

**PREVALENCE OF CHILDREN ‘AT RISK’ OF
DEVELOPMENTAL COORDINATION DISORDER
IN A PRIMARY SCHOOL IN EAST LONDON,
SOUTH AFRICA**

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Thesis statement:

‘A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science (Medicine) Child Health Neurodevelopment’

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DECLARATION

I, Kerrin Judy Raats, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Science (Medicine) Child Health Neurodevelopment at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



_____ (Signature of candidate)

24th day of July 2020 in East London, South Africa

DEDICATION

In dedication to my family and my God.

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ABSTRACT

Developmental Coordination Disorder (DCD) affects motor skills in 5-6% of children globally, impacting academic and sporting performance. This study investigated the screened 'at risk' of DCD prevalence in a group of children in a single school in the Eastern Cape, South Africa and how this impacted on academic performance and sporting participation. The Developmental Coordination Disorder Questionnaire (2007) (DCDQ'07) was used as a parent-completed, standardised outcome measure. Demographic, coordination, academic and sporting performance data was collected from 69 children, mean age of eight years (range five to eleven years). Eight children (11.6%; n=69) screened positive for 'at risk' of DCD. The male to female ratio of 'at risk' of DCD was found to be 2.5:1, closely matching global norms. Boys and those repeating a school grade were significantly more likely to have fine motor and handwriting coordination difficulties ($p=0.04$ and $p=0.001$ respectively). Children who had repeated a grade also showed more difficulty with controlling the amount of pressure or effort required to write or draw ($p=0.00$). Running speed and pattern was shown to affect boys more than girls ($p=0.03$). Children not participating in team sports were significantly more likely to experience overall coordination difficulties ($p=0.010$). Academic performance was shown to be significantly affected in children who had repeated a grade and who were found to be 'at risk' of DCD compared to those 'not at risk' ($p=0.0179$). Although higher than the global diagnosed prevalence, screened 'at risk' of DCD prevalence results are similar to other South African data. Increased awareness of the disorder and early screening may aid optimal referral of children 'at risk' of DCD with the aims of thereby improving academic performance and sporting participation.

TABLE OF CONTENTS

DECLARATION	ii
DEDICATION.....	iii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
LIST OF TABLES.....	ix
NOMENCLATURE	x
CHAPTER 1: INTRODUCTION	1
1.1_General Introduction.....	1
1.2 Problem statement	2
1.3 Significance of the study.....	2
1.4 Aim of the study	2
1.5 Objectives of the study	3
1.6 Conclusion	3
CHAPTER 2: LITERATURE REVIEW	4
2.1 Introduction.....	4
2.2 Definition	5
2.2.1 Current definition of DCD.....	5
2.2.2 Other terminologies used for DCD	5
2.3 Prevalence	7
2.3.1 Comparing South African to global findings.....	7
2.4 Aetiology.....	9
2.4.1 Functions of brain areas linked to DCD	11
2.5_Clinical presentation	12
2.6 Coordination of movement	144
2.6.1 Motor skills and their impact on ADLs.....	144
2.6.2 Psychosocial impact	14

2.7 Functional outcomes	14
2.7.1 Academic performance	15
2.7.2 Sporting participation	15
2.8 Comorbidities	17
2.9 Risk factors.....	17
2.10 Outcome measures.....	18
2.10.1 Selection of the DCDQ'07 outcome measure.....	19
2.11 Intervention approaches	20
2.12 Conclusion.....	21
CHAPTER 3: METHODOLOGY	23
3.1 Introduction	23
3.2 Ethical clearance.....	23
3.3 Study population and location.....	23
3.4 Inclusion criteria	24
3.5 Exclusion criteria.....	24
3.6 Study design	24
3.7 The DCDQ'07 outcome measure	25
3.8 Procedure	27
3.9 Data analysis	29
3.10 Funding	29
3.11 Anticipated limitations and potential solutions.....	29
3.12 Conclusion.....	30
CHAPTER 4: RESULTS	31
4.1 Introduction.....	31
4.2 Data analysis	31
4.3 Demographics.....	32

4.3.1 General demographics	32
4.3.2 Academic data.....	34
4.3.3 Sporting data	35
4.3.4 Additional medical information	36
4.3.5 Parental/ guardian comments.....	36
4.4 Results of the DCDQ'07.....	39
4.4.1 Control During Movement Scale (Q1-Q6).....	39
4.4.2 Fine Motor/ Handwriting Scale (Q7-Q10)	40
4.4.3 General Coordination Scale (Q11-Q15).....	41
4.5 Children 'at risk' of DCD	42
4.5.1 Data profiles of children 'at risk' of DCD.....	42
4.5.2 Prevalence of children 'at risk' of DCD	44
4.5.3 Factors affecting coordination in cohort.....	44
4.6 Factors correlated with coordination difficulties.....	45
4.6.1 Correlations affecting academic performance	45
4.6.2 Correlations affecting sporting participation	47
4.7 Comparison of children 'at risk' with those 'not at risk' of DCD	48
4.7.1 Comparison of the two groups for academic performance.....	49
4.7.2 Comparison of the two groups for sporting participation	49
4.8 Conclusion	50
CHAPTER 5: DISCUSSION	52
5.1 Introduction.....	52
5.2 Return rate of questionnaires	52
5.3 Demographics.....	53
5.3.1 General demographics.....	53
5.3.2 Academic performance.....	54

5.3.3 Sporting participation	55
5.3.4 Additional medical information	57
5.3.5 Parent/ guardian comments.....	60
5.4 Discussion of findings of the DCDQ'07 outcome measure.....	60
5.4.1 Control During Movement Scale (Q1-Q6)	61
5.4.2 Fine Motor/ Handwriting Scale (Q7-Q10)	62
5.4.3 General Coordination Scale (Q11-Q15).....	63
5.5 Prevalence of children 'at risk' of DCD	65
5.5.1 Global versus South African prevalence of DCD	65
5.5.2 Screened prevalence of 'at risk' of DCD in cohort.....	66
5.5.3. Data profiles of children 'at risk' of DCD	67
5.5.4 Factors affecting coordination in cohort.....	71
5.6 Factors correlated with coordination difficulties.....	74
5.6.1 Correlations affecting academic performance	74
5.6.2 Correlations affecting sporting participation	76
5.7 Comparison of children 'at risk' to those 'not at risk' of DCD	78
5.7.1 Comparison of the two groups for academic performance.....	78
5.7.2 Comparison of the two groups for sporting participation.....	78
5.8 Implications of this study	79
5.9 Limitations of this study	80
5.10 Recommendations for further research and clinical work	80
5.11 Conclusion.....	80
CONCLUSION.....	82
APPENDICES	84
REFERENCES	122

LIST OF TABLES

Table	Page
3.1 Internal consistency of the DCDQ'07 in cohort	26
3.2 Standardised South African report card scores	28
4.3 General demographics (n=69)	33
4.4 Academic performance data (n=69)	34
4.5 Sporting participation data (n=69)	35
4.6 Additional medical information (n=69)	36
4.7 Parental/guardian comments	37
4.8 Control During Movement Scale (n=69)	40
4.9 Fine Motor/Handwriting Scale (n=69)	41
4.10 General Coordination Scale (n=69)	42
4.11 Data profiles of 'at risk' of DCD participants. 'Red flags'(n=8)	43
4.12 Correlations between coordination and male gender	45
4.13 Correlations between coordination and repeated grade	46
4.14 Correlations between coordination and team sport participation	47
4.15 Correlation between male gender and gait	48
4.16 Comparison of children 'at risk' to 'not at risk' for academic performance	49
4.17 Comparison of children 'at risk' to 'not at risk' for sporting participation	49

NOMENCLATURE

ADL	Activities of daily living
ADD	Attention Deficit Disorder
ADHD	Attention Deficit Hyperactivity Disorder
ASB	Aptitude test for School Beginners
ASD	Autistic Spectrum Disorder
BOT 1/2/-SF	Bruininks Oseretsky Test of Motor Proficiency (First/ Second version/ -Short form)
CD	Conduct Disorder
DAMP	Disorder of Attention and Motor Planning
DCD	Developmental Coordination Disorder
DCDQ'07	Developmental Coordination Disorder Questionnaire (2007)
DSM-V/ -IV	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition/ Fourth Edition
EACD	European Academy of Childhood Disability
EEG	Electroencephalogram
ELBW	Extremely Low Birth Weight
fMRI	Functional Magnetic Resonance Imaging
GA	Gestational age
HREC	Human Research Ethics Committee
ICF	International Classification of Functioning, Disability and Health
IQ	Intellectual Quotient
MABC 1/2	Movement Assessment Battery for Children, First/ Second Edition
MBD	Minimum Brain Dysfunction
NSS	Neurological soft signs
OT	Occupational Therapy
ODD	Opposition Defiance Disorder
PROM	Premature rupture of membranes
QOL	Quality of life
ROM	Rupture of membranes
SD	Standard Deviation
SDDMF	Specific Developmental Disorder of Motor Function
TD	Typically developing
UK	United Kingdom
VMI	Visual Motor Integration
VMI-4	The Beery-Buktenica developmental Test for Visual Motor Integration, Fourth version
VPT	Very preterm
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION

1.1 General Introduction

Developmental Coordination Disorder (DCD) is a disorder resulting in motor incoordination, the aetiology of which is currently not well understood. Difficulty is experienced in the affected individual's ability to acquire and execute different types of motor movements which are necessary for learning and functioning in various life domains. A thorough review of the literature is summarised below.

The definitions and terminologies used to describe DCD and other motor challenges have changed over the last few decades. The latest definition of DCD by the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition (DSM-V) (1) is currently in use and is less broad in its reach than the previous World Health Organisation (WHO) definition (2) which also included (and excluded) other motor difficulties. Terminologies such as Specific Developmental Disorder of Motor Function (SDDMF) and developmental dyspraxia, amongst others, have been used to define the condition. There has been some confusion amongst medical professionals and others due to the different motor conditions and their differing terminologies. DCD is currently the most widely accepted term used and the current definition in the DSM-V aims to bring clarity to this heterogenous condition.

The prevalence of DCD appears to vary considerably amongst researchers and in different regions but generally is said to be approximately 5-6% globally (3, 4) in children and adults alike. The presentation of this disorder is broad resulting in a range of challenges which can affect the individual physically, socially and psychologically, as well as within the scholastic and sporting arenas (1, 5, 6). Awareness of the disorder varies from country to country and within regions; as well as amongst health professionals and the general population (7, 8). The importance of early screening, accurate diagnostic assessment tools for clinicians and educational resources for families has been recommended to manage this condition optimally (8).

1.2 Problem statement

Despite some ongoing research into DCD having been conducted in South Africa in more recent years, the majority of knowledge gained regarding this disorder to date has originated from first world countries with a scarcity of published research coming from South Africa when compared to other countries. Awareness of this disorder is also poor, with health professionals either having not heard of DCD or having little exposure to or experience in diagnosing this disorder (7, 8). Another area of concern is that DCD is not only a motor problem but has been shown to negatively affect many functional life domains such as in the scholastic, sporting and psychosocial arenas (5) with potentially long lasting impact (6).

1.3 Significance of the study

South Africa is often defined as being both first and third world in its socioeconomic status versus countries of a more first world nature such as Canada from which the DCDQ'07 screener was developed. Within the African landscape, additional benefit could be gained from continued studies being undertaken, specifically in countries such as South Africa, as well as other Sub-Saharan African and other low to middle-income countries. Although similar studies have been completed in other provinces of South Africa (9-11), there appears to be a paucity of published research in the Eastern Cape province to date.

1.4 Aim of the study

This locally based work therefore aims to add to the current South African DCD knowledge base, thereby assisting in the management of children's academic performance and sporting participation in the local context. The study investigated the prevalence of children 'at risk' of DCD, in a group of school children in the Eastern Cape and this disorder's possible impact on their academic performance and sporting participation. Other factors, including differential diagnoses or confounders; comorbid conditions; risk factors; and parental concerns amongst others, were also considered and will be discussed in detail in the sections below.

1.5 Objectives of the study

In this study the following objectives were investigated:

1. To determine the prevalence of children in Grades 00 to 4 (aged five to eleven years) screened 'at risk' of DCD within a single school in the Eastern Cape, South Africa.
2. To compare children screened 'at risk' of DCD to children screened 'not at risk' of DCD in terms of their academic performance.
3. To compare children screened 'at risk' of DCD to children screened 'not at risk' of DCD in terms of their sporting participation.

1.6 Conclusion

In conclusion, DCD is a heterogenous disorder of motor incoordination which may be associated with a number of risk factors and comorbidities. The International Classification of Functioning, Disability and Health (ICF) framework has shown that these factors do influence the presentation and management of this disorder (11). Various terminologies have been used to define DCD and the disorder has been shown to influence different life domains and often continues into adulthood. Global prevalence of DCD has been found to be 5-6% of the general population. A paucity of South African published research has been noted with no known studies published to date in the Eastern Cape province. This study therefore investigated the prevalence of children 'at risk' of DCD in a primary school in the Eastern Cape province in South Africa, as well as the effect on these 'at risk' individual's academic performance and sporting participation. Findings of the study aim to add to the current DCD knowledge base thereby improving awareness of this disorder in terms of its 'at risk' or suspected prevalence, with the hope of specifically improving affected individual's academic and sporting outcomes.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

DCD has been included in the DSM-V under both learning and motor disorders of neurodevelopmental origin (1). The term was agreed upon at the European Academy of Childhood Disability (EACD) in 2012 (12).

In 2019, the EACD reconvened as an international, multidisciplinary panel of experts in the field of Paediatric neurodevelopment and included parental representation, to revise the collaborative meeting by the EACD in 2012, in order to include new research on DCD (3, 12). The panel gathered information through comprehensive literature reviews and expert consensus in order to review the key areas of: assessment criteria; underlying mechanisms; treatment interventions and psychosocial concerns in adolescents and adults with DCD. Twenty-two new recommendations, rated according to the Oxford Centre for evidence-based medicine, were added to the database in the 2019 collaboration. This international collaboration of experts performed extensive meta-analysis studies of the current literature and aimed to inform good clinical practice in the area of DCD. The new recommendations were added to the 2012 knowledge base specifically in the following areas: diagnosis; assessment; psychosocial outcomes; adolescents and adults with DCD and lastly the usefulness of active video games, compared to the more traditional activity or participation-orientated interventions often used for DCD. The publication has been internationally validated until the next five-yearly review in 2022. As new research is published, additional relevant data will be added to this growing knowledge base (3).

This Literature Review aimed to critique key research articles regarding the current global and South African knowledge base on DCD and will be addressed in the subsections below. Studies from renown published sources, for example, PubMed with strong methodology and good sample sizes will be included for this review, with year ranges from 1986 to present day, although the majority of the reported studies have been from more recent years. Relevance to the local South African context will also be considered.

2.2 Definition

2.2.1 Current definition of DCD

The DSM-V currently uses the following criteria to define DCD:

Difficulty in learning and performing coordinated motor skills relative to chronologic age, despite the opportunity to develop skills; often seen as clumsy, slow or inaccurate when performing motor skills.

- The above deficits significantly or frequently affect age-appropriate activities of daily living and impact scholastic performance; vocational success and recreation and play activities
- Early developmental onset of symptoms
- The motor skills deficits are not due to intellectual disability, visual impairment or any other neurologic condition affecting movement (1).

2.2.2 Other terminologies used for DCD

Over the years a variety of terms such as ‘motorically awkward’, ‘clumsy’ and ‘dyspraxic’ have been used to describe children affected by motor difficulties (13). One of the earliest terms used to describe DCD was developmental dyspraxia. An older source from 1995 referred to dyspraxia as a broad term used to describe problems of planning and motor sequencing, including other areas such a speech motor function. According to this source, individuals with DCD, on the other hand, often have more difficulty with their ability to acquire new, as well as execute learned, motor movements (14).

According to a review in 2007, many health care professionals use developmental dyspraxia as synonymous with DCD, although DCD is becoming the preferred term in most countries at present having a formal DSM-V definition (15). This research also mentions other terms such as: clumsiness or ‘the clumsy child syndrome’; minimal brain dysfunction (MBD); developmental apraxia; perceptual motor dysfunction; motor learning difficulty; sensory integration disorder; disorder of attention and motor perception (DAMP) and Developmental Coordination Disorder (DCD) (15).

The acronym DAMP, like ‘Clumsy child syndrome’, as DCD was also previously named, is viewed by many professional as derogatory and can cause unhelpful labelling or stigmatization of a child, with a potentially negative impact (16). This author has suggested that DAMP be changed to DCD ‘plus’ as this disorder involves both coordination and attention difficulties. Attention Deficit Hyperactivity Disorder (ADHD) is often seen as a comorbid disorder in DCD individuals, hence this suggestion (15).

Specific Developmental Disorder of Motor Function (SDDMF) was another term later used by the WHO to describe DCD until 2012 (2). SDDMF was thus defined by the WHO in the following way:

‘A disorder in which the main feature is a serious impairment in the development of motor coordination that is not solely explicable in terms of general intellectual retardation or of any specific congenital or acquired neurological disorder. Nevertheless, in most cases a careful clinical examination shows marked neurodevelopmental immaturities such as choreiform movements of unsupported limbs or mirror movements and other associated motor features, as well as signs of impaired fine and gross motor coordination.

