang and Yu (2010) cite differing evidence as to whether teachers are able to identify handwriting difficulties or not. They note that 13% to 27% of children experience handwriting difficulties. Prevalence of Manual Dexterity difficulties in this study was higher at 41% (95% confidence interval 30% to 52%). A possible reason for this is scoring the drawing trail item. One of the mistakes characterised as an error was lifting the pen, and another was drawing outside the lines. In order to turn a corner some children tended to lift the pen and re-orientate it. This was then marked as an error. During the 'practice' trial and between trials they were reminded not to do this, but the pen lifting still persisted. It is possible that they had been taught to lift their pen rather than make a mistake, which resulted in additional errors being scored on the MABC-2.

6.3.2Aiming and Catching

For Aiming and Catching the sensitivity of the teachers was 0.33 and the specificity was 0.79, again below the APA (1985) recommendations. For this section the prevalence of difficulties was very low at four percent, or three out of the total of 81. Of those three, only one was identified correctly ('true positive') while another 16 were incorrectly identified as having difficulties ('false positives').

The Aiming and Catching section of the MABC-2 consists of two tasks: catching a beanbag, and throwing a beanbag onto a mat. Grade 0 is part of pre-school rather than primary school, and even in schools where it is attached to the primary school, Grade 0 forms a separate unit with different activities and times. A possible reason for teachers poor performance in this area is that formal sport is not yet part of their curriculum, and therefore teachers will not have had a chance to observe aiming and catching skills in a more formal setting. This is consistent with teachers' response to the question 'what is motor impairment', where not a single answer related to such skills. Typically developing children may choose aiming and catching games during free play, but children with motor difficulties will usually avoid such activities (Magalhães et al, 2011; Missuina et al, 2008; Dewey and Wilson, 2001).

6.3.3Balance

For Balance the teachers' sensitivity was 0.25 with a specificity of 0.68. These values are lower than for any other section. However, balance difficulties are part of teachers' concept of motor impairment, with six responses to the question 'what is motor impairment' relating to balance specifically or postural control in general.

The tasks in the Balance section of the MABC-2 include both static (standing on one leg) and dynamic (jumping on mats, walking on toes on a line) elements. Humphriss et al (2011) found in a large population-based study that static and dynamic balance appear to be independent measures, and that both are more compromised with eyes closed. They also found that test-retest reliability was low. Cousins et al (2003) found that both static and dynamic balance were impaired in a group of adults who had received a childhood diagnosis of DCD or dyspraxia, with dynamic balance more affected. The authors attribute this to postural instability. Some of the teachers in this study recognise this. Responses to the question 'what is motor impairment' included 'control, 'stability' and 'core muscles'.

In a well-designed set of three experiments measuring static balance, Geuze (2003) found that children with DCD had a reduced ability to adapt to initial perturbations, but were able to adapt when the same perturbation was applied repeatedly. He suggests several reasons for this decreased balance, including reduced cerebellar control; increased co-activation of the gastrocnemius-soleus complex; lower sensitivity of the visual, proprioceptive and the vestibular systems; and slow feedback processing of sensory information. He concludes that static balance in not normally a problem for these children, but becomes so in novel situations. Geldhof et al (2006) found moderate variability in repeated measures of static and dynamic balance in children with DCD, which they attributed to natural variations in postural stability caused by physical, biomechanical, metabolic and psychosocial factors.

Teachers' ability to identify balance difficulties was particularly poor. Two possible reasons for this are:

1. Given the independence of static and dynamic balance discussed above, it may be inappropriate to group them together as one balance score on the MABC-2. No studies establishing the construct validity for the balance section of the MABC-2 with other measures of balance, such as force plates, were found. Each item consists of a practice and two trials, of which the best score is used to obtain the standard score. This should control for test-retest reliability on a given day.

2. Given that static and dynamic balance are independent, and a child's performance will not be consistent (test-retest reliability), it is possible to understand how a teacher's repeated observations of the same child will not give a clear indication of the child's true balance ability.