Including:

Clumsy child syndrome
Developmental Coordination Disorder
Developmental Dyspraxia

Excluding:

Abnormalities of gait and mobility
Lack of coordination secondary to ‘mental retardation’

Although the term SDDMF is no longer used, this previous ICD-10 code diagnosis may still be useful in terms of accurately describing DCD as not only a disorder of coordination but also one that affects other areas of the individual’s functioning abilities (3). SDDMF is also useful descriptively, as within this definition above lies some of the effects of this disorder for example, choreiform movements and fine and gross motor incoordination, which are less specified in the current DCD definition by the DSM-V (1).

The numerous labels used for either developmental dyspraxia or DCD can often lead to confusion of both the diagnosis and therefore treatment approaches. This highlights the importance of having a multidisciplinary team approach to management, not only according to a diagnostic label, but more importantly according to thorough, standardised clinical assessment by the multidisciplinary team. Consensus should be reached by all members of this team, including the individual, in order that correct intervention approaches for this individual can be attained for their long-term functioning success. Having a correct clinical understanding of the various terms used for the different motor problems is therefore important in determining the correct treatment approach to be recommended.

2.3 Prevalence

2.3.1 Comparing South African to global findings

According to global studies the prevalence of DCD appears to be 5-6% of the general population (3, 4, 17) although studies from certain countries have shown varying results to this percentage. The majority of knowledge gained regarding DCD to date has originated from first world countries, with some ongoing research into DCD being started and conducted in South Africa in more recent years (9-11, 18). Within the South African context, additional benefit could be gained from continued studies being carried out specifically in Sub-Saharan Africa and other low/middle-income countries. South Africa is often defined as being both first and third world in its socioeconomic status versus countries of a more first world nature such as Canada from which the DCDQ'07 screening instrument was developed (19).

As noted above, the EACD conducted a meta-analysis in 2019 where extensive reviews of the current published DCD data was critiqued by a multidisciplinary, international panel of experts and the global prevalence was found to be 5-6% (3). Representatives from a number of countries, including South Africa, were included on the panel and authored the work which may be viewed as the gold standard for the present clinical guidelines regarding DCD. This meta-analysis included amongst other discussions, diagnosis, mechanism, outcome measure and interventions best suited to DCD based on the current global knowledge base.

An earlier study conducted in the United Kingdom (UK) in 2009 investigated the prevalence of DCD in a group of seven-year-old school children (17). Interestingly this study used the previous Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (20) to define diagnostic criteria in the participants. The DSM-IV criteria for DCD are similar to those of the DSM-V, but it can be noted that amongst some of the criteria that were removed from the DSM-IV, which is now obsolete, were: 'poor participation in sport'; 'poor handwriting' and 'poor academic performance'. These criteria may have been removed from the DSM-V definition, as other causes of poor performance in these areas, besides coordination difficulties, need to be excluded, for a DCD diagnosis to be definitively made. This study used data from the Avon Longitudinal Study of Parents and Children, a UK birth cohort. The results were gathered from 6990 children, of whom 123 children were diagnosed with DCD following a coordination assessment of their manual dexterity, ball skills and balance. Data from the national handwriting tests and an Activities of Daily Living (ADL) Scale was also used to quantify the disorders impact of the children's quality of life (QOL). The results of this substantial, although older study, showed a prevalence of 1,8% with a further 2,3% 'at risk' of DCD being shown, these 'at risk' children still requiring further assessment to confirm or reject a DCD diagnosis (17).

A Canadian study done in 2000 measured the motor difficulties amongst 103 school children who showed scholastic challenges. The children were tested by their teachers using the MABC (Movement Assessment Battery for Children) checklist. A prevalence of eight to fifteen percent of the children were found to have motor difficulties, as assessed by the teachers (21). The prevalence when again tested by a physiotherapist was found to be considerably different. This study concluded that testing by teachers for this population was not recommended and should instead be performed by the appropriate member of the multidisciplinary team (21).

A South African study conducted by de Milander, Coetzee and Venter in 2016, in the Free State Province in South Africa, investigated the prevalence of DCD in 347 Grade One children between the ages of five and eight years old and how this condition affected scholastic learning areas (18). The prevalence of DCD was assessed and diagnosed using the MABC-2 and the learning areas were assessed using the Aptitude test for School Beginners (ASB). The prevalence of DCD, where the participants were severely motorically impaired, was shown to be six percent, with an additional six percent of the children tested, shown to be 'at risk' of

DCD, being moderately motorically impaired. The study was conducted in a similar socioeconomic population (middle to higher socioeconomic) to that of the current study. Gender was not noted to be significant in this study (18). These motorically-affected children were also shown to perform more poorly in five out of the eight learning areas tested in the study, namely: reasoning; numerical skills; gestalt; coordination and memory, when compared with their unaffected peers. Performance in the areas of verbal comprehension; spatial orientation and visual perception was not affected. It was also noted in this study that awareness of this disorder, which appears to affect a relatively significant amount of the general population, by medical professionals, teachers and parents, is not well established in the South African context and further studies to investigate this awareness would be useful.

Another study, conducted in the North West Province of South Africa by Venter et al in 2015, again assessed pre-schoolers, aged three to five years old, for motor difficulties in five different socioeconomic settings. The authors concluded a prevalence of 11.32% of DCD in their study population. Age and gender were shown to be significant, but not socioeconomic status (22). These findings appear to compare more with the findings of the current study, which was carried out in the Eastern Cape, South Africa.

It does appear that the above studies completed in different provinces in South Africa show a higher prevalence or 'at-risk' of DCD than some of the global findings. Despite the current global prevalence norms, there have been studies carried out in other countries that differ from these norms (23). It is noted that some of the criteria for measuring motor difficulties versus diagnosed DCD differ and most likely result in the differing prevalence rates. The scarcity of both global and local South African prevalence studies of DCD specifically, rather than generalised motor difficulties, is also noted.

2.4 Aetiology

In 2016, a critical review of specific MRI studies was undertaken and included analysing data gathered from nine functional Magnetic Resonance Imaging (fMRI); two structural MRI (sMRI) and three Diffusion Tensor Imaging tractography (DTI) studies (24). All 14 studies aimed to investigate the areas of the brain affected in children with DCD compared to typically developing (TD) children. Most of the DCD participants in the studies were assessed using the MABC. Unfortunately, the review showed that there was poor overlap in the findings of the

studies and speculated that this may be due to the heterogenous nature of DCD as a condition, as well as poor control measures, such as a lack of baseline motor assessments, for the TD control population. Small sample sizes and comorbidities, such as ADHD and ASD, were also not considered in the analysis of the data therefore making definite, consistent findings largely inconclusive. Another variable, which was viewed by the researchers as problematic, was that the participants were not stratified by age and considering that the brain develops over time, the MRI findings in different age groups were therefore difficult to compare. Despite the bias noted in the majority of the MRI studies, certain brain areas were shown repetitively to be affected in the DCD population and these were: the Cerebellum; the Parietal lobe; the Basal Ganglia (as previously hypothesized), as well as other areas, including the Limbic Lobe; the Frontal Lobe (medial and orbitofrontal cortex and dorsolateral prefrontal cortex) and the Lingual Gyrus (24). Lastly the reviewers discussed two of the studies that hypothesized that brain specialization was abnormal in the DCD participants and that these individuals' executive functioning tended to recruit left-lateralization networks in the brain as opposed to right-lateralization networks as in the TD population (24).

The above atypical neural and brain development, also known as the 'neural signatures'(24) was also discussed by the 2019 EACD review panel (12). In the analysis of the above 14 studies within the review, as well as an additional study which included Electroencephalogram (EEG) findings, the following was again noted and shown to be evident in DCD individuals : reduced cortical thickness in the right orbitofrontal cortex and alternating brain activation patterns across the functional networks within the cerebellum, prefrontal cortex and parietal lobe. The role of the basal ganglia is also being postulated to be of importance (3). Such research should be continued as it provides anatomical evidence for the disorder, thereby promoting improved awareness of DCD, specifically within the scientific medical community. The functions of the different brain regions and their relevance will be discussed in more detail below.

Another Australian study conducted in 2018 further analysed the same above seven fMRI studies using a method called Activation Likelihood Estimation (ALE). The researchers then also compared the manual dexterity tasks performed by 86 school-aged children with DCD, compared to 84 age-matched controls. According to this research, children with DCD showed reduced activation in the middle frontal gyrus; superior frontal gyrus; cerebellum;

supramarginal gyrus and inferior parietal lobes during a manual dexterity task, compared to the control group. The thalamus showed greater neural activity in the DCD group compared to the controls (25).

2.4.1 Functions of brain areas linked to DCD

The following areas of the brain are postulated to be affected in DCD individuals. The main functions of these areas, as they relate to DCD specifically, are summarised below with reference to Fitzgerald's Clinical Neuroanatomy and Neuroscience, Seventh Edition (26). It should be noted that these brain areas do have other functions which are not included in the following list and are not as clearly defined in functionality as described below.

Cerebellum

The cerebellum is involved in the coordination of all movement, including ocular and speech components of movement. It plays an important role in the planning and adjustment of movement; postural stabilization and postural fixation. It is also linked to the following neurocognitive functions of: reasoning; attention; some other speech functions, for example, grammar; spatial sense; memory; emotional affect; it appears to influence thalamic neural projections associated with cognitive and affective areas; and behaviour.

Parietal lobe

The parietal lobe is involved in the processing of sensory information and the coordinated manipulation of objects. Visuospatial and proprioceptive functions are also partially controlled by this lobe. It also plays a role in language expression in the left hemisphere (in the majority of people) and comprehension/ reception or the emotional use of language in the right hemisphere.

Basal Ganglia

The basal ganglia function as the central control area for the coordination of all movement. Wide neural projections link the basal ganglia to all areas of the central nervous system and the body to perform this role.

Limbic Lobe

This lobe is often referred to as the Limbic system. This area assists in the regulation of emotions; memory and endocrine (autonomic) functions. It is also involved in the control of reinforced behaviour and the perception of sensory information.

Frontal Lobe

The frontal lobe can be divided into different areas involved in the following functions:

- **superior area:** higher cognitive functions; working memory
- **prefrontal area:** planning complex cognitive behaviour; personality expression; decision making; moderating social behaviour
- **medial frontal:** decision making; long-term memory retrieval
- **middle frontal:** attention
- **orbitofrontal:** decision-making
- **dorsolateral prefrontal:** higher cognitive centre involved in the assessment of visual scene; voluntary (internally generated) saccades (or eye movements); voluntary repression of reflexive (automatic peripheral field) saccades.

Supramarginal gyrus

This area is part of the somatosensory association cortex and is involved in the interpretation of tactile sensory information; proprioception; and identifying postures and gestures as part of the mirror neuron system.

Thalamus

The thalamus provides sensorimotor integration through conscious perception of sensation (external or internal to the body) to guide the motor system.

Lingual Gyrus

This area is involved in visual processing, especially relating to letters; logic; and visual memory encoding.

White matter tracts

White matter tracts within the central nervous system are responsible for linking all functional areas.

2.5 Clinical presentation

On observation and according to research studies, a child with DCD typically presents with motor planning difficulties affecting a specific type of action that is required for a specific activity. The child also finds it challenging to adjust the force and timing needed for the required motor task, as well as having difficulty changing their motor output when their

environment or task changes. The child may find it difficult to detect errors in motor output and struggle to correct the movement required to perform the task accurately. The child's sensory systems (vestibular, proprioceptive and visual) may also be impaired (27, 28).

Postural control and comorbid ADHD can result in further coordination difficulties (27). The challenge of performing fine motor tasks such as writing, often leads to a child trying to avoid certain activities because they feel unable to perform the task as required of them (29). Challenges performing ADLs, such as eating, dressing, et cetera, as well as ball skill activities, are also present in the DCD child's profile and will be discussed in more detail below under the effects of DCD.

The clinical examination of DCD patients may reveal neurological immaturity which can, on occasion, according to some research findings, be shown by the following features: choreiform movements which are repetitive, rapid and jerky involuntary movements of the unsupported limbs (14); mirror movements which are seen as visible, involuntary movements of the hand not in use which replicates the movement of the hand in use and is often seen in the fingers predominantly (30), although according to the 2019 extensive meta-analysis of evidence-based research conducted by the EACD, there is little evidence as yet for either choreiform and mirror movements as being part of the clinical presentation of DCD (3).

Neurological soft signs (NSS) are abnormalities that can be seen when clinically examining a patient using standardised assessment methods, but no specific brain abnormality or defined syndrome is identifiable (24, 31). An example of a NSS is motor incoordination, clumsiness, lack of handedness for age et cetera and these are often seen in DCD individuals (24). Generalised impairment of fine and gross coordination of movement (17) are also often present in DCD individual's on examination. In a study which examined other associated motor features for example, ophthalmic abnormalities, it was shown that children who had been diagnosed with severe DCD often presented with abnormalities in binocular vision, refractive errors, and ocular alignment. The authors recommended ophthalmic assessment to be carried out in children with DCD in order to identify and manage any visual comorbidities to more successfully address both visual concerns and DCD (32)

2.6 Coordination of movement

2.6.1 Motor skills and their impact on ADLs

DCD is known to affect gross and fine motor coordination skills which in turn affect how efficiently an individual is able to coordinate their ADLs. These are the daily functional skills needed by people to maintain independence, for example, dressing, eating, tying of shoelaces et cetera. DCD impacts these and other areas of function in affected individuals, making life much more challenging, therefore having an influence on quality of life (5, 6).

Gross motor skills involve the bigger movements of the body and limbs, for example walking, throwing a ball. Postural control is important for movements to occur freely and with coordination. Fine motor skills alternately involve the smaller, often faster muscle movements, for example those used in writing (31). ADLs require both gross and fine movements, together with good postural control and coordination to be effectively carried out. An inability to coordinate motor control adequately leads to suboptimal levels of function for a given individual such as those with DCD.

2.6.2 Psychosocial impact

The importance of an emotional and social evaluation, as well as parental support for children with DCD has been highlighted, as poor self-esteem can affect both scholastic performance and sporting involvement (6). Teenagers are also at risk of having an increased body mass index as a result of decreased physical fitness and a lack of confidence in the sporting area, often being labelled ‘clumsy’, ‘annoying’ or ‘slow’ (33). The need for ongoing awareness, investigation into the effect of this disorder in young adults’ lives and how best to assist the affected individual, has also been recognised (3).

Poor participation of the affected child or adult with DCD, due to an inability to compete in some of these domains, adversely affects the long-term personal and social arenas of the DCD population (5, 6), as well as the caregivers of these children (34)

2.7 Functional outcomes

An individual’s ADLs are a vital part of their independent functioning. Achieving good academic performance and sporting participation is important to maintaining a healthy life

balance in children (and adults) and allows them a feeling of inclusion amongst their peers. This study investigates the challenges that a child with coordination problems or ‘at risk’ of DCD may face in these two key areas.

2.7.1 Academic performance

Academic performance has been noted in a number of studies to be affected by DCD (18, 35). As discussed above in the South African de Milander et al study, the scholastic areas of the Grade one participants which this study found to be affected by DCD were: reasoning; numerical skills; gestalt; coordination and memory. Verbal comprehension; spatial orientation and visual perception were not affected (18).

Another cross-sectional, longitudinal study conducted in the North West Province in South Africa in 2014, investigated 812 Grade One children with a mean age of 6.78 years (SD 0.49) to determine the relationship between academic success and perceptual-motor skills in this population and whether low SES (socio-economic status) school type influenced this relationship (35). Visual motor integration (VMI); visual perception (VP) and hand control was measured using The Beery-Buktenica developmental Test for Visual-Motor integration-4 (VMI-4). Overall motor proficiency was measured using the Bruininks Oseretsky Test of Motor Proficiency, short form (BOT2-SF). The areas of academic performance assessed were maths, reading and writing using The Mastery of Basic Learning Areas Questionnaire. The results of this study showed a strong relationship between academic performance and VMI; visual perception; hand control and motor proficiency, with specific significance for the VMI and the VP academic scores noted. SES school type was found to be negatively associated with academic performance, the reasons for this are likely to be multifactorial and not only related to motor perception or coordination problems. Perceptual motor performance was shown to be important to all of the basic learning areas of maths, reading and writing. DCD which affects motor perception, was therefore found to affect academic performance in these basic foundational areas of scholastic learning (35).

2.7.2 Sporting participation

Difficulties with coordination make sporting performance and therefore often participation more challenging for children with DCD due to the complex motor skills required in the

sporting domain (11, 36-38). This in turn, often affects their self-confidence as concluded by a study in 2010 (37). Sporting codes that involve coordinated ball manipulation skills, as found in many sporting codes, often present as an area of difficulty for DCD children (3, 39-41). Team sports have also been shown to be challenging for the DCD population group (36, 41). The current study aimed to further investigate how coordination difficulties affected sporting participation in the selected population of children.

A South African study in 2014, using the ICF as a framework, investigated factors associated with skill acquisition and participation levels in DCD children. The study concluded that children's ability to acquire new skills was affected by their internal neural structures, as postulated in DCD children (24), as well as their external environments which influence this acquisition to some extent (11). Another study completed in 2011 analysed 63 young children's (mean age 4,96 years, SD=0,62) reported levels of enjoyment and participation in daily activities, 21 of whom had been diagnosed with DCD. Results showed that the DCD children experienced less enjoyment of their daily tasks, including sporting and leisure activities compared to their TD peers. Their participation in these activities was also less, as a result of this decreased enjoyment, even at a young age (36). This concurs with the previously mentioned study regarding DCD children's perceived self-efficacy in tasks where they feel unable to perform tasks at the same level as their TD peers (37).

A study in 2006, which compared the skill of two-handed catching between DCD and TD children, found that the motor systems of the DCD children were less adaptable when it came to this skill than their TD peers (41). The catching was viewed via videoing of the activity which was useful for analysis of the movements. The sample size, in this study though, was small. Another study in 2008 found that children with lower motor competencies, such as those with DCD, were less able to participate in sporting and other leisure activities than their TD peers (38).

Lastly, a meta-analysis study was completed to investigate the brain areas activated when DCD children performed tasks of manual dexterity (25), as would be needed for sporting and other participation. This study analysed data from a number of fMRI studies and concluded that differential neural brain activation areas have been identified in DCD compared to TD subjects. The functions of these areas are discussed above. Team sport participation which usually

requires a certain level of manual dexterity and self-confidence may likely present as a challenge for individuals with DCD.

2.8 Comorbidities

One of the challenges faced when diagnosing and treating DCD are the co-morbidities associated with this disorder such as: Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD) and behavioural problems such as Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD). According to the EACD, dual diagnoses should be identified and treated simultaneously to best manage the individual's long-term outcomes (42). ADHD specifically seems to be a predictor of poor outcomes in children when combined with DCD where both or one of the disorders is undiagnosed and/or untreated (43). Full standardised assessments and appropriate referrals by members of the multidisciplinary team are required to accurately diagnose and manage any suspected disorders and existing comorbidities to ensure optimal outcomes for the affected individual.

2.9 Risk factors

In this study, we compared the associations between children who were screened 'at risk' of DCD, with those who were 'not at risk' and selected factors which potentially affect academic performance and sporting participation. Literature has shown a gender disparity in the occurrence of DCD with a male: female risk ratio of 2:1 (44). Gestational age and preterm delivery (<36 weeks) (45) and ADD/ADHD (27) have also been shown to be risk factors for DCD. In this study we focused specifically on these known risk factors. Additional risk factors such as very preterm (VPT) delivery (<32 weeks gestational age) and extremely low birth weight (ELBW) (<1000g) (45); prolonged rupture of membranes (PROM) (46); retinopathy of prematurity (ROP) (46) and postnatal steroid exposure (47) have also been described in the literature.

The majority of these risk factors appear to be due to antenatal or perinatal, rather than postnatal influences, although this observation requires additional investigation in order to draw more definite conclusions. It has been postulated that DCD may have similar causal

pathways to cerebral palsy but present in a milder form, but evidence does not appear to currently support this view conclusively (45).

VPT children score significantly lower on motor tests than their TD or full-term peers and can experience motor deficits in the areas of coordination; balance skills; ball skills; gross and fine motor control and visual motor integration (48). These deficits were measured in a study in 2019 which aimed to determine whether the early assessment of VPT children, at two years of age, using the MABC-2, was able to successfully determine the risk of DCD outcome in these children at the age of four and a half years. The MABC-2 proved to be a sensitive instrument for assessing ‘at risk’ children for motor difficulties such as coordination disorders from as early as two years old (48).

2.10 Outcome measures

There are several standardised assessment and screening instruments used to diagnose or screen for DCD. Amongst the most commonly used assessment instruments in diagnosing DCD is the MABC; the MABC-2; the Bruininks-Oseretsky Test for Motor Proficiency (BOT) and the BOT-2 (Bruininks-Oseretsky Test for Motor Proficiency- Second Edition). There are numerous other standardised outcome measures which are also suitable for use and the selection of the most appropriate one is determined by the health professional in any given context. These assessment tools, as well as their clinical interpretation, are used worldwide by professionals within the medical multidisciplinary team. The multidisciplinary approach remains the most preferable one to accurately diagnose and manage an individual. Involvement of all stakeholders, including the individual themselves, as well as the parent or caregiver is also important to successful outcomes. Due to the standardisation of assessment tools, there is often training and cost involved to be able to apply the tests, usually only by a member of the multidisciplinary team. Parents, caregivers or teachers are therefore usually not able to perform the assessment batteries.

There is therefore a use for screening instruments to be used in the screening of individuals for potential conditions. This approach is often used when testing a group of individuals to identify ‘at risk’, or suspected individuals, who may or may not have a certain condition. Screening instruments usually do not require training or cost and are often freely available. It remains important for screening instruments to be standardised nevertheless, to minimise the margin of

error when screening. If an individual is screened to be ‘at risk’ of a condition such as DCD, further assessment then needs to be carried out by a professional of the multidisciplinary team to accurately diagnose the screened condition, thereby allowing for intervention to be started. Screening of children generally can cause anxiety in both parents and their children and so should always be approached with sensitivity and explanation of the process to be undertaken (34).

Screening, in this study, was therefore selected and proven to be helpful in identifying children ‘at-risk’ of DCD. There are a number of standardised screening tools available, for example the DCDQ’07 (44, 49) which is a parent-completed screening questionnaire for DCD. Often the parent or teacher may have recognised that the child has a problem scholastically or in the sporting arena and therefore requests an assessment to identify possible causes. In DCD, as in many other childhood conditions (50), early identification and intervention is preferable in order to minimise the long-term, compounding effects of this disorder.

Further evaluation of the identified child, by a member of the multidisciplinary team, using an well-selected, standardised assessment tool needs to be undertaken to confirm the diagnosis in children who have been screened and found to be ‘at risk’ of DCD in order to most effectively manage the individual child within their environment. A multidisciplinary team approach tends to be the most effective way to manage an affected individual.

2.10.1 Selection of the DCDQ’07 outcome measure

For this study, the DCDQ’07 was selected as a standardised screening instrument. Although developed in Canada, the DCDQ’07 it is a simple, easy to use parent screening instrument. During its development when it was initially standardised, the DCDQ’07 showed an overall specificity of 70,8% and a sensitivity of 84,6% (19). To date, the DCDQ’07 has not been standardised for the South African population as a whole, although in 2015, the ‘Little’ DCDQ (L-DCDQ), a version of the DCDQ designed to screen for DCD in three to five year-olds, was tested for reliability and validity in a group 53 South African children aged from three to five years old (51). The results of this study found that the L-DCDQ showed good internal consistency (CA, $\alpha > 0.8$); poor sensitivity (57,14%) but reasonable specificity (81.25%). This

indicated that the L-DCDQ was a potentially good screening instrument for South African use although a few adjustments were recommended (51).

To ensure the internal consistency of the DCDQ'07 screener in this population group, the data obtained from the entire study population's completion of the DCDQ'07, was statistically analysed using the Cronbach alpha (CA) method and shown to be suitable as a screener for this population, with good overall internal consistency shown (CA, $\alpha = 0,905$). The results of this analysis are discussed in more detail in the methodology section below.

The screener was therefore deemed suitable for the study population who were able to easily understand all questions posed in the questionnaire. It must be noted that as the DCDQ'07 has not been standardised for the South African context, challenges in certain socioeconomic or language groups within the South African population may limit the use of this screener in the South African context as a whole. This potential limitation is therefore acknowledged in the results section of this research.

2.11 Intervention approaches

A thorough assessment which is conducted by the collaborative approach of the multidisciplinary team, using standardised assessment tool/s, would follow the identified screening of an 'at risk' individual. Assessment will result in the confirmation or exclusion of a diagnosis of DCD. A thorough medical history, including an antenatal and birth history is important to ascertain during the assessment process, as well as the identification of any comorbidities or confounders which may be present. Most treatment approaches would then be directed by an occupational therapist or physiotherapist. In certain cases, a speech therapist would also be involved if a comorbid verbal apraxia, affecting speech and language learning, is identified. Medical intervention may be needed to manage other comorbidities, while psychological intervention would address behavioural or social concerns (52, 53).

A number of assessment approaches can be used by the appropriate professionals of the multidisciplinary team and may include, for example, functional skills assessments; a general abilities approach; neurodevelopmental theory assessments (biomedical model); a dynamic

systems approach or other assessments, as required. Treatment of DCD, once identified, needs to address the affected fine motor; gross motor and functional areas (amongst others) where coordination is problematic and impacts on scholastic, sporting and social involvement, therefore impeding success in these life domains. Treatment plans need to involve the family and the teachers of the child, as the children may require additional support and access to helpful resources. Psychosocial support is also important for diagnosed individuals and their caregivers.

There are many different treatment approaches for children who have been diagnosed as having DCD. Examples of these approaches include:

- Sensorimotor approach – facilitating and moderating the participant’s sensory input to allow active motor patterns to be learned and practiced thereby aiming to improve coordination (54),
- Wii Training approach – using the Wii electronic game as a tool to assist in improving the learning of motor patterns (55),
- Motor imagery training – using visual input to facilitate the learning of repetitive motor actions (55),
- Direct-instruction intervention – directing the participant to complete and repeat motor tasks to improve their performance (56).

A 2015 meta-analysis showed that most forms of evidence-based interventions yielded improvement in coordinated motor tasks despite the differing approaches used. It has been shown that children with comorbidities, for example, ADHD, took longer to show improvement than those without comorbidities and required the management of both conditions in order to show significant improvement in the affected areas of functioning (57) .

2.12 Conclusion

The above Literature Review has aimed to cover an overview of the research studies available through renowned published sites using extensive online searches. Studies which appear to show sound methodology; have adequate sample sizes and that showed useful, statistically proven findings have been included. The current definitions and other terminologies used to describe DCD, as well as postulated aetiologies, including brain areas affected, have been

discussed. The global and South African prevalence and the awareness of DCD amongst the medical and general population is also mentioned. The clinical presentation of DCD, including poor gross and fine motor coordination control and the impact on an affected individual's ADLs. This study also specifically investigated the impact of coordination difficulties on the academic and sporting domains. The psychosocial impact, the comorbidities and the risk factors associated with DCD are also detailed above. Lastly, outcome measures, with a specific emphasis on the selection of the DCDQ'07 as a screening instrument for this study have been elaborated on. Specifically-designed intervention approaches by members of the multidisciplinary team remains essential to optimising the affected individuals' quality of life.

CHAPTER 3: METHODOLOGY

3.1 Introduction

In this chapter the methodology used in this report will be presented. This is a cross-sectional study where the prevalence of 'at risk' of DCD in a single school in South Africa was investigated. A standardised screener, the DCDQ'07, was used to gather information and required parental input to complete. Academic performance and sporting participation have been shown to be impacted by DCD and this study aimed to investigate these factors, as well as other known associated risk factors and comorbidities in this population, in order to add to the current DCD knowledgebase thereby assisting in the management of this disorder.

3.2 Ethical clearance

The following permissions were obtained prior to the commencement of this study:

- Human Research Ethics Committee (HREC) of the University of the Witwatersrand study approval was given (HREC approval number: M180912) (Appendix 10).
- Approval from the Headmaster of Merrifield Preparatory School and College (Appendix 4).
- Signed informed consent forms from the parents or legal guardians of all participants enrolled in the study.

The principal investigator does not stand to benefit financially from this study and is bound by the ethical code of the Health Professionals Council of South Africa (HPCSA). Confidentiality, sensitivity and parental decisions regarding the management of the outcomes of the screening were adhered to and respected at all times.

3.3 Study population and location

The study was carried out at a primary school in East London in the Eastern Cape province of South Africa where 69 school children, aged from five to eleven years (mean age eight years), were screened for DCD using a parent questionnaire, the DCDQ'07. The learners were all in

Grades 00 to Grade 4. The target population was 234 parents, of whom the above 69 participated in the study.

3.4 Inclusion criteria

1. All Gr 00 to Gr 4 children (both genders, all races), aged between five and eleven years, attending a single primary school in East London.
2. All children had an Intellectual Quotient (IQ) above 70. The school routinely administers IQ testing and entrance assessments prior to admission to the school to ensure this criterion of IQ scoring >70 is met. (An IQ score >70 is not seen as an intellectual disability).
3. Include children with known co-morbid conditions/dual diagnoses (for example: ADHD, ASD, ODD, and CD).

3.5 Exclusion criteria

1. Children with IQ < 70 would be excluded from the study according to standardised screening/diagnostic criteria.
2. Data analysis from children with diagnosed physical, neurological or genetic disabilities (for example, Cerebral Palsy) would be excluded from the study as per the diagnostic criteria for DCD. Parents of these children would still be allowed to complete the forms and be given individual feedback despite the data exclusion.

3.6 Study design

The study was designed as a quantitative, cross-sectional survey. Data from sixty-nine children from three age groupings between Grade 00 and Grade 4 at a primary school in East London, South Africa were collected and analysed according to the study objectives discussed above. Children from the youngest group (5-7 years, 11 months) are typically in Grade 00 to Grade 2; children from the middle group (8-9 years, 11 months) are typically in Grade 2 to Grade 4 and children from the older age group (10-15 years) are in Grade 4 in this cohort.

The DCDQ'07 includes a Coordination Questionnaire and Score Sheet (Appendix 7). The questionnaire was redesigned for this study, so that all identifiers to the study participants

would be removed (Appendix 6). In all other aspects the questionnaire remained the same. The redesigned DCDQ'07, as well as an Additional Data Collection Sheet (Appendix 8), were used to gather information from the study population. The data from these two sources were then analysed to answer the research objectives of the study. The rationale and validation of the DCDQ'07 as the selected outcome measure is discussed below.

3.7 The DCDQ'07 outcome measure

The DCDQ'07 was developed by B. N Wilson and S. G. Crawford in Canada as a screening instrument for DCD for use in children aged between 5 to 15 years old and consists of the DCDQ'07 Coordination Questionnaire and Score Sheet. The questionnaire can be administered to parents/guardians directly, telephonically or can be completed independently by the parent. It is freely available via the internet and can be used without permission from the authors (19). The scores from the questionnaire are then inputted into the scoring sheet, usually by a member of the multidisciplinary team such as a physiotherapist, where the results of the screener can then be interpreted and appropriate suggestions made.

The questionnaire consists of 15 questions grouped into three scales: Control During Movement; Fine Motor/Handwriting and General Coordination. Each scale is composed of six, four and five questions respectively which are scored on a numerical scale of one to five where one indicates a complete inability to perform the task and five indicates perfect execution of the task. Total scores are calculated and categorised according to the child's age at the time of questionnaire completion. The scores place children into one of two categories, either 'at risk' of DCD or 'probably not at risk'. For example, children aged one to seven years 11 months, achieving a total questionnaire score of 15-46 would be classified as 'at risk' of DCD; those achieving a score of 47-75 would be classified as 'probably not at risk' of DCD. The scoring categories are detailed in the Score Sheet of the DCDQ'07 (Appendix 7). The overall score is calculated by adding the total scores from all three scales, calculated according to this sheet. Scores for each of the three scales, as well as scores for individual questions, can also be scrutinised by a member of the multidisciplinary team, to facilitate specific intervention strategies if necessary. The scores of individual questions were interpreted by the primary investigator as follows: children scoring between one and three (out of five) may be found to

have a poorer outcome than children scoring four or five, who experienced less difficulty in the specific skill tested. Total scale scores, as well as overall scores, would also require examining to determine the areas of coordination difficulty. The overall score would determine whether the child is found to be ‘at risk’ of DCD or not.

Cronbach’s alpha method was used to determine the internal consistency of the instrument specifically in this study context, by statistically analysing the questionnaire data gathered from the entire study population. This analysis was done after ethical clearance was obtained but prior to the main study. These findings were not part of the aims or objectives of this study but rather showed that this instrument was suitable for use in this population and are thus tabulated below.

Table 3.1: Internal consistency of DCDQ’07 in cohort

Scale	Internal consistency (Cronbach’s alpha)
Control During Movement Scale (Q1-Q6)	0.857
Fine Motor/Handwriting Scale (Q7-Q10)	0.879
General Coordination Scale (Q11-Q15)	0.882
All scales combined scale (Q1-Q15)	0.905

The DCDQ’07 was previously analysed by the developers of this outcome measure, Wilson and Crawford according to age groups (rather than by its scales as seen above) and was shown to have an overall sensitivity of 84.6% and specificity of 70.8% (58). Both of the above statistical testing results reiterate the DCDQ’07 to be an effective, standardised screening instrument for DCD both in a global and in the local study context. This study population was representative of a first-world socioeconomic context and so the measure was seen to be suitable for this study. Additional testing in other South African study contexts would be useful as this version of the instrument has not been standardised for the South African population as a whole, this being much more diverse. This has been acknowledged as a limitation of this study and South African standardisation of the DCDQ’07 is therefore recommended in the Discussion section below.