6.4 Overscoring and Underscoring

In the results reported by Junaid et al (2006) teachers had a tendency to under-estimate the children's ability, with more 'false negatives' (over-scoring) at 12% than 'false positives' (under-scoring) at 2%, resulting in high specificity but low sensitivity. Piek and Edwards (1997) also found a tendency to over-score ('false negatives') at 14%, as opposed to under-score ('false positive') at 10%. This is inconsistent with the results from this study, where 13% were over-scoring ('false negatives') as compared to 20% underscoring ('false positives').

The only section where teachers had a tendency to over-score rather than underscore was for Manual Dexterity. Manual Dexterity also had the highest sensitivity, at 0.36. However, the prevalence was also highest at 41%, as was total number of teacher identifications at 23. Therefore, while it may appear that over-scoring rather than under-scoring was linked to the highest sensitivity, it is most likely because it was the area where teachers identified the most children, and identified the most children correctly due to the high prevalence.

Teachers had a tendency to under-score for both Aiming and Catching and Balance, assuming that children had motor difficulties when in fact they were 'typically developing'. However, sensitivity for these sections was lower, at 0.33 and 0.25 respectively. This indicated that while teachers were identifying a relatively high number of children with motor difficulties, they were not identifying those who were actually displaying motor difficulties.

6.5 Prevalence

A secondary objective of this study was to obtain information on the prevalence of DCD in the population in Johannesburg, Gauteng. Prevalence in the current study was found to be 20%, far higher than the internationally reported figure of six percent (American Psychiatric Association, 2000). It is higher even than the figure quoted by some authors of between five and 15 percent, including Martin et al (2010); Wu et al (2009); Missiuna et al (2006); Wilson (2005); and Gwynne and Blick (2004). However, it is more similar to the prevalence of hypotonia Dawson and Puckree (2006) found in KwaZulu Natal of 25% in six- to seven-year olds. It must be noted that the methodological quality of the study was poor. It is also similar to the prevalence found by Piek and Edwards (1997), in a study of similar design to this study, also found a higher than expected prevalence of 18%.

There are three possibilities for the higher prevalence than internationally reported. The first is inherent in the sample. As noted above under Demographic Information page 73, as parental consent was required it is possible that parents considered the study as on opportunity for a motor assessment. Therefore the parents of the more affected children may have consented more frequently than the parents of unaffected children. A second possibility is that the prevalence of DCD in the South African population is higher than that of the international population, particularly those in developed countries. While the quality of the study on hypotonia by Dawson and Puckree (2006) is poor, the prevalence they reported may nonetheless be true. Finally, the MABC-2 has not been normed on a South

African population, and it is possible that the scoring and results are not appropriate for the current sample.

6.6 Teacher Factors

For teacher education level the teachers with an Honours level degree performed worst, with a sensitivity of only 0.09 and a specificity of 0.67. The teachers who performed best were those with a Nursery School Teachers diploma had a sensitivity of 0.54 with a specificity of 0.66. This result was surprising, since it is generally assumed that a higher level of education will lead to a greater degree of skill. These teachers may have greater skills with regard to teaching, but their ability to observe motor difficulties was less accurate than any other group. It is possible that the Nursery School Teachers diploma places more emphasis on motor ability than any other degree, resulting in the highest sensitivity. However, the difference between the groups was not significant, with p values of 0.61 and 0.63 for sensitivity and specificity respectively ($p>0.05$).

Teachers who reported 'always' feeling confident did have a higher sensitivity than those who reported being 'sometimes or usually' confident, at 0.43 and 0.25 respectively. This supports their belief in their own abilities. Specificity was lower for the 'always' confident teachers, at 0.7 compared to the 'sometimes or usually' confident teachers 0.8. However, their sensitivity and specificity did not reach the acceptable level of 0.8 and 0.9 respectively recommended by the APA. Nevertheless, the differences between the two groups was not statistically significant, with p values of 0.9 for sensitivity and 0.48 for specificity ($p>0.05$).

6.7 Screening tools

Several tools are currently available to screen for DCD. Some of these tools, with their reported sensitivity and specificity. A more detailed list is included in the Literature Review. Three tools in particular show good sensitivity and specificity, and could be applicable to the South African context, specifically the Motor Observation Questionnaire for Teachers (MOQ-T) (Schoemaker et al, 2008), the Teacher Estimation of Activity Form (TEAF) (Faught et al, 2008), and the Revised Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, et al 2009).