3.8 Procedure

All the parents/guardians of the children in Grades 00-4, aged five to eleven years old, were given an envelope containing the following documents, thereby inviting them to participate in the study:

1. A Study Information Form (Appendix 1) which explained, in detail, the purpose of the study which was to identify any coordination difficulties in the study population, which may affect their children's overall scholastic performance. This may include areas such as fine motor skills; sports participation and functional abilities. Parents/guardians were given the opportunity to ask questions prior to the completion of the forms either via email or telephonically;
2. A Parental/Guardian Informed Consent Form (Appendix 2) to be signed if participation in the study was consented to;
3. A de-identified, standardised DCDQ'07 Coordination Questionnaire (Appendix 6). This allowed parents/guardians to screen for DCD in their children;
4. An Additional Data Collection Sheet (Appendix 8). This sheet included the following: the above-mentioned study participation number; the age and gender of the child to be screened; the number of children in the family; the birth order of the child; current grade; parental concerns and other diagnosed medical conditions (such as ADHD) and whether the child was receiving treatment for these conditions. The child's sporting codes (or the child's chosen sports); their participation and ability therein; as well as their academic performance and any grades repeated, were also included in the data gathered.

Academic performance was measured by asking the parent/guardian which of the following categories their child fell into, according to the latest term average noted on their report card: 1-3 (<50%) ; 4-5 (50-69%) or 6-7 (>70%). South African schools use this standardised method of reporting academic performance: scores between one and seven are used to represent percentages in both the subjects and for overall term averages. This gave the author a good overall idea as to the child's academic performance. The percentages above are related to the actual South African report score card system outlined in detail in the table below:

Table 3.2: Standardised South African report card scores

ACADEMIC LEVEL KEY

Level	Percentage	Descriptor
7	80-90%	Outstanding achievement
6	70-70%	Meritorious achievement
5	60-69%	Substantial achievement
4	50-59%	Adequate achievement
3	40-49%	Moderate achievement
2	30-39%	Elementary achievement
1	0-29%	Not achieved

Any other known physical, neurological or genetic diagnoses were also noted on this form. The additional data was itemised and categorised to simplify data collection and analysis.

5. A separate Confidential Information Form (Appendix 5), where a participation number was allocated to each participant and the parent/guardian's contact details could be recorded. This allowed for de-identification of the participants to ensure confidentiality, while still allowing the principal investigator to contact the parent/guardian should the parent/guardian so request. This also allowed for feedback and recommendations to be made in the best interest of the child.

Completed forms were returned by the parent/guardian in a supplied, sealed envelope directly to the school office and posted into a locked post-box. The principal investigator ensured that this box remained secure to maintain confidentiality and collected the envelopes after a set time period. A notice was also sent out separately, via the child's homework book, notifying the parents of the study, with a reminder notice sent out a few weeks later, to encourage participation in the study.

Data was then entered into a secure electronic database created for the purpose of this study. Data was anonymised/de-identified and study numbers allocated to all participants. Only the principal investigator had access to the study information obtained and the study numbering allocation. Data was then recorded, collated and analysed. All study-related forms were securely stored in a locked filing cabinet in a locked office. After the study has been completed,

back up of all electronic information will be kept securely on an external drive belonging exclusively to the principal investigator.

On completion of the forms, the parent/guardian was given an option to receive feedback of the results of the screening via an email. Feedback to the school was also given as requested in order that the school be involved in assisting their learners, where possible, through insights gained from the study. Individual participation information was not disclosed to the school.

3.9 Data analysis

The demographic data, as well as the results from the DCDQ'07 coordination screening, were collected, recorded and initially analysed using descriptive statistics. Data was normally distributed. Pearson's Correlation Coefficient Statistical Method was then used to investigate the correlations between the demographic data and coordination scores in the study population, for both strength of association and statistical significance. Fisher exact t-tests were then performed to compare the children screened 'at risk' to those 'not at risk' of DCD in terms of factors identified to potentially affect their academic performance and sporting participation. All p -values ≤ 0.05 were considered statistically significant. Data analysis was performed using SPSS V25 software.

3.10 Funding

This study was self-funded. All photocopies of the questionnaires and any additional documentation; data collection; telephone calls et cetera, were funded by the principal investigator.

3.11 Anticipated limitations and potential solutions

- Non-completion of the coordination questionnaire and other study forms by parents/guardians.
- The parent/guardian Informed Consent Form; Parent/guardian Study Information Form; DCDQ'07 and the Additional Data Collection Sheet may have been lost when relying on the child to take these forms home.

Reminders, on a number of occasions, were sent home to the parents via the homework diary; to the teachers individually and electronically via the D6 school communication platform.

- Parental anxiety when completing the questionnaire.

Parents were well assured that although they would need to sign a consent form for their child to participate in the study, the child would then be given a non-identifiable number which only the principal investigator would have access to and which would be treated confidentially. Their child's identification would not be disclosed for any reason, to any other party, without their permission. The 2-page questionnaire given to the parent for completion was named the 'Coordination Questionnaire' and did not mention the diagnosis (DCD) thereby avoiding anxiety regarding early, unnecessary 'labelling' of a child with or without a potential problem. The aim of this study was to screen for early potential problems and therefore to start intervention, only if necessary and after further discussion with the parent. Reassurance of the parent was given, via the Study Information Form, that this would only be undertaken for the benefit of the child.

- Self-reporting or parental bias when completing the questionnaire.

The importance of confidentiality, as assured in the Study Information Form, attempted to improve unbiased parent/guardian reporting, thereby minimising this bias to the potential benefit of the child.

- Parents/guardians are busy and would rather not participate in a study unless it is compulsory.

This study was voluntary by ethical design with no coercion used.

3.12 Conclusion

In conclusion, the study was completed strictly according to its design and data was securely stored and then analysed as described. The results of the study findings are discussed in the Results chapter below.

CHAPTER 4: RESULTS

4.1 Introduction

The results of this study aimed to investigate the prevalence of children screened to be ‘at risk’ of DCD in primary school children in a school in the Eastern Cape, South Africa and how these findings impacted on the children’s academic performance and sporting participation.

In summary, 234 parents/guardians of learners from Grade 00 to Grade 4 (aged from five to eleven years) were requested to complete the DCDQ’07 Coordination Questionnaire and an Additional Data Collective Sheet in order to collect data regarding their children’s coordination status and other demographics. All 234 parents/guardians were given hard copies of these forms to complete. Parents/guardians were reminded via email to volunteer of their time to complete the given forms. In addition, individual printed reminder messages were sent home via the class teachers in the children’s homework diaries. A month later, another follow-up reminder email was resent via the school office to encourage parent participation. Teachers were also requested to motivate parents to complete the questionnaire. Parents/guardians were not given any reimbursement for the completion of the forms but were asked if they would like feedback of their child’s results. A total of sixty-nine parents/guardians participated in the study showing a response rate of 29.5% (69; n=234). The majority of parents/guardians who participated in the study requested this feedback, which was therefore completed in order to both assist the children screened ‘at risk’ of DCD, as well as to address any incidental concerns that were raised by any of the parents/guardians or that came to light during the screening process.

4.2 Data analysis

The DCDQ’07 has been standardised as an outcome measure in Canada where it was developed. It was therefore deemed useful to re-analyse it for this study population. The results in this CA analysis, which were carried out using the data collected from the entire study population, have been tabulated in Table 3.1 in the Methodology section above (CA, $r = 0,905$). The results of the data collection and analysis recorded in the above section were then used to

address the three objectives of this study, as well as any other useful findings. These are addressed separately below in the following subsections:

Objective 1: To determine the prevalence of children ‘at risk’ of DCD (4.5), expanding on:

-data profiles/ demographics of the ‘at risk’ group (4.5.1)

-results of DCDQ’07 to determine the ‘at risk’ of DCD prevalence (4.5.2)

-factors potentially affecting coordination in cohort (4.5.3)

-significant correlations between coordination and factors (4.6) potentially associated with academic performance (4.6.1) and sporting participation (4.6.2)

Objective 2: To compare children ‘at risk’ to those not ‘at risk’ of DCD for academic performance (4.7.1)

Objective 3: To compare children ‘at risk’ to those ‘not at risk’ of DCD for sporting participation (4.7.2)

4.3 Demographics

The target population size of this study was 234 parents from which 69 parents/guardians chose to participate in the study. This resulted in a response rate of 29.5% (69; n=234). The mean age of the cohort was 8 years (range: 5-11 years). The demographics of the cohort were subdivided into: General demographics; academic data; sporting data and additional medical information. The results are tabulated and discussed in the tables below.

4.3.1 General demographics

The general demographic data gathered is tabulated below and included: gender; age; number of children in the family and the order of the child within the family.

Table 4.3: General demographics (n=69)

Demographic variable		Frequency (n=69)	Percentage (%)
Gender	Male	30	43.5
	Female	39	56.5
Age	5y -7y 11m	39	56.5
	8y -9y 11m	22	31.9
	10y -15y	8	11.6
No. of children in family	1	6	8.7
	2	39	56.5
	3	19	27.5
	4	1	1.4
	5	3	4.3
	11	1	1.4
Order of child in family	1	33	47.8
	2	24	34.8
	3	7	10.1
	4	4	5.8
	5	1	1.4

In the screened cohort, more responses were received from parents of female children than males (56.5% versus 43.5%; n=69), even though there is an even sex distribution in Grades 00 to 4 according to the confirmed school policy. Study participants were selected from Grades 00 to Grade 4, these children being aged from five to eleven years. The youngest age group (5 years-7 years 11 months) accounted for the majority of participants with 39 (56.5%; n=69); followed by the middle age group (8 years- 9 years 11 months) with 22 (31.9%; n=69); while the oldest age group (10 years -15 years) had the smallest number of participants with eight (11.6%; n=69). The majority of the participants are either first (47.8%; n=69) or second (34.8%; n=69) born children.

4.3.2 Academic data

The children’s academic data was captured in table 4.4, according to the following: the child’s current grade; if a grade was repeated; and if so, which grade and the child’s academic performance according to the last term report card average# (see table 3.2 for report score card).

Table 4.4: Academic data (n=69)

Demographic		Frequency (n=69)	Percentage (%)
Current Grade	00	7	10.1
	0	8	11.6
	1	14	20.3
	2	14	20.3
	3	11	15.9
	4	15	21.7
	Repeated grade	Yes	6
No		63	91.3
Grade repeated	00	1	1.4
	0	1	1.4
	1	1	1.4
	2	1	1.4
	3	0	0
	4	2	2.9
	Total no. of repeats	6	8.7
Academic performance	50-69% #	11	15.9
	>70% #	33	47.8
	Not provided	25	36.2

The above table shows that six of the participants repeated a grade and this accounted for 8.7% (n=69) of the sample. Grade 4 showed slightly more participants having repeated the grade than Grades 0, 00, 1 and 2. No repeated grades were seen in Grade 3 in this sample. The majority of the children for whom academic performance was disclosed, acquired a level of >70%; while 11 (15.9%; n=69) of the participants who provided this information achieved between 50% and 69%. A proportion of parents/guardians did not disclose or did not know their children’s level of academic performance.

4.3.3 Sporting data

The sporting data collected, was tabulated below, according to the following sections: if the child participated in sport; if the child participated in ball skill sporting codes (namely, Tennis; Squash; Soccer; General Ball Skills; Cricket; Hockey; Netball; Rugby*) or other sporting codes not involving ball skills (namely, Swimming; Surfing; Ballet; Cross Country; Gymnastics; Athletics; Trampoline; Dancing; Running; Karate; Motor cross; Cycling**); if the child participated in team sports and the level of sporting participation (good, fair or challenging or if this information was not provided).

Table 4.5: Sporting data (n=69)

Demographic		Frequency (n=69)	Percentage (%)
Sporting participation	Yes	68	98.6
	No	1	1.4
Ball Skills	Yes *	60	87.0
	No **	9	13.0
Team Sports	Yes	52	75.4
	No	17	24.6
Level of participation	Good	47	68.1
	Fair	19	27.5
	Challenging	2	2.9
	Not provided	1	1.4

All but one child (1.4%; n=69) participated in sport. Nine (13%; n=69) of the children did not participate in a sporting code involving ball skills where a ball required coordinated manipulation. Seventeen (24.6%; n=69) children did not participate in team sports. Nineteen (27.5%; n=69) of the children showed fair, rather than good, sporting participation, whereas two (2.9%; n=69) of the children found sport participation to be challenging for them.

4.3.4 Additional medical information

The additional medical information is tabulated below to show any possible comorbid or associated factors (for example: ADHD/ADD; visual problems; hearing problems; developmental problems); confounding factors (for example: genetic disorders) or risk factors (for example: prematurity) in the study sample.

Table 4.6: Additional medical information (n= 69)

Additional medical information	Frequency (n=69)	Percentage (%)
ADHD/ADD	5	7.2
Visual problems	4	5.8
Hearing problems	1	1.4
Genetic disorder	0	0
Developmental problems	3	4.3
Prematurity <36 weeks GA	4	5.8
None to report	52	75.4

4.3.5 Parental/ guardian comments

Parents/guardians were given the option to receive feedback after participation in this study. They were also given an option to comment and/or express any concerns regarding their child. Below is a tabulated summary of all the quoted parental/guardian comments offered during the study, together with the main objectives of the study, including: if the child was screened ‘at risk’ of DCD or not; the academic performance (percentage level and repeated grade) and sporting participation level. Any medical conditions and interventions have also been included.

Table 4.7: Parental/guardian comments

Parents concern (quoted)	Academic performance (%)	Repeat grade (Y/N)	Sporting participation	Medical conditions (reported by parent)	Interventions (if any reported)	'at risk' DCD (Y/N)
'wears glasses'	50-69%	Y: Gr R	Good	'Visual problems'	glasses	N
'twins 36 weeks'	>70%	N	Good	'Prematurity'		N
'she is slow to complete tasks as she is a perfectionist'	>70%	N	Good			Y
'moved from Germany halfway through the year, so not true repeated year. Did not speak English initially. dislikes drawing and tidying up'	Not provided	N	Good			N
'speaks very loudly, over eager, rushes everywhere, wants to do everything now.'	Not provided	N	Good			Y
'writing letters transposed, reading mixes up W and M; B and D'	Not provided	N	Fair			N
'Speech therapy attended over past 20m. Significant improvement'	Not provided	N	Good	'developmental problems'	Speech therapy	N
'tires easily; not physically strong/average; clumsy; closed pencil grip/lots of pressure; teacher- requests info re fine and gross motor activities/research info'	50-69%	N	Fair			N
'parent is only concerned that child is overdoing it: does on average 9 activities. Not lacking in energy, doesn't tire.'	>70%	N	Good			N
'Attending OT for poor shoulder muscle endurance (sitting at table for long periods of time)'	Not provided	N	Good		OT	N

'lack of physical growth; inability to process a problem'	50-69%	Y: Gr 4	Good			Y
'Grommets inserted'	Not provided	Y: Gr 2	Good	'Hearing problems'	Grommets	Y
'My child is slightly lacking in emotional intelligence; otherwise intelligent child.'	>70%	N	Good			N
'ball skills at home'	>70%	N	Good			N
'coping well with school and sport'	>70%	N	Good			N
'<36 wks; operation for hip dysplasia (battles a bit more physically); takes time to complete puzzles'	Not provided	N	Fair	'Developmental problems'; 'Prem'		Y
'wears glasses'	>70%	N	Good	'visual problems'		Y
'younger, smaller than peers; parent concerned re her ability to keep up with peers'	>70%	N	Good			N
'concerta; wears specs. Parent would (like) child to be able to concentrate without concerta and to learn to avoid distractions'	50-69%	N	Good	'ADD/ADHD'; 'Visual problems'	Concerta; Wears glasses;	N
'fit; sporty; loves sport'	Not provided	N	Good			N
'attending remedial classes for reading and fine motor skills. Difficulty concentrating for long periods; easily distracted'	>70%	N	Good	'Developmental problems'	Remedial attendance	N
'parent requested child repeat Gr RR due to being born in September. More emotionally mature now/thriving'	>70%	Y: Gr RR	Good			N
'speech therapy for pronunciation and clarity'	50-69%	N	Good	'Prem <36 weeks'	Speech therapy	N
'36 weeks Twins'	>70%	N	Fair	'Prem'		N

4.4 Results of DCDQ'07

The results of the screening for 'at risk' of DCD, using the DCDQ'07, have been recorded according to the three scales (or sections) of the Coordination Questionnaire: Control During Movement; Fine Motor/Handwriting and General Coordination. These have been tabulated below according to the number and percentage of the participants, with each question being shown separately within the appropriate scale. The results give an indication of the areas of (scales) and individual (questions) coordination difficulties experienced by the children when completing certain skills or functional activities.

Each question has been separately recorded for patterns in frequency and percentage. The difficulty of the task has been measured in relation to the score levels between one and five, with one being the most difficult and five presenting no difficulty in task completion when compared to their peers. For example, scoring four out of five or five out of five, would be interpreted as a child having very slight or no difficulty (respectively) when performing the task when compared to their peers; a score of three out of five, would be seen as a child having moderate difficulty completing the task and a score of one or two out of five, would be viewed as a child being unable to complete the task or completing it only with great difficulty, respectively.

This study focused attention on the lower score ranges (one, two and three out of five), as these scores indicate that the child found the task difficult and this would therefore indicate an area of concern to be addressed. The higher scores of four and five out of five, would be acceptable scores for children and would not be viewed as needing to be addressed as areas of concern. In all of the questions below, the majority of the children were able to perform the tasks without difficulty or with very little difficulty, scoring five or four out of five, respectively. The total scale scores, as well as the overall scores, would also need to be considered in the analysis of the data to identify possible 'at risk' of DCD children.

4.4.1 Control During Movement Scale (Q1-Q6)

The Control During Movement scale of the questionnaire investigates the following skills for all the participants: throwing, catching and hitting of a ball respectively (Q1-3); jumping over

obstacles (Q4); running speed and pattern (Q5) and the ability of the child to plan, organise and complete an activity (Q6). The results are tabulated below.

Table 4.8: Control During Movement Scale (n=69)

	QUESTION	Score	1/5	2/5	3/5	4/5	5/5
Q1	Your child throws a ball in a controlled and accurate fashion	N %	0 (0)	2 (2.9)	13 (18.8)	27 (39.1)	27 (39.1)
Q2	Your child catches a small ball (eg., tennis ball size) thrown from a distance of 6 to 8 feet (1.8 to 2.4 meters)	N %	0 (0)	7 (10.1)	16 (23.2)	23 (33.3)	23 (33.3)
Q3	Your child hits an approaching ball or birdie with a bat or racquet accurately	N %	0 (0)	6 (8.7)	24 (34.8)	22 (31.9)	17 (24.6)
Q4	Your child jumps easily over obstacles found in garden or play environment	N %	0 (0)	2 (2.9)	5 (7.2)	20 (29.0)	42 (60.9)
Q5	Your child runs as fast and in a similar way to other children of the same gender and age	N %	0 (0)	2 (2.9)	6 (8.7)	24 (34.8)	37 (53.6)
Q6	If your child has a plan to do a motor activity, he/she can organise his/her body to follow the plan and effectively complete the task (eg., building a cardboard or cushion “fort”, moving on playground equipment, building a house or a structure with blocks, or using craft materials)	N %	0 (0)	2 (2.9)	5 (7.2)	17 (24.6)	45 (65.2)

According to the findings in table 4.8 above, some children found certain activities to be moderately difficult, scoring three out of five on these questions. A few children found the activities required in questions one, four, five and six to be difficult, scoring two out of five. Slightly more children battled with the coordination skills required in questions two and three, compared to the other questions, scoring two out of five. None of the children found any of the activities (or skills) tested in this scale impossible to complete.

4.4.2 Fine Motor/ Handwriting Scale (Q7-Q10)

The Fine Motor/ Handwriting Scale of the questionnaire investigates the following skills of all the participants: printing/writing/drawing speed (Q7); legibility and recognition of

printing/writing/drawings (Q8); appropriate effort/tension when writing/drawing (Q9) and lastly the ease and accuracy of cutting out shapes (Q10). The results are tabulated below.

Table 4.9: Fine Motor/Handwriting Scale (n=69)

	QUESTION	Score	1/5	2/5	3/5	4/5	5/5
Q7	Your child's printing or writing or drawing is fast enough to keep up with the rest of the children in the class	n %	1 (1.4)	3 (4.3)	15 (21.7)	29 (42.0)	21 (30.4)
Q8	Your child's printing or writing letters, numbers and words is legible, precise and accurate or, if your child is not yet printing, he or she colours and draws in a coordinated way and makes pictures that you can recognize	n %	0 (0)	4 (5.8)	9 (13.0)	21 (30.4)	34 (49.3)
Q9	Your child uses appropriate effort or tension when printing or writing or drawing (no excessive pressure or tightness of grasp on the pencil, writing is not too dark, or too light)	n %	1 (1.4)	4 (5.8)	9 (13.0)	21 (30.4)	34 (49.3)
Q10	Your child cuts out shapes accurately and easily	n %	0 (0)	2 (2.9)	12 (17.4)	28 (40.6)	27 (39.1)

From the above table, it is noted that more children found the Fine Motor/Handwriting Scale to be more difficult than the previous scale, which measured control during movement. Two children (n=69) were not able to perform the tasks in questions seven or nine.

4.4.3 General Coordination Scale (Q11-Q15)

The General Coordination Scale of the questionnaire investigates the following skills of all the participants: the child's enjoyment of/interest in and participation in sport/games requiring good motor skills (Q11); ability to learn new motor skills (Q12); speed and competency when tidying up, dressing etc (Q13); whether child would be described as very clumsy (Q14); ability to sit well in chair without fatiguing (Q15). The results are tabulated over.

Table 4.10: General Coordination (n=69)

	QUESTION	Score	1/5	2/5	3/5	4/5	5/5
Q11	Your child is interested in and likes participating in sports or active games requiring good motor skills	n %	0 (0)	0 (0)	8 (11.6)	20 (29.0)	41 (59.4)
Q12	Your child learns new motor skills (e.g. swimming, rollerblading) easily and does not require more practice or time than other children to achieve the same level of skill	n %	0 (0)	3 (4.3)	9 (13.0)	25 (36.2)	32 (46.4)
Q13	Your child is quick and competent in tidying up, putting on shoes, tying shoes, dressing etc.	n %	1 (1.4)	10 (14.5)	19 (27.5)	21 (30.4)	28 (40.6)
Q14	Your child would never be described as a “bull in a china shop” (that is, appears so clumsy that he or she might break fragile things in a small room)	n %	4 (5.8)	7 (10.1)	9 (13.0)	21 (30.4)	28 (40.6)
Q15	Your child does not fatigue easily or appear to slouch and “fall out” of the chair if required to sit for long periods	n %	5 (7.2)	3 (4.3)	10 (14.5)	27 (39.1)	24 (34.8)

In the above results, it is noted that more children than the previous two scales, found some of the tasks involving general coordination difficult or were unable to complete the tasks in question.

4.5 Children ‘at risk’ of DCD

The results of the screening for ‘at risk’ of DCD in this cohort, using the DCDQ’07, will be addressed in the three subsections below for clarity.

4.5.1 Data profiles of children ‘at risk’ of DCD

Data gathered from these ‘at risk’ participants is visually presented below for factors that may be of concern (‘red flags’). It is important to note that as the DCDQ’07 is a screening rather than an assessment tool, therefore additional clinical assessment and evaluation by a member of the multidisciplinary team will be required to accurately identify these areas of possible concern as a result of this screening process. The following possible ‘red flags’ are marked in the table using the primary investigator’s clinical reasoning but require further assessment to investigate these areas of concern. Certain factors are not apparently concerning, for example,

current grade, and are therefore not included in the table below. The actual, de-identified participant numbers of this study have been used. Data not provided is marked NP.

Table 4.11: Data profiles of ‘at risk’ participants (n=8) ‘Red flags’

‘At risk’ of DCD participant study number	11	17	24	29	33	39	41	53
Gender	F	M	M	M	M	F	F	M
Age	8-9y11m	5-7y,11m	10-15y	10-15y	8-9y11m	5-7,11my	8-9y,11m	5-7y,11m
Repeat grade	N	N	Y	Y	Y	N	N	N
Academic performance	>70%	NP	50-69%	50-69%	NP	NP	>70%	NP
Sporting participation	Y	Y	Y	Y	Y	Y	Y	Y
Level of participation	Fair	Good	Fair	Good	Good	Fair	Good	Good
Ball skills Participation	Y	Y	Y	Y	Y	Y	Y	Y
Team sport participation	Y	N	Y	Y	Y	Y	Y	Y
Medical diagnosis	N	N	N	N	Hearing problems	Developmental problems ; premature	Visual problems	N
Summarised parental comments <i>see full comments in Table 5 above</i>	Y: Slow, perfectionist	Y: speaks loudly; over-eager; rushes everywhere; wants everything now	N	Lack of physical growth; inability to process problem	Grommet	36w; operation for hip dysplasia ; battles a bit physically; takes time to complete puzzles	Wears glasses	N
Total DCDQ’07 /75	48	44	34	56	51	45	51	46

4.5.2 Prevalence of children ‘at risk’ of DCD

The DCDQ’07 identified a total screened ‘at risk’ of DCD prevalence of 11.6% (n=69) in the study cohort. Eight out of the sixty-nine study participants were screened to be ‘at risk’ of DCD. The global reported actual (or diagnosed) prevalence of DCD has been found to be 5-6% (1, 3, 4).

4.5.3 Factors affecting coordination in cohort

In this cohort the following factors appeared to affect coordination: male gender; repeating a grade; sporting participation and younger age. Each of these four factors, amongst others, also appeared to influence, either or both, the child’s academic performance or sporting participation and will be individually reported on in 4.6. to show these statistically significant correlations.

Male gender

The number of male children screened to be ‘at risk’ for DCD in this study was five out of the eight children in this group (62.5%; n=69).

Repeating a grade

Six children in the study population repeated a grade, three of whom screened positive for the ‘at risk’ of DCD group (50%; n=69).

Sporting participation level

According to the parent/guardian information, of the eight children screened ‘at risk’ of DCD, three reportedly participated ‘fairly well’ in sports, compared to ‘good’ participation being reported amongst the majority of the study population (37.5%; n=69). One of the ‘at risk’ group did not participate in team sports (0.03%; n=69). Parental/guardian comments, as tabulated in detail above, are also of interest in this section.

Youngest age group

Three of the eight children who screened positive for ‘at risk’ of DCD fell into the youngest age group (5 years -7 years, 11 months) (37,5%; n=69); four children fell into the middle age

group (8 years- 9 years, 11 months) (50%; n=69), while only one of the eight children fell into the oldest age group (10 to 15 years) (0.125%; n=69). The true association of this variable will be debated in the discussion section below, as other factors may influence these results.

4.6 Factors correlated with coordination difficulties

Pearson’s Correlation Coefficient Statistical Method revealed significant correlations between certain factors and coordination difficulties amongst the cohort, which appeared to influence academic performance and sporting participation. The statistical significance as well as the strength of these correlations is detailed below.

4.6.1 Correlations affecting academic performance

In this study, male gender and repeated grade were shown to be significantly correlated with poor scores on the DCDQ’07 coordination questionnaire which, in turn, is postulated to affect the child’s academic performance, the results of which are tabulated below.

Correlations between coordination and male gender

Table 4.12: Correlations between coordination and male gender (n=69)

Question	Measuring	Pearson Correlation Coefficient (R- value)	P-value (≤0.05)
Q5 (CDM scale)	Running speed and pattern	0.257	0.033
Q7-Q10	Fine motor/ Handwriting overall scale scores	0.342	0.04
Q7	Writing/ Drawing speed	0.280	0.020
Q8	Legibility of writing/ Drawing	0.314	0.009
Q9	Appropriate effort/ Tension during writing	0.285	0.017
Q10	Ability to cut shapes easily/accurately	0.317	0.008

The coordination skills tested in the Fine Motor/Handwriting Scale of the DCDQ'07 reflect part of the child's academic performance, as these skills are required in the scholastic domain. The overall scale scores, as well those for individual questions, are shown to be correlated with male gender and are tabulated above.

Boys, when compared to their female peers in this cohort, were shown to score lower overall on this scale. This correlation, although weak, was shown however, to be statistically significant and demonstrated a positive, linear relationship between these factors ($R=0.342$; $p\text{-value}=0.04$). These findings showed that boys in this cohort found this area of coordination more challenging than girls of the same age. This in turn may lead to poorer academic performance outcomes for boys. Literature appears to support this finding (59).

The results seen above in question five, which measured running speed and pattern, are part of the Control During Movement Scale. It appeared that boys in this cohort were also correlated with this area of coordination, scoring lower than their female peers. This will be included under sporting participation below, as running speed and pattern, are likely to affect this domain.

Correlations between coordination and repeated grade

Table 4.13: Correlations between coordination and repeated grade (n=69)

Question	Measuring	Pearson Correlation Coefficient (R- value)	P-value (≤ 0.05)
Q7-Q10	Fine motor/handwriting overall scale scores	0.394	0.001
Q9 (Control During Movement Scale)	Effort and pressure when writing/ Drawing	0.461	0.00

Children in this cohort who had repeated a grade, when compared to those who had not, were shown to score more poorly overall on the Fine Motor/ Handwriting Scale. This correlation, although weak, was shown however, to be statistically significance and demonstrated a positive, linear relationship between these factors ($R=0.394$; $p\text{-value}=0,001$). These findings showed that children who had repeated a grade experienced more fine motor and handwriting

coordination difficulties than their peers. As these skills are important for academic success, these children therefore appeared to be more at risk of repeating a grade than their peers.

Repeating a grade has also been significantly correlated specifically with question nine, which measured the effort and pressure required when writing or drawing ($R=0.461$; p -value of 0.00). This correlation was found to be moderately statistically significant and demonstrated a positive, linear relationship between these factors. The child’s ability to coordinate the amount of effort and pressure required to write or draw is also seen as an important skill, likely to impact on their academic performance. It appeared that children who had repeated a grade found this specific skill relatively more challenging than the other skills tested on this scale.

4.6.2 Correlations affecting sporting participation

Team sport participation and male gender, in this study, were shown to be significantly correlated with poor coordination scores and were postulated to influence sporting participation in this cohort.

Correlations between coordination and team sport participation

Table 4.14: Correlations between coordination and team sport participation ($n=69$)

Question	Measuring	Pearson Correlation Coefficient (R- value)	P-value (≤ 0.05)
Q1-Q15	Total/Overall scores	-0.307	0.010
Q7-Q10	Fine motor/Handwriting	-0.264	0.028
Q11-Q15	General coordination	-0.305	0.011

The coordination skills required in all three scales of the DCDQ’07 reflect part of the child’s ability to participate in sport. Many sporting codes include team sports which involve ball skill coordination. Team sport participation has been shown, in this cohort, to be inversely correlated to poor overall coordination scores ($R= - 0.307$; p -value = 0.010). Team sport participation was also inversely correlated to the total Fine Motor/Handwriting Scale ($R= - 0.264$; p -value = 0.028) and the total General Coordination Scale ($R= - 0.305$; p -value = 0.011).

These correlations, although weak, were shown however, to be statistically significance and demonstrated negative, linear relationships between these factors.

It therefore appeared that children in this cohort who did not participated in team sports experienced more coordination difficulties overall than those who did and they likewise found fine motor and handwriting, as well as general coordination skills to be more challenging than their peers.

Correlations between male gender and gait

Table 4.15: Correlations between male gender and gait

Question	Measuring	Pearson Correlation Coefficient (R- value)	P-value (≤0.05)
Q5	Running speed and pattern	0.257	0.03

The coordination skills required in question five, which measured running speed and pattern, reflected part of the child’s ability to participate in sport. Boys in this study were shown to be correlated with poor scores on this particular question of the Control During Movement Scale (R= 0.257; p-value= 0.03) compared to their female peers. This correlation was shown to be statistically significant and demonstrated a positive, linear relationship between male gender and the coordination skills required by this question. Boys, therefore, were shown to experience more coordination difficulties than their girl peers when running, both in speed and pattern.

4.7 Comparison of children ‘at risk’ to those ‘not at risk’ of DCD

Fisher exact t-tests were used to statistically compare the children in the cohort who screened ‘at risk’ of DCD (n=8) to those ‘not at risk’ (n=61) in terms of the factors found to potentially influence their academic performance and sporting participation. This analysis was performed in conjunction with the above correlation analysis in order to adequately address the objectives of the study. These results are tabulated below.

4.7.1 Comparison of ‘at risk’ to ‘not at risk’ groups for academic performance

The factors identified from the correlation findings which appeared to affect academic performance in the cohort were: repeated grade; academic percentage <70%; male gender and youngest grade. These are tabulated below.

Table 4.16: Comparison of children ‘at risk’ to ‘not at risk’ for academic performance

Factors affecting academic performance	Children ‘at risk’ of DCD (n=8)	Children ‘not at risk’ of DCD (n=61)	Data not provided (missing)	Total (n=69)	P-value (≤ 0.05)
Repeat grade	3	3	0	6	0.0179
Term average <70%	2	11	28	13	0.6228
Male gender	5	25	0	30	0.2811
Youngest age	3	36	0	39	0.2811

From the calculations above, only repeat grade (p-value=0.0179) was shown to have a statistically significant effect on academic performance when comparing children ‘at risk’ to those ‘not at risk’ of DCD in this cohort. Children who were screened to be ‘at risk’ of DCD therefore were shown to be more at risk of repeating a grade than those who were ‘not at risk’.

4.7.2 Comparison of ‘at risk’ to ‘not at risk’ groups for sporting participation

The factors identified from the correlation findings appearing to affect sporting participation in the cohort were: non-participation in sport; ‘fair’ or ‘challenging’ rather than ‘good’ level of participation in sport; non-participation in ball skill sporting codes; non-participation in team sports. These are tabulated below.