Two teacher tools appear to be useful. The Motor Observation Questionnaire for Teachers (MOQ-T) (Schoemaker et al, 2008) has a reported sensitivity of 80.5% and a specificity of 62%. It has 18 items in the fine and gross motor domains. The tool is designed for children ages five to 11. This tool was developed in the Netherlands. The Teacher Estimation of Activity Form (TEAF) (Faught et al, 2008) has a reported sensitivity of 74% and a specificity of 62%. It has ten items. The tool is designed for children primary school. It was developed in Canada. However, both of these tools were developed in developed countries, and therefore construct validity for a South African population would need to be investigated.

A parent report tool currently in frequent use in the literature is the Revised Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, et al 2009). It has with a reported sensitivity of 85% and a specificity of 71%. There are 15 items divided among the following scales: fine motor and gross motor ability, controlled movement, and general motor coordination. The tool was designed for children aged five- to 14.5-years-old, but has been adapted for three- and four-year-olds by Rihtman et al (2011) in Israel. This tool was developed in Canada. Again, the specific items would need to be evaluated for cultural relevance and adapted as necessary.

CHAPTER 7: CONCLUSION

The purpose of this study was to evaluate the ability of Grade 0 teachers to identify children with motor difficulties. The teachers and children were from various independent schools in an area of Johannesburg. The tool used to objectively assess motor ability was the Movement Assessment Battery for Children Second Edition (MABC-2). A specifically designed questionnaire following the sections of the MABC-2 was used to obtain the teacher's opinion on the motor ability of each child.

The findings of this study support previous research showing that teachers are not able to accurately assess the motor ability of children in their class (Junaid et al, 2006; Piek and Edwards, 1997). The poor sensitivity and specificity for each section of the MABC-2 and overall suggest that teacher opinion of motor ability is not a reliable means to identify children with motor difficulties. Overall prevalence, at 20 percent, was found to be higher than the APA (2000) reported statistic of six percent. Information regarding teachers' opinions of what constituted motor difficulties was obtained, but a detailed analysis of why this was so was not in the scope of this research. The use of standardised questionnaires to identify children with motor difficulties should be considered.

7.1 Implications of the Findings

Poor sensitivity and specificity was demonstrated when comparing teachers' opinions of the motor ability of children to a standardised assessment of motor ability in children, the MABC-2. It should therefore be assumed that teachers are unable to identify children with motor difficulties. This is true for both fine motor (Manual Dexterity) and gross motor (Aiming and Catching and Balance) abilities. However, some limitations of the study should be taken into account when interpreting the implications of this study.

7.2 Limitations of the Study

- The sample size was relatively small, at only 16 teachers.

- The MABC-2 is currently the best available tool, but there is not yet a 'gold standard' for identifying children with motor difficulties.

- The MABC-2 has not been normed on a South African population.

- The study involved only Grade 0, and therefore the results should be applied with care to other age groups.

- The study was only conducted in Independent schools, and therefore care should be taken when applying the results to Gauteng Department of Education schools.

7.3 Recommendations

- Teacher assessments of children's motor ability should not be relied on as the main referral source for children with DCD.

- A standardised, well validated screening tool should be normed on the South African population, and should routinely be used to screen pre-school and primary school populations to identify children with motor difficulties.

- A well-designed, comprehensive prevalence study should be conducted in South Africa in order to establish the true prevalence of DCD in this country.

- Further qualitative research should be done to establish why teachers are unable to accurately assess motor ability, and which areas they have the most difficulty in.

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APPENDIX I: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Ms Tamara B Gritzman

CLEARANCE CERTIFICATE	**M091124**
PROJECT	An Evaluation of Teachers' ability to Identify Children with Motor Difficulties
INVESTIGATORS	Ms Tamara B Gritzman.
DEPARTMENT	Department of Physiotherapy
DATE CONSIDERED	2009/11/27
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 19/01/2010 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : N Hilburn

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...

APPENDIX II: COMPLETED CONSENT FORMS FROM SCHOOLS

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, VAL ARONSON, principal of KING DAVID LINKSFIELD School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 5

Signed: [signature]

Print: : VAL ARONSON

Date: 20 July 2010

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, Lucy de Sousa, principal of Linksfield Castle Pre-Primary School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 18

Signed: [signature]

Print: : L.A. De Sousa

Date: 7/10/10

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, ELIZABETH HUMAN, principal of ELMA PARK PRE-PRIMARY School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 2

Signed: E Human.

Print: : E.C. HUMAN

Date: 12 OCTOBER 2010.

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, Barbara Eaton, principal of Crawford Village Pre-Primary School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 2.

Signed: BEaton

Print: : B.A. EATON

Date: March 2011

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, Yvonne, principal of Dunvegan Nursery School School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 2

Signed: [signature] ______________

Print: : ______________ ______________

Date: March 2011

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, DOROTHY MATTHEWS, principal of Bedfordview Pre-primary School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: 1

Signed: D Matthews ______________

Print: : D MATTHEWS ______________

Date: 10 June 2011

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, Rabbi Zeev Krainer MEd, principal of Shaarei Torah School School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: ______________________

Signed: [signature] Principal

Print: : RABBI Zeev KRAINER

Date: 4/7/2011

APPENDIX III: SCHOOL INFORMATION SHEET

To Whom It May Concern:

I am a Physiotherapy Masters Student at the University of the Witwatersrand. I am evaluating whether Grade R teachers in an area of Johannesburg, South Africa, are able to identify children with motor difficulties. Ethical clearance for this study has been obtained from the Human Research Committee of the University of the Witwatersrand (Clearance number: M091124).

In order to collect the relevant data, I would ask Grade 0 teachers interested in participating in the study to submit a class list. From that list I would select several children. Once informed consent and basic demographic information has been obtained from parents of the selected children, the teachers would be asked to complete a short questionnaire relating to the each selected child's motor performance. In addition, each teacher will be asked to complete a separate, single page questionnaire relating to his/her own experience and understanding of children with motor difficulties. Each of the selected children will then be tested using the Movement Assessment Battery for Children Second Edition (Henderson and Sugden, 2007). This is a standardized test designed to evaluate motor function in children. Testing will be conducted by myself and my research assistant.

Should any of the parents of the selected children request specific feedback on their child, this will be provided. In addition, once the study is completed, the school will be offered in-service training for teachers or for parents on the findings of the study as well as general information on children with motor difficulties.

Should your school be willing to participate in such a study, please fill out the consent form below.

Yours sincerely,

Tamara Gritzman
BSc Physiotherapy (University of the Witwatersrand)

082 685 4475
tamaragritzman@gmail.com

APPENDIX IV: SCHOOL CONSENT FORM

An Evaluation of Teachers' Ability to Identify Children with Motor Difficulties

I, ____, principal of ____ School, consent for Tamara Gritzman (BSc Physiotherapy), to use our school as part of her study evaluating Grade 0 teachers' ability to identify children with motor difficulties.

Number of Grade 0 classes: ______________________

Signed: ______________________ ______________________

Print: : ______________________ ______________________

Date: ______________________

APPENDIX V: TEACHER INFORMATION SHEET

Dear Teacher,

I am a Physiotherapy Masters Student at the University of the Witwatersrand. I am evaluating whether Grade R teachers in an area of Johannesburg, South Africa, are able to identify children with motor difficulties. Ethical clearance for this study has been obtained from the Human Research Committee of the University of the Witwatersrand, clearance certificate number M091124.