Table 4.17: Comparison of children ‘at risk’ to ‘not at risk’ for sporting participation

Factors potentially affecting Sporting participation	Children ‘at risk’ of DCD (n=8)	Children ‘not at risk’ of DCD (n=61)	Data not provided (missing)	Total (n=69)	T-test (p-value)
Non-participation in sport	0	1	0	1	1
Fair/challenging level of participation	3	19	1	22	0.7073
Non-participation in ball skills sports	0	9	0	9	0.5843
Non-participation in team sports	1	16	0	17	0.6689

None of the factors above showed any statistically significant effect on sporting participation when comparing children 'at risk' to those 'not at risk' of DCD in this cohort.

4.8 Conclusion

In conclusion, the results of this study investigation, using the DCDQ'07 Coordination Questionnaire and Additional Data Collection Sheet to gather data in this population of school children, aged five to eleven years, yielded the following results: Eight out of the sixty-nine children screened positive 'at risk' of DCD resulting in a screened prevalence of 11.6% in the cohort. Additional assessment and evaluation by a member of the multidisciplinary team would be required to confirm or exclude DCD as a diagnosis as the actual cause of the coordination and/or other difficulties experienced by the child.

According to the demographic data collected male gender; repeated grade; sporting participation and younger age were shown to be potential factors associated with coordination difficulties to varying extents in this cohort.

Pearson's Correlation Coefficient statistical method was used to investigate for correlations between all factors and coordination difficulties and revealed that male gender and repeated grade appeared to be statistically associated with coordination difficulties in this cohort and likewise appeared to influence academic performance. Coordination skills, especially those required in the Fine Motor/Handwriting Scale of the DCDQ'07, appeared to be more challenging for male children and for children who had repeated a grade. These two groups showed more coordination concerns than their peers, which appeared to negatively affect their academic performance.

Team sport participation was found to be significantly associated with all the scales of the DCDQ'07, as well as with the Fine Motor/Handwriting and General Coordination Scales individually. Question five, which investigated gait speed and pattern, seemed to be associated with male gender, which in turn appeared to influence sporting participation. The other factors investigated in this study have been detailed above but were not shown to correlate significantly with coordination difficulties and were thus not postulated to affect either academic performance or sporting participation in this population group.

Fisher exact T-tests were then conducted to compare children 'at risk' to those 'not at risk' of DCD in the cohort in terms of the factors, postulated in the correlation findings, to affect academic performance and sporting participation. This additional analysis was done in conjunction with correlation analysis in order to address the objectives of the study. Repeated grade was shown to significantly affect academic performance in children 'at risk' of DCD.

CHAPTER 5: DISCUSSION

5.1 Introduction

The results of the above section will be discussed in detail in the subsections below and for ease of reference, the numbering of these two chapters corresponding as closely as possible. Results will be addressed according to the following subsections: data collection (including the return rate of the questionnaires); demographics (general; academic and sporting); additional medical information (where possible comorbidities, risk factors and confounders will be addressed) and parental/guardian comments.

The results of the DCDQ'07 questionnaire, according to its three scales, will be discussed for factors appearing to affect coordination, including significant correlations found to be associated with coordination difficulties. The screened prevalence for 'at risk' of DCD, including the data profiles of the 'at risk' group for possible 'red flags', will be elaborated on. Lastly, the comparison of the 'at risk' with the 'not at risk' of DCD group will be discussed in terms of the possible effect of DCD on academic performance and sporting participation. The study's implications and limitations, as well as recommendations for ongoing research is addressed at the end of this section.

5.2 Return rate of questionnaires

Sixty-nine of the 234 parents approached to participate in the study completed the forms requested. This results in a response rate of 29.5% (69; n=234) which, although low, has been found to be in line with other questionnaire type study designs (60). A study conducted in 2008 investigated response rates for a total of 490 out of more than 400 000 individual and 100 000 organisational surveys, the research findings of which were published in refereed academic journals. These findings showed that the average response rate for individual surveys was 57,7% (SD= 20.4%) and for organisational surveys was 35.7% (SD= 18.8%). The use of incentives was also not shown to be related to the response rate (60)

5.3 Demographics

The information gathered from the participants in this study cohort yielded much data which has been recorded using descriptive statistics. The data was then analysed for correlations using Pearson's Correlation Coefficient statistical method, the results of which were tabulated above, for discussion according to the subsections below.

5.3.1 General demographics

According to the general demographic data gathered, the number of children in the family and the child's order in the family did not appear to affect the findings in this study, while the gender and age of the participants required some discussion.

Male gender

More female than male children were screened by their parents in this study, although sex is evenly distributed in the school according to school policy. Despite this, more male children were found to have coordination problems, screening 'at risk' of DCD compared to their female counterparts, with the ratio of males to females screening positive being 2.5:1. This presents as a similar male: female ratio to most global trends which is 2:1 (29, 61). There appears to be a paucity of South African literature regarding gender ratios in the local context.

Younger age

The youngest age group (5-7 years, 11 months) accounted for the most participants in this study, with the oldest group (10 -15 years) contributing the least. This may be that parents of the younger children are more involved in or more concerned with their children's progress at school or that younger children are still developing scholastic skills and so may not have attained all their milestones as yet. Despite this postulation, in this study, 56% (n=69) of the children who screened positive for 'at risk' of DCD were in the youngest age group (5 years – 7 years 11 months) indicating the possibility of this younger group of children being more 'at risk' of DCD than the older individuals.

Global research has shown that DCD usually persists well into adolescence (62-64), with one study showing prevalence into adolescence and beyond to be measured at 50-70% (65). Coordination appears to improve with age, along with other motor skills in both genders, with

boys more comparable to girls as they mature within a typical population group (59). On the contrary, in individuals with lower motor competencies, such as DCD individuals, improvement does not seem to occur at the same rate as with typical individuals (38). DCD would therefore appear to ‘improve’ with age, although research has shown that adults who were diagnosed with DCD as children tend to continue to find coordination and its many affected functions compromised (3). Continued coordination difficulties may be due to white matter brain changes, as seen on MRI scans in adults with probable DCD. White matter tracts within the central nervous system are responsible for linking all functional areas (66).

It is postulated that, given the evidence above, adults with coordination difficulties would be more likely to pursue fields of interest that do not involve the need for superior coordination skills and may not be proficient sports people. Academic pursuits in the adult population may likewise be affected by coordination, as scholastic difficulties experienced by children affected by DCD, may perpetuate into adulthood or affect the normal progression of scholastic milestones which would, in turn, affect the adult in later life.

5.3.2 Academic performance

Current grade did not appear to be significant in this study, while the other factors relating to the child’s academic performance are discussed below for their relevance.

Grade repeated

Despite the grade repeated not appearing to be significant in the analysis of this data set, it is noted that Grade 4 did show slightly more repeats than the other grades. This may be coincidental, or it may be that by the time the child has reached a Grade 4 level, they are finding it more challenging to complete the scholastics tasks assigned to them, many of which involve coordination skills.

Repeated grade

Within the study population, six participants repeated a grade (n=69), three of whom were male and were also found to be ‘at risk’ of DCD (n=8). It appears then, in this study, that both gender and coordination correlate with repetition of a grade, which in turn, is usually an indication that the child is not managing to attain academic success in that grade. These

correlations will be expounded on and shown to have statistical significance below in 5.6 (Correlations).

Level of academic performance

The level of the child's academic performance was also supplied by the parent according to the standardised report card levels which includes the child's average term percentage. Of the total number in the study, 36.2% (n=69) of the parents did not disclose their child's academic performance level. This may be due to the young age of the cohort, where academic levels are not yet viewed to be of great value by the parents, as their children are still attaining the skills needed to be successful scholastically. It may also be that some parents, not wanting their children to be labelled as having academic difficulties, would still rather not disclose their child's academic level, despite the study being a confidential, de-identified one.

While 47,8% (n=69) of the children achieved academic levels of over 70%, another 15,9% (n=69) achieved between 50 and 69%. This may be of some concern, especially in these lower grades. A balanced view of these results would need to be taken as, on the one hand, children are still developing the scholastic skills needed to achieve academic success and so results need to be seen as part of the holistic view of the child. On the other hand, should a parent or teacher be concerned or other factors such as, for example, coordination difficulties are present, further assessment and possible intervention at an early age would be preferable in order to optimise the child's academic success and overall health and wellbeing.

5.3.3 Sporting participation

Sporting participation was measured in this study by collected data regarding the child's participation in sport and their level of participation, as well as if the child participated in ball skills and team sports. It should be noted that the level of ball skill and team sport participation was not requested as, especially in the younger age groups, focus is on participation, rather than on competition or level.

Sporting participation and level

All, but one child in the cohort, participated in sport at some level. 27,5% (n=69) of the children were reported to have a sporting 'fair', rather than 'good' sporting level, while 2.9% (n=69) of

the children were reported to find sport ‘challenging’. Only one participant’s (n=69) sporting participation was not provided, compared to 25 (n=69) of the children’s academic levels not being provided, as shown in the previous subsection. It may be postulated that parents are more concerned with their children’s academic performance compared to their sporting participation at this age, or alternately, may be less aware of their children’s academic difficulties compared to their sporting or gross motor skills. Gross motor skills also develop earlier than some of the fine motor skills required for academic success (67), therefore possibly being more easily measured or recognised by the parent in these younger age groups.

Ball Skills

It has been noted that besides the gross motor skills, good fine motor skills and coordination are required for skilful ball skill manipulation (41). Nine (n=69) of the participants in this cohort did not participate in sport involving ball skills. This does not necessarily equate to them being unable to perform sports involving ball skills, as it may be their preference not to do so. It may alternately suggest that sporting codes requiring ball skill manipulation, are more challenging for some children. Literature has found that ball skills have been shown to be more challenging for DCD children (41). Correlations between these factors will be discussed in more detail in 5.4 below.

Team Sports

Out of the total cohort, 17 (n=69) children did not participate in team sports. As mentioned above, participation data regarding team sports, rather than the level of participation was gathered. Team sports would likely present as an area of difficulty for individuals with DCD. In a study undertaken in 2000, where the previous diagnosis of DAMP (Deficits in Attention and Motor control and Perception) was commonly used to describe DCD individuals, it was shown that none of their cohort of 11 and 12 year old boys participated in team sports (68). In the current study, the correlation between team sports and the different coordination scales of the DCDQ’07, is elaborated on to show that this area is significantly correlated with difficulties in all areas of coordination (see section 5.4).

5.3.4 Additional medical information

The following additional medical information data collected, also reveals some relevant findings which will be addressed individually.

The literature has shown that there are a number of comorbid or risk factors that influence coordination which would need to be considered in the analysis of this data set. In this study, five (7.2%; n=69) of the children presented with ADHD, representing the most significant of these factors. ADHD is known to be a common comorbidity associated with DCD (27, 29, 43). Studies have also shown visual problems being associated with DCD in some individuals (32) and in this sample, four children (5.8%; n=69) reported visual concerns. Prematurity at birth (<36 weeks' gestational age) was noted in three (4.3%; n=69) of the children. This is known to be one of the risk factors associated with DCD (46, 47). The other risk or comorbid factors associated with DCD have been discussed in the literature review.

ADHD

ADHD is the most common comorbid disorder associated with DCD (27, 43, 69). A DCD individual's academic and other life domain outcomes are usually more affected if ADHD is comorbid. Both disorders require correct management for good functional outcomes to be achieved. As mentioned above, five children (7.2%; n=69) were reported to have been diagnosed with ADHD. None of these children were screened to be 'at risk' of DCD and all appeared to be well managed medically for ADHD. ADHD can lead to difficulties with academic performance and fine motor skills, as well as coordination, if unmanaged. A full clinical assessment by a medical practitioner is necessary to diagnose and manage ADHD, preferably in collaboration with the appropriate members of the multidisciplinary team.

Visual Problems

In this study four children (5.8%; n=69) were reported to have visual problems. According to the literature, visual comorbidities are also fairly common with DCD and require separate management to optimise the individual's outcomes (32). One of these four children screened positive for 'at risk' of DCD in this cohort. This child wore glasses and no academic or sporting concerns were noted in the information received from the parent. It appears that despite this

child's coordination and visual problems, she was well managed for both diagnoses and appeared to be coping well in both academic and sporting domains.

Hearing Problems

One child in the cohort (1.44%; n=69) was reported to have hearing problems and had had grommets inserted according to the parent comments. This child was screened to be 'at risk' of DCD and had repeated Grade 2. Her academic performance was not provided by the parents and her sporting participation appeared to be good. Although hearing does not appear in the literature to be directly comorbid with DCD, studies have shown DCD to affect the individual's vestibular, proprioceptive and visual sensory systems despite the mechanisms for this being poorly understood (27, 28). It would therefore be reasonable to assume that if hearing is affected, the vestibular system may be impaired, causing a possible delay in certain motor milestones such as balance reactions, coordination, or other motor skills in the developing child. Again, the importance of assessment and correct multidisciplinary management of each individual child, according to their clinical presentation, remains key to optimizing each individual's outcomes.

Genetic disorders

Genetic disability, according to the latest definition of DCD, is a confounding variable and would exclude the diagnosis of DCD from being made (61). No children in this cohort were found to have diagnosed disorders or disabilities of a genetic nature.

Developmental problems

The motor skills deficits found in DCD, according to its definition, cannot be caused by a diagnosed neurological condition affecting movement (61). Developmental problems would therefore need to be assessed initially to determine if they were causative in the motor deficit or comorbid with the underlying DCD. In this study, parents of three of the children reported their children to have developmental problems. These are individually expounded below with the *parental comments and their management* (if any):

- 'speech problems'; 'speech therapy attended over past 20 months. Significant improvement.'

- ‘prematurity (<36 weeks)’; ‘has had an operation for hip dysplasia (battles a bit more physically)’; ‘takes time to complete puzzles’
- ‘attending remedial classes for reading and fine motor skills. Difficulty concentrating for long periods; easily distracted’

Of the three children above, the second child was screened positive for ‘at risk’ of DCD. It is noted that this child was born prematurely (<36 weeks) which may be a risk factor for DCD, as low birth weight children or very preterm children (VPT) are at risk for DCD (45, 47). This child also has physical challenges following hip dysplasia and an operation, which would likely affect her coordination to some extent. Lastly, the parent has also reported that this child takes longer than expected to complete a puzzle. This may be due to fine motor difficulties, coordination, or processing problems. All of these problems are often associated with DCD (68). It is also to be noted that the parent of this child did not provide their child’s academic percentage and reported ‘fair’, rather than ‘good’ sports participation.

Prematurity

Four (4.3%; n=69) of the participants were reported to have been born prematurely (before 36 weeks GA). Very preterm (VPT), as well as low birth weights, is a risk factor for DCD as mentioned above (45, 48). Of these participants, only one child (n=8) was screened ‘at risk’ of DCD. This child is discussed above, as she was also reported to have developmental problems.

None to report

Of the total number of participants, 52 (75.4%; n=69) were not reported to have any medical conditions. Interestingly, five (n=8) of the children who screened ‘at risk’ of DCD did not report any comorbid medical conditions or risk factors. This does appear to support the research that DCD can be a standalone diagnosis in some instances (61) and may therefore not always be easily identified by parents, teachers, or medical professionals. Awareness of this disorder is therefore important (7) to correctly identify DCD children to timeously intervene, as appropriate for each individual, to prevent unnecessary delays in scholastic and other life domains such as sporting participation.

5.3.5 Parent/ guardian comments

Parents or guardians play a vital role in the success of a child as they are the primary nurturers, supporters and often teachers of their children. This study design therefore included a section where parents were able to comment or voice concerns regarding their children. Twenty-four (n=69) parents/guardians offered comments, and these were addressed individually by the principal investigator if the parents requested feedback. Most parents did request feedback showing an interest in their children's wellbeing.

Six of the eight parents (n=8) whose children were screened to be 'at risk' of DCD offered comments regarding their children, while two (n=8) did not. One (n=8) of these parents did not request feedback regarding the outcome of the screening.

These comments were informative and often, but not always, aligned with the objective outcomes of the data collection, therefore adding value to the information gathered. It was also noted that most parents had already started suitable interventions for their children, but a few had not. Feedback was given to all the parents in the cohort who requested it. Recommendations were also given to all the parents, if this was deemed necessary by the primary investigator and not only to the parents whose children had been screened to be 'at risk' of DCD (n=8) in accordance with good ethical practice.

5.4 Discussion of findings of the DCDQ'07 outcome measure

The DCDQ'07 measures different areas of coordination according to three scales in children aged five to fifteen years. Stratification according to three age groups is therefore built into this screening tool to allow for the natural progression of milestones that occur as children develop. The DCDQ'07 has been shown to be a useful standardised outcome measure, not only as a screening instrument, but also to allow the medical professional access to clinically useful information to best inform individual intervention strategies depending on the profile of the child's DCDQ'07 coordination results (44).