In order to collect the relevant data, I would ask Grade 0 teachers interested in participating in the study to submit a class list. From that list I would select several children. Once informed consent and basic demographic information has been obtained from parents of the selected children, the teachers would be asked to complete a short questionnaire relating to the each selected child's motor performance. This questionnaire includes sections on manual dexterity, aiming and catching, and balance. It also includes more general questions on the teacher's opinion of the child's general gross and fine motor function, as well as a general concerns section. This should take approximately five minutes to complete. In addition, each teacher will be asked to complete a separate, single page questionnaire relating to his/her own experience and understanding of children with motor difficulties. Again, this should take approximately five minutes to complete. Each of the selected children will then be tested using the Movement Assessment Battery for Children Second Edition (Henderson and Sugden, 2007). This is a standardized test designed to evaluate motor function in children. Testing will be conducted by myself and my research assistant. The results of the teacher questionnaire and the Movement Assessment Battery for Children Second Edition will then be compared.

Should any of the parents of the selected children request specific feedback on their child, this will be provided. In addition, once the study is completed, the school will be offered in-service training for teachers or for parents on the findings of the study as well as general information on children with motor difficulties.

All information regarding each individual teacher and child will remain anonymous. By completing the teacher questionnaires you are giving your consent to participate in the study, which you may withdraw at any time. Should you have any questions, please do not hesitate to contact me.

Yours sincerely,

Tamara Gritzman
BSc Physiotherapy (University of the Witwatersrand)

082 685 4475
tamaragritzman@gmail.com

APPENDIX VI: TEACHER QUESTIONNAIRE

Motor Ability – Questionnaire for Teachers

Teacher's name: ____

School: ____

Qualifications: ____

Years of teaching: ____

In your understanding, what is motor impairment?-

____

____

____

Have you attended any talks / workshops motor difficulties in children? If yes, when?

____

____

____

Do you feel confident in identifying children with motor difficulties who need referral? Why?-

____

____

____

Would you like more information on the subject?

____

Thank you for your participation.

APPENDIX VII: MOTOR ABILITY QUESTIONNAIRE FOR TEACHERS

Child's Name: ______________________________

Gender: Male ☐ Female ☐

Please rate this child's motor performance in the specified area.
Normal – Normal motor ability
At Risk – At risk for motor difficulties
Impaired – Impaired motor ability

	Normal	At Risk	Impaired
Manual Dexterity *(how the child copes with precision manual tasks i.e. how he/she uses his/her hands)*	☐	☐	☐
Aiming and catching *(how the child throws and catches i.e. how he/she uses his/her arms and body together)*	☐	☐	☐
Balance *(how the child holds steady when keeping still or moving i.e. how he/she controls his/her body)*	☐	☐	☐

Please answer *Yes* or *No* to the following questions.

	Yes	No
In your opinion, does this child have gross motor difficulties?	☐	☐
In your opinion, does this child have fine motor difficulties?	☐	☐
Do you think this child should be referred for a physiotherapy assessment?	☐	☐
As far as you are aware, is this child receiving physiotherapy?	☐	☐
As far as you are aware, have they in the received physiotherapy in the past?	☐	☐

Are there any other areas of this child's function that concern you?

____

Thank-you for your participation

Based on the Movement Assessment Battery for Children II
Compiled by Tamara Gritzman (BSc Physiotherapy)

APPENDIX VIII: PARENT INFORMATION SHEET

Dear Parent,

I am a Physiotherapy Masters Student at the University of the Witwatersrand. I am evaluating whether Grade 0 teachers in an area of Johannesburg, South Africa, are able to identify children with motor difficulties. Ethical clearance for this study has been obtained from the Human Research Committee of the University of the Witwatersrand, clearance certificate number M091124.

There are several different terms for children who experience motor difficulties, including ‘developmental coordination disorder’, ‘clumsy’, ‘developmental apraxia’, and colloquially ‘low tone.’ Essentially, all these terms imply difficulty with motor tasks, both fine and gross motor, that impair the child’s ability to function in daily life. Currently the established prevalence of such motor difficulties in the population is known to be around 6%. By definition, DCD significantly impacts a child’s performance in activities of daily living and academic achievement. Research has shown that without intervention and treatment these difficulties persist through school and continue to limit the child’s academic and social performance. It is therefore important to identify children having motor difficulties as early as possible in order to limit the long term impact. Often it is the teachers who first identify children having such difficulties in the classroom.

In order to collect the relevant data, I have asked Grade 0 teachers interested in participating in the study to submit a class list. From that list I have randomly selected several names, including that of your child. The motor ability of the selected children is unknown prior to assessment, and selection is completely random. For those children whose parents give consent to participate, the teachers would be asked to complete a short questionnaire relating to the child’s motor performance. Each of the selected children will then be tested using the Movement Assessment Battery for Children Second Edition (Henderson and Sugden, 2007). This is a standardized test designed to evaluate motor function. Testing will be conducted by myself and my research assistant.

Should you wish to have specific feedback on your child’s performance, this will be provided. In addition, once the study is completed, the school will be offered in-service training for teachers or for parents on the findings of the study as well as general information on children with motor difficulties.

Should your be willing for your child to participate, please fill out the consent form and demographic information below. **Please note that the selection is random and does not in any way imply that your child has difficulties.**

Yours sincerely,

Tamara Gritzman
BSc Physiotherapy (University of the Witwatersrand)
082 685 4475
tamaragritzman@gmail.com

APPENDIX IX: PARENT CONSENT FORM

Consent Form

Child's name: ________________________ **Date of Birth:** __________________

School: ______________________ **Teacher:** __________________

Male ☐ **Female** ☐

Birth History

Duration of Pregnancy (Weeks) ________________ **Type of Delivery** (Normal, Caesar, etc) ______________

Baby's Birthweight ________________ **APGAR scores** ______________

Was your child in ICU? ________________ **Duration** ______________

Was she/he ventilated? _________________ **Duration** ______________

Medical and Surgical History

Serious illnesses:

____

Operations/accidents:

____

I, _________________________________, parent/guardian of __________________________, consent for him/her to participate in the study on Grade 0 teachers' ability to identify children with motor difficulties. I give permission for his/her teacher to complete a questionnaire on his/her motor performance, and for him/her to be tested with the Movement Assessment Battery for Children Second Edition (Henderson and Sugden, 2007). I understand that I may withdraw from the study at any point.

Signed: __________________________________ **Date:** _________________________________

Would you like specific feedback on your child's performance? Yes ☐ **No** ☐

Thank-you for your interest and cooperation.

APPENDIX X: FEEDBACK FORM

Dear parent/s of ______________________,

Thank you for allowing me to assess your child as part of my study towards a Masters Degree in Physiotherapy. As explained in the consent form and information sheet, I randomly selected children from each class and compared the teacher's opinion of their motor ability to the results of a standardized test, the Movement Assessment Battery for Children Second Edition (MABC-II) by Henderson, Sugden and Barnett (2007). The MABC-II is a standardized test designed to differentiate between children with severe, mild and no motor difficulties. It looks at three different sections, namely manual dexterity (fine motor), aiming and catching, and balance. Scores for each section are given in percentiles, with 0 being the lowest motor ability and 100 being the highest. The activities used to test each section have been researched extensively and have been shown to be indicative of overall motor performance.

Your child's scores were as follows:

On the ______ percentile for the manual dexterity section, indicating
____
____

On the ______ percentile for the aiming and catching section, indicating
____
____

On the ______ percentile for the balance section, indicating
____
____

On the ______ percentile overall, indicating
____
____

Thank-you for allowing your child to participate in this study. Should you have any other questions, please do not hesitate to contact me.

Yours sincerely,

Tamara Gritzman
BSc Physiotherapy (University of the Witwatersrand)
0826854475
tamaragritzman@gmail.com

APPENDIX XI: STANDARD ANSWERS FOR FEEDBACK FORM

Answers for each percentile score

<u>1st, 2nd and 5th</u>

indicating that your child is having significant difficulty in this area, and further assessment to identify any weaknesses is advised.

<u>9th and 16th</u>

indicating that your child is in the 'at risk' category, and is therefore may be experiencing difficulties. Further assessment is recommended.

<u>25th and 37th</u>

indicating that your child is performing within normal for their age range, although slightly below average.

<u>50th</u>

indicating that your child is performing exactly at average when compared to other children of the same age.

<u>63rd and 75th</u>

indicating that your child is performing above age-average in this area.

<u>91st, 95th, 98th and 99th</u>

indicating that your child is within the top 10%/5%/2%/1% of children of the same age in this area.