The overall and individual scale results, as well as individual questions, will be discussed, specifically the areas which children found to be challenging. The numbers and percentages have been tabulated in the results section and reasons for these results will be expounded on

below. This study investigated academic performance and sporting participation specifically and so reasoning will be approached with these aims in mind.

5.4.1 Control During Movement Scale (Q1-Q6)

This scale measures ball skills (throwing, catching, and hitting) in questions one to three respectively; jumping in question four; running (speed and pattern) in question five; and the ability to plan, organise and complete an activity in question six. All these functional activities are required in sporting participation, either in individual sporting activities or in team sports or those sports involving ball skills, which are often required in team sports too. Poor performance in these areas shown by a low score on questions one to five, would be indicative of potentially poor sporting performance. This may lead to an unwillingness to participate in sporting activities, either in individual or team sports or in sports involving ball skills, or both.

In this study, slightly more children found catching and hitting a ball (in questions two and three) more challenging than the other questions. Coordination required to target an object is a learned skill which typically develops with age, but when coordination is less developed, this skill will be challenging. Throwing a ball (question one), albeit in a controlled and coordinated fashion, therefore appeared to be easier than catching and hitting a ball, in this population.

Jumping over an object (question four) can be difficult for some children, with two (n=69) of the participants scoring two out of five for this question, showing this to be a difficult skill for them.

The speed and pattern of running (question five) was seen to be difficult for a few children too. This question appeared to show a correlation with gender, with boys scoring lower than girls. This will be discussed in detail in 5.4.

Again, only a few children found the planning, organising and completion of a task (question six) to be difficult, with two (n=69) children scoring two out of five and five (n=69) scored three out of five. The majority managed sufficiently with this task, scoring four out of five and five out of five. It should be noted though that these skills (planning, organising and completion of a task) are needed for all motor tasks both in the academic or sporting arenas, as well as in all other life domains. Difficulty with this question (question six) would require early and

effective intervention, as an inability to plan, organise and complete a task severely limits the individual's ability to accumulate the functional skills required to advance in all life areas.

The majority of the children screened, did not find the questions on this scale difficult, which is what would be expected, as the screener compares typically developing to possible 'at risk' of DCD children with the known global prevalence to be 5-6% (61). *Screened or 'at risk' prevalence* will be discussed in 5.5 as it differs from *actual prevalence*, as screening identifies possible, rather than diagnosed (actual) individuals of a condition.

5.4.2 Fine Motor/ Handwriting Scale (Q7-Q10)

This scale investigates the coordination skills required to perform the important fine motor or handwriting tasks which are required in the scholastic environment. The questions measured the child's (writing or drawing) speed (question seven), legibility (question eight), amount of tension used (question nine) and their ability to cut out accurately and easily (question 10). If a child finds these skills difficult, academic performance is likely to be affected. Early identification, to inform the appropriate intervention approach, is important for the child who struggles with the coordination skills needed in this area. Typically, children will develop improved coordination skills as they age, ongoing difficulties in this area will tend to compound the child's academic challenges as time passes. The child may feel at a disadvantage if they perceive that they are not performing at the level of their peers. This often causes an added disadvantage as they get older (6). For this reason, age is stratified in the measurements of this screening instrument.

Clinical reasoning, by a member of the multidisciplinary team, is important to correctly interpret the findings of the DCDQ'07, in order to best determine the type and intensity of intervention required, as well as to assess whether the poor score on a skill is likely or not to correct with age. The need for further assessment for screened individuals is therefore reiterated as essential not only to confirm a diagnosis, but for this necessary clinical reasoning component.

In this study, the Fine Motor/Handwriting Scale showed that more of the children found this scale to be challenging than the previous scale (Coordination During Movement). This may be that gross motor coordination skills developmentally precede fine motor coordination skills

(70), resulting in less children having become proficient at fine motor skills by the ages of the study, when compared to the above scale, which measures gross motor skills predominantly. One child (n=69) was neither able to write nor draw as fast as their peers (question seven), nor were they able to use the correct amount of effort or pressure when writing (question nine), scoring one out of five on these two questions. This individual child did screen to be positive 'at risk' of DCD and it was therefore recommended that they be referred to either an occupational therapist or physiotherapist, who would be able to assess this child for DCD or other concerns in order to intervene, thereby aiming to assist this child academically. Appropriate referral to other members of the multidisciplinary team would be recommended if deemed necessary.

5.4.3 General Coordination Scale (Q11-Q15)

This scale questioned the child's enjoyment and participation in sports or games requiring good motor skills (question 11); their ability to learn new motor skills (question 12); their proficiency at activities of daily living such as dressing themselves, tidying up etc (question 13); 'clumsiness of the child in a small space'(question 14) and how quickly a child fatigues when sitting for extended periods (question 15). This scale would affect sport participation, academic performance, and general activities of daily living (ADLs), all of which impact on most life situations.

In question 11, it was noted that most child wanted to participate in sports, but some found this to be moderately challenging, perhaps having some difficulty with the motor skills required for good participation and scored three out of five on this question. No lower scores were seen in this sample. It is encouraging to note that children were at least interested in sports participation in most cases.

A few children found the ability to learn a new skill difficult, as measured in Question 12, scoring two and three out of five. The learning of a new motor skills, or activities that required planning, organisation and repetition to master, have been found in children with DCD to be an area of weakness (71).

In this study, it appears that slightly more children found questions 13, 14 and 15 challenging. Question 13 addressed activities of self-care such as dressing and tidying up. It showed a

distributed spread of results between the scores, rather than the expected higher scores being more apparent. This may be interpreted as more children having found the coordination required for these daily skills more challenging than some other skills involving coordination. It could likewise also mean that parents often assist their children with these tasks, perhaps slowing down their children's ability to acquire these skills independently at a younger age. For example, if a parent always assists a child with tying their shoelaces or a child is not expected to tidy up after themselves, they will take longer to acquire these skills. It would be important to facilitate the child in their attempt at mastering difficult tasks, rather than either completing the task for them or not assisting them at all. This is where graded therapeutic intervention is often very useful to support these children to functional independence (49).

Question 14 investigated clumsiness in a small space, which could result in breakages. A few children found this area to be challenging. Correlations to gender and age, in relation to this question specifically, will also be discussed in section 5.4, as these factors are postulated to potentially affect this area of coordinated activity more in male or younger children (64). More children found this and question 15 to be more challenging than the previous questions of this scale.

Question 15, which investigated sitting posture for extended periods, would be viewed as a very important component of the child's ability to achieve academic success in a typical school environment. Several children scored low on this question (one or two out of five) with a fairly even spread of responses across the other scores. This appeared to show that some children did find this functional skill to be quite difficult, although it is postulated that most children would likely improve in this skill as they got older. Age as a factor is discussed in detail in section 5.3.1 under General demographics, as it developmentally affects motor skills, including coordination, which in turn influences the success of most functional skills. Therapeutic, postural intervention would be recommended should seating at school for extended periods be found to be affecting the child's ability to concentrate or achieve academic success.

Individual children in this study, screened to be 'at risk' of DCD, would therefore be referred on to a member of the multidisciplinary team for further assessment to allow for appropriate intervention.

5.5 Prevalence of children ‘at risk’ of DCD

The first aim of this study was to investigate for screened prevalence of ‘at risk’ of DCD in the cohort. The screened ‘at risk’ of DCD prevalence findings of this study were compared to global and South African data prevalence findings. The data profiles of the ‘at risk’ of DCD group, as tabulated above, will be discussed in detail. The factors, which appear to be associated with coordination difficulties in this study, are identified in relation to their possible influence on Academic Performance and Sporting participation.

5.5.1 Global versus South African prevalence of DCD

Most research investigating the prevalence of DCD has been conducted in higher to middle income European countries (for example; England, Switzerland and Germany) (3, 42) and Canada (72, 73) and has shown a prevalence of 5-6% of children and adults being diagnosed with DCD within the general population. Whilst the majority of DCD research has been conducted in these higher income centres, South African studies have started emerging more in recent years (18, 28, 29, 35, 74-76).

A South African study conducted in 2016, in the Free State Province in South Africa, investigated the prevalence of DCD in 347 Grade One children between the ages of five and eight years old and how this condition affected scholastic learning areas (18). The prevalence of DCD was assessed and diagnosed using the MACB-2 and the learning areas were assessed using the Aptitude test for School Beginners (ASB). The prevalence of DCD, where the participants were severely motorically impaired, was shown to be six percent (n=347), with an additional six percent (n=69) of the children tested, shown to be ‘at risk’ of DCD, being moderately impaired. The study was conducted in a similar socioeconomic population (middle to higher socioeconomic) to that of the current study. Gender was not noted to be significant in this study (18).

Another study carried out in the North West Province of South Africa also investigated academic performance in Grade One children (n=812), focusing on perceptual motor function in lower socioeconomic schools in South Africa. The study did not focus specifically on DCD but concluded that there was an inverse correlation between lower socioeconomic school type and academic performance, with a common perceptual motor foundation shared by all learning areas (35).

A further study conducted in the North West Province in South Africa in 2015 assessed pre-schoolers for motor difficulties in five different socioeconomic settings. The authors concluded a prevalence of 11.32% (n=53) of DCD in their study population. Age and gender were shown to be significant, but not socioeconomic status (22). These findings appear to compare more with the findings of the current study, which was carried out in the Eastern Cape, South Africa. The above studies, completed in different provinces in South Africa, showed higher ‘at-risk’ of DCD prevalence findings than the actual global prevalence findings. A Canadian study done in 2000, showed similar findings to the current study with an ‘at risk’ of DCD prevalence of eight to fifteen percent (n=103), in a cohort of seven and eight year old school children tested for motor difficulties using the MABC checklist as a screening measure (21). The ages of the Canadian study were not as broad as the current study which screened children between five and eleven years old. The Canadian study also screened more broadly for motor coordination difficulties, which resulted in a wider ‘at risk’ of DCD prevalence range concluded, with the authors of the study postulating this may be due to their selection of the MABC checklist screening instrument which has a low sensitivity.

5.5.2 Screened prevalence of ‘at risk’ of DCD in cohort

According to the findings from this study, using the standardised DCDQ’07 screener, eight children (n=69) from the total population were found to be ‘at risk’ of DCD. This reflected a *screened* prevalence of 11.6% (n=69) of the total study population, which is higher than the known global *actual* prevalence of DCD of 5-6%. A screening instrument, such as the DCDQ’07, which involves self-reporting by the parent, identifies *possible risk* for a condition. Additional assessment using for example, the MABC-2, an internationally standardised movement assessment battery for children, is always needed to confirm a definitive diagnosis. Therefore, an individual who is screened positive for a disorder, is ‘at risk’ of, but not yet definitively diagnosed with, a condition. A number of the screened participants would therefore possibly not be diagnosed with the screened condition following assessment, thereby decreasing the actual prevalence of DCD in this population. The current study findings closely compared to the findings of the Free State study discussed above when the numbers of both the severely (diagnosed with DCD) and moderately (‘at risk’ of DCD) motorically impaired

children were included in the findings of the study and totalled 12% (n=347) of their study population (18).

The number of children who screened ‘at risk’ of DCD is also likely to be higher than the actual diagnosed percentage of DCD in this population. The reason for this is that a screener, such as the DCDQ’07 which has an overall specificity of 70.8%, will also identify other reasons for coordination difficulties besides DCD, for example visual impairments (19) which may impair an individual’s ability to acquire motor skills at the same developmental rate as individuals without this impairment. Visual impairment is therefore seen as either a comorbid impairment to be managed in conjunction with DCD or as a confounding variable to the diagnosis of DCD. Further assessment, after screening, is therefore important and may likely then exclude any other possible causes of coordination difficulties, thereby giving the actual prevalence in the population. This actual value is thus likely to be lower than that which was initially screened.

This re-emphasises the need for further assessment in order to prevent over-diagnosis of this condition. Recommendations to the study population were made to therefore seek further professional and thorough assessments to conclusively determine the actual DCD diagnosis (or alternate diagnoses for these children when other incidental findings or parental concerns were noted). This was important ethically in order to assist these children with the necessary intervention/s required to optimise their long-term outcomes in the areas of scholastic performance, sporting involvement and other activities of daily living necessary to their success.

5.5.3. Data profiles of children ‘at risk’ of DCD

The results in Table 4.11 indicate the data profiles of the individual children who were screened to be ‘at risk’ of DCD from the study cohort. The specific participant de-identified numbers have been used for ease of data referencing. The principal investigator identified or ‘red flagged’ certain data from the table as factors that *may* be of concern and where recommendation for further assessment would be suggested. Clinical reasoning, when data regarding an individual is being evaluated, is key to selecting the correct approach for intervention, if the clinician deems this to be necessary following the assessment of the screened ‘at risk’ individual. It should be restated that the ‘red flags’ identified in this study

are as a result of the principal investigator's clinical reasoning and are therefore open to interpretation. A 'red flag', by definition, implies the above, rather than assuming definite conclusions that would require objective assessment (or outcome measures) to confirm.

The following interesting observations were made from the data profiles of the 'at risk' of DCD group in Table 4.11:

- Five of the eight 'at risk' children were males (62.5%; n=8), giving a male to female ratio of 2.5: 1 in this cohort. This corresponds closely to the global 2:1 male: female ratio findings for DCD (61).
- Three of the eight children were in the younger age group (37.5%; n=8); three were from the middle age group (37.5%; n=8) and two from the oldest age group (25%; n=8). It is likely that younger children do experience more difficulty with certain coordination skills, as development of motor skills improves with age. This may account for these numbers to some extent.
- Three of the eight children (37.5%; n=8) repeated a grade, all three of whom were male.
- Four of the eight children's parents (50%; n=8) did not provide their academic performance results, one of these having repeated a grade. Two of the children (25%; n=8) averaged 50-69% and both had repeated a grade and were boys.
- All eight children participated in sport, but three of the eight (37.5%; n=8) were noted to be 'fair' at participation, rather than the other five who reported 'good' participation.
- All eight children participated in ball skills (100%, n=8) and all but one (12.5%; n=8) participated in team sports.
- The comorbid medical diagnoses reported were the following: hearing problems (one child; n=8); visual problems (one child; n=8); developmental problems and prematurity (one child; n=8).
- Parent comments of the 'at risk' of DCD group were varied and are recorded below. These comments are useful and should always be considered when evaluating a child, as the parent has much insight to give regarding their child. The starting point in gaining a thorough history of any affected child is to question the caregiver concerned. Each parental comment, in relation to each 'at risk' of DCD child's data profiling, is therefore discussed in detail below:

- *'slow, perfectionist'* – This girl achieved >70% and was reported to be 'fair' rather than 'good' at sport. She may or may not be diagnosed with DCD, as a child with this 'perfectionist' nature may be taking their time to complete a task out of choice, rather than needing to do so due to poor coordination skills. Further assessment is required to confirm or reject a diagnosis of DCD, as with all the screened 'at risk' children.
- *'speaks loudly; over-eager; rushes everywhere; wants everything now'* – This boy's academic results were not provided and although he was reported to be 'good' at sport participation, he did not participate in team sports. He was in the youngest age group screened. No reported comorbid ADHD was reported although assessment may reveal this as a comorbidity or standalone diagnosis. His age and gender may also explain the parent comment to some extent.
- *'lack of physical growth; inability to process problems'* – This boy had repeated a year; showed a 50-69% term average and was 'good' at sport. His lack of physical growth and inability to process a problem are both areas of concern which require assessment to confirm or exclude DCD, as well as to determine if any other possible comorbid or confounding conditions exist which may require additional management.
- *'grommets'* - This boy was reported to have hearing problems; had repeated a grade; his academic results were not provided, and he was 'good' at sport. His parent was also the only one of the above eight participants who did not request feedback from the screening. This parent may or may not be aware of their child's coordination difficulties. Hearing may be a confounding condition, rather than DCD, which may have affected his academic performance. Again, assessment is required for clarity and intervention, if necessary.
- *'36w; operation for hip dysplasia; battles a bit physically; takes time to complete puzzles'* – This girl was reported to have 'developmental problems' and was born prematurely (<36 weeks GA). She had not repeated a grade, although her academic average was not reported, and she was 'fair' rather than 'good' at sport participation. She was in the youngest age group screened. Assessment and further questioning would reveal if her physical challenges alone impaired her coordination or if she may be diagnosed with DCD. The reported 'developmental problems' would also need to be investigated, to determine if this was a confounder to DCD by being a diagnosed premorbid condition or rather a developmental milestone delay, as a result of a idiopathic hip dysplasia not

associated with a confirmed diagnosis such as Cerebral Palsy. 'Taking time to complete a puzzle'- as a child in the youngest age group, this may be within a normal range or may be an area of potential concern, which could lead to academic challenges in the future, if this issue is not addressed timeously.

- '*wears glasses*'- This girl had visual problems; had not repeated a grade; was academically averaging >70% and was 'good' at sport participation. Her coordination concerns did not seem to impact on her academic performance or sporting participation and so further assessment into this area would be recommended to investigate which areas of coordination she was finding challenging in order to recommend strategies to assist her if necessary. Her comorbid (or perhaps confounding) visual problems, for which she is wearing glasses may be the reason for her coordination difficulties to some extent. Again, DCD as a diagnosis, would be confirmed or excluded on further assessment.

Two (n=8) of the parents of children found to be 'at risk' of DCD, did not comment or report any concerns regarding their children, both of whom were boys. One (n=8) of the boys had repeated a grade; had a grade average of 50-69% and was 'fair' rather than good at sport participation. The other boy's academic results were not provided; he had not repeated a year and was reported to be 'good' at sport participation. It is noted that this boy was in the youngest group screened (n=8).

The above discussion and comments offer a varied, but insightful clinical picture of some of the presentations seen when evaluating children with 'at risk' of DCD. The individual scale scores (as well as the individual questions within these scales) of the DCDQ'07 coordination questionnaire are also a useful source of information in terms of the areas of coordination that the individual child finds to be challenging. Recommendations would be made according to the data gathered above, the clinical picture that emerges from this data, as well as the further assessment required to diagnose each individual child following this screening investigation.

5.5.4 Factors affecting coordination in cohort

From the discussion above, certain factors were noted to be associated with coordination difficulties in the ‘at risk’ of DCD group, these being male gender; repeating a grade; sporting participation and younger age.

Male gender

Published literature has shown globally, that the ratio of boys to girls who present with DCD is 2:1 (44). In this study, of the eight children screened to be ‘at risk’ for DCD, five (62,5%; n=8) were boys, showing a ratio of 2,5:1, which is comparable to global norms. Boys, in this study, showed more ‘red flags’ or concerns (as discussed above) than did their female peers. These concerns may be as a result of being ‘at risk’ of DCD or due to other comorbid factors known to be associated with DCD in boys, for example ADHD which is also more prevalent in males than females (43).

Repeated grade

As seen above, three of the six children in the cohort (50%; n=6) reported to have repeated a grade, were screened to be ‘at risk’ of DCD. This study therefore appears to compare with current literature that has showed that DCD can affect academic performance (18, 35, 72) and sporting participation (65). All three (n=6) of these children were also boys, two (n=6) in the oldest and one (n=6) in the middle age group screened. Two (n=6) of these children reported academic averages of 50-69% and one (n=6) was not provided, with this particular child also reported to have hearing problems and grommets. The other two children (n=6) did not report any medical diagnoses. One (n=6) of the children’s parent did comment on their child’s ‘lack of physical growth’ and ‘inability to process a problem’. Studies have noted processing difficulties to be present in the DCD population (25, 72). The specific brain areas responsible for motor processing may also be postulated to affect other areas of processing, such as those involved in certain problem-solving tasks required academically (25). This child also scored particularly low in the Fine Motor/Handwriting Scale of the DCDQ’07, the skills of which would affect the scholastic skills needed to perform at an academic level comparable to one’s peers.

Sporting participation

It should be noted that most of the participants did participate in one or more sporting codes. Three of the eight (n=8) 'at risk' of DCD group, reported 'fair' rather than 'good' sporting participation. All participated in ball skills and one (n=8) did not participate in a team sport. The ability or level of the child's ball skill and team sport proficiency was not the aim of this study, but rather their participation in sport. These areas would be of interest to investigate in future studies. Research does suggest that children with DCD show difficulties with the fine motor skills required for adept ball skill manipulation which is often needed in a team sport environment (68). Team sports participation is often affected in children with DCD as confidence in this domain is often poor and children report being excluded from games and sport due to poor sporting performance (5). Of the children who reported 'fair' participation (n=3), the one child's parent reported her to be 'slow; perfectionistic' and another reported the child to have been born prematurely (<36 weeks GA) and have experienced 'developmental problems', including hip dysplasia and an operation for this condition. This child has also been discussed in more detail in the section above.

Younger Age

Coordination was screened in this study population according to three age groups, namely: 5-7 years, 11 months (youngest age group); 8-9 years, 11 months (middle age group) and 10-15 years (oldest age group). The reasoning behind the age groupings is because motor milestones, like all developmental milestones, develop with age (70). It is therefore important and logical to stratify the sample according to age groupings as has been done in the DCDQ'07 coordination questionnaire. In this study, three children (n=8) from the 'at risk' of DCD group were from the youngest age group; three (n=8) from the middle group and two (n=8) from the oldest group.

None of the parents whose children were 'at risk' of DCD in the youngest group (n=3) provided academic results. This may be due to them having been in the lowest grades where less emphasis is placed on academic performance, as well as the child possibly still learning some of these skills. Formal testing at school has also not begun at this point, although point scores (and percentages) are still allocated to the children. No children had repeated grades in this group as most of these children would have been in their first year of school. Many parents

would simply prefer not to 'label' their children to be having any academic challenges at such a young age. Likewise, only one (n=3) of these youngest aged 'at risk' children reported 'fair' sporting participation (n=3) rather than 'good'. One of these children (n=3) did not participate in team sports. These skills might also still be in the process of being acquired, although this particular child did have a physical problem (hip dysplasia) and had been born prematurely, leading to possible confounding diagnoses. Assessment would bring clarity to these areas of concern.

The middle age grouping showed one child (n=3) having repeated a grade (n=6), for whom the academic percentage was not provided (n=28). The other two children (n=3) showed good academic performance at >70%, with one (n=3) of these children showing 'fair' sporting participation (n=3), this child being 'slow and perfectionist' according to the parent's comment.

Lastly, of the oldest group of two children, both were males and had both repeated a year (n=6), with lower academic scores of 50-69% (n=13). The one boy's (n=2) parent reported a 'fair' level of participation (n=3) and had scored very low on the Fine Motor Skills/Handwriting Scale of the DCDQ'07; the other (n=2), a 'lack of physical growth' and 'an inability to process a problem'.

A number of points of interest are apparent when considering the above relating to age. All children develop over time and therefore age needs to be carefully considered when determining if this is an actual factor affecting coordination or whether the child is still developing this skill. Despite this, a child who presents with DCD will continue to struggle with coordination skills beyond what is typically expected for their age (1, 20, 44, 70, 77). DCD has been shown to continue to affect their performance, both in the academic and sporting domains (43, 68). Poor physical growth is often, but not always, found to be present in a child with DCD (65). DCD is also known to continue into adolescence and beyond (65) therefore underlining the importance of early intervention to mitigate these and other ongoing challenges, for example weight gain (76) in these children. Quality of life is often affected in DCD individuals as a result of cumulative and ongoing effects of this disorder (5).

5.6 Factors correlated with coordination difficulties

Pearson's Correlation Coefficient Statistical Method was used in this study to statistically analyse the correlations between the gathered data and different coordination skills. These results have been tabulated in the section above and the statistical significant, as well as the strength of these correlations, will be discussed in detail below according to the aims of this study, these being academic performance and sporting participation. Reasons for these correlations will be investigated and compared to current literature findings.

5.6.1 Correlations affecting academic performance

Male gender and repeated grade were found to be correlated with poor coordination scores on the DCDQ'07. Certain scales, as well as specific questions within these scales, were seen to be correlated with male gender and repeated grade. This can be interpreted as follows: certain coordination skills (questions) or group of these skills (scales) would be more affected in male children or in children who have repeated a grade.

Male gender

The coordination skills required in the Fine Motor/ Handwriting Scale of the DCDQ'07 reflect part of the child's academic performance. All of these scholastic skills are required for success in the academic sphere at school and therefore an individual experiencing difficulty in these areas would be likely to meet with academic challenges.

The results of the study found that male children experienced more difficulties, than their female peers, when required to perform coordination tasks involving fine motor activities and handwriting. Despite the correlation between gender and coordination on this scale being shown to be a weak positive one, it was none the less, statistically significant. According to research on gender in this specific area of coordination, there does appear to be evidence for this relationship, with boys, especially during their younger years, finding fine motor tasks to be more challenging than girls (59, 78). This information may be of clinical use, assisting teachers and parents to ensure that male children are supported from an early age to optimise their fine motor and handwriting coordination skills, better enabling them to achieve academic success in these areas.

In question five of the Control During Movement Scale which measures running speed and pattern, boys also scored lower than their female counterparts. This will be discussed in detail below under sporting participation, as this skill would partly reflect the child's ability to participate in the sporting domain.

Repeated grade

Children who had repeated a grade were found to have poor coordination scores on the Fine Motor/Handwriting Scale of the DCDQ'07. This correlation was found to be of weak, yet positive, statistical significance. This corresponds to the current knowledge base which indicates that DCD can affect both executive functioning and therefore scholastic performance in children (35, 71). Question nine on this scale, which measured the effort and pressure required when drawing or writing, showed a moderate (more strongly correlated) positively significant correlation. This can be interpreted as an important coordination requirement leading to academic success or conversely, when affected, to academic difficulties, possibly resulting in the need to repeat a grade as in some cases seen in this study.

Fine motor skills are a vital part of scholastic activities and require significant coordination. If a child is battling in this area, intervention would be important, as repetition of a grade, while at times necessary, is ideally avoided if possible. Awareness of the areas of coordination difficulties would assist the intervention and approach of professionals and parents alike. Children who experience difficulties with fine motor and handwriting coordination may be at risk of repeating a grade, as these skills are important for academic success in the schooling system (35). Of the six children in this study who repeated a grade, three (50%; n=6) were shown to be 'at-risk' of DCD. This suggests that coordination affects academic outcomes.

Planning and organisational skills known to affect coordination in DCD individuals were also shown by the South African study in Bloemfontein to significantly affect five of the eight learning areas measured on the ASB in their Grade One population (n=347); these being: reasoning; numerical skills; gestalt; coordination and memory. The numerical skills; gestalt and memory learning areas were not shown to be significantly affected by DCD in this study (18).

5.6.2 Correlations affecting sporting participation

Team sport participation and male gender were shown to be correlated with poor coordination scores in this cohort. These findings can therefore be interpreted as boys being shown to present with more coordination difficulties resulting in less participation in sport. Likewise, team sport participation in the cohort would be affected by coordination difficulties. These two factors will be extrapolated on below.

Team sport participation

Team sport participation was correlated with poor overall scores on the DCDQ'07, meaning that the coordination skills tested in all three scales of this questionnaire were required to participate well at a team sport level. This correlation was weak and negative but still statistically significant. This showed that children with poor overall coordination were less likely to participate in team sports.

A weak, negative, yet statistically significant correlation was also seen on both the fine motor/handwriting and the general coordination scale showing that children with poorer fine motor and general coordination skills were less likely to participate in team sports.

A possible reason for these results is that, in order to participate proficiently in team sports, a child would require a good ability to manipulate objects, for example, balls, as well as good general coordination (41). In children with DCD this would prove to be challenging and they would therefore underperform in the area of team sports as has been shown in previous literature (40).

As reported in the results section of this study, for children with DCD, sporting participation, especially sporting codes involving ball skills, requiring coordinated manipulation, often presenting as an area of difficulty (48). Difficulties with coordination makes sporting participation more challenging, due to the motor skills required in the sporting domain (11, 36-38). The coordination tasks measured in question two and three, which tested catching and hitting a ball respectively, seemed to be the most challenging for a number of the participants. This may be due to the young age of the cohort, as children may only become proficient with hand-eye ball coordination skills at an older age. Ball skills though, have been shown to be an area of difficulty experienced by individuals diagnosed with DCD (40, 41).

It should be noted that participation in sport is not the same as the level of participation. A good level of participation implies a proficiency at a sporting code which is more likely to be needed, to achieve in a team sport environment, rather than that needed within individual sporting codes. Literature has shown similar finding with regard to team sports affecting individuals with DCD. In a study in 2011, it was found that the 21 pre-schoolers diagnosed with DCD (n=63) using the MACB outcome measure, were reported to find participation in leisure activities such as sport more challenging than their typical peers. The children's enjoyment of the sporting activities, their processing skills required for such activities and their levels of achievement even at a young age, was found to be poorer amongst the DCD participants compared to their peers. Parents were also reported to be dissatisfied with their children's performance in leisure activities, which was postulated in this study to be a possible predictor of DCD outcome (36).

Male gender

The coordination skill required in question five of the DCDQ'07 measured running speed and pattern and is an important part of most individual and team sports. In this study, male children were found to underperform on this task when compared to their female peers in terms of coordination.

Running pattern indicates how an individual runs, while their speed measures how fast they do so (79). This area of coordination will also likely affect a child's sporting participation, as the child's ability to compete with their peers in sporting codes involving running, will require adequate speed and a good running pattern. This contributes to their sporting ability and most likely their participation.

Although it would seem, on observation of boys and girls gross motor skills generally, that boys appear to be more proficient at performing gross motor skills than girls, a Norwegian study (n=300) conducted in 2014 which investigated this claim, found that younger girls outperformed their male counterparts in most areas of the gross motor abilities tested. The researchers surmised that this may change with age, as the children mature developmentally (59). Gross motor ability, which includes coordination and balance skills, affects all areas of gross motor functioning, including running gait, which appears to explain why this study

showed girls scoring better on coordination of running speed and pattern compared to boys of the same age group.

5.7 Comparison of children ‘at risk’ to those ‘not at risk’ of DCD

Fisher exact T-test were performed to compare the ‘at risk’ to the ‘not at risk’ of DCD group, to determine if the academic performance or sporting participation of children in the ‘at risk’ group was affected by being ‘at risk’ of DCD. The factors selected for comparison were repeated grade; and academic percentage <70%; male gender and younger age to investigate academic performance and non-participation in sport; if sporting participation was reported as ‘fair’ or ‘challenging’ rather than ‘good’; non-participation in ball skill sports and non-participation in team sports, to investigate sporting participation. The results of the analysis are discussed below.

5.7.1 Comparing the two groups for academic performance

In this analysis, when comparing the group of children ‘at risk’ of DCD to the ‘not at risk’ group, the children in the ‘at risk’ group, were shown to have more repetitions of a school grade within this group, than those within the ‘not at risk’ group. As repetition of a grade is, in most cases, indicative of poor academic performance, it appears that children who are ‘at risk’ for DCD, who experience more coordination difficulties, would therefore be more at risk for repetition of a school grade than children who did not experience coordination difficulties. Coordination, therefore, is seen as an important part of achieving academic success and difficulties in this area should be addressed as early as possible to prevent long term negative academic outcomes for the child. The other factors measured in this analysis were not shown to be statistically significant when comparing these two groups in the study cohort.

5.7.2 Comparing the two groups for sporting participation

None of the factors measured that were postulated to affect sporting participation when comparing the two groups were found to be statistically significant in this analysis.

5.8 Implications of this study

The results of this study offer some insight into the prevalence of coordination difficulties amongst children, some of whom would be ‘at risk’ of DCD. Awareness of the factors that were found in this study to affect coordination in these children which, in turn, may lead to academic and sporting difficulties, would be insightful in assisting these children and their caregivers. Early intervention would be useful to counter any possible negative outcomes of coordination difficulties in these ‘at risk’ children, in order to prevent long term sequelae, specifically in their academic and sporting domains.

With early therapeutic intervention, compensation strategies have been shown to assist children with DCD to perform better than if this condition is not identified and treatment started (49), along with the management of any comorbid diagnoses such as ADHD (27). All developmental conditions should be addressed as early as possible, as the loss of developmental milestones in the formative years can impact the individual’s life in the long term. Whether this is the explanation for ‘life-long’ diagnosis of DCD or whether the condition persists due to permanent brain changes that remains atypical, is still being investigated. In either case, correct treatment of both DCD and any comorbidities, as early as possible post-identification, is important in order that any neuroplasticity of the brain areas affected may be optimised. Long-term negative sequelae should likewise be minimised for each individual.

Boys and children that had repeated a grade, were shown to be more likely to have coordination problems, which in turn was shown to affect their academic performance. Boys and children who did not participate in team sports, were also shown to have more coordination problems which, in turn, was likely to have an impact on their sporting participation. Being aware of these identified factors as well as other demographic, risk and comorbid factors would be useful in identifying risks, in order to better manage them in these children.

When comparing the children ‘at risk’ of DCD to the ‘not at risk’ children, those children who had repeated a grade were shown to have more coordination difficulties than those who had not. Coordination may therefore be shown to potentially affect academic performance. Awareness of DCD and its possible effect on academic performance and sporting participation may assist with early identification and intervention measures to improve long term outcomes.

5.9 Limitations of this study

A number of the above factors may have resulted in limited participation numbers thus making the population size of 69 learners (n=234) relatively small. Return rate of the questionnaire was also lower than hoped for at 29.5%, although this appears to be consistent with this type of study design as discussed above (60).

The DCDQ'07 has not been standardised for the South African population as a whole which would be a limitation of this study, although the measure was tested for internal consistency for this study population and shown to be a suitable instrument for use in this cohort (CA, $r=0.905$). The Little DCDQ, another version of this screener, for use in the younger three to five year old population, was standardised in the South African population and showed that it was a suitable screening measure, although the authors suggested a few adjustments may be required to clarify any language ambiguities (51). Despite this, according to the primary investigator's opinion, language does not appear to be an obvious concern and therefore the DCDQ'07 appears to remain a clear, easy to use screening tool.

5.10 Recommendations for further research and clinical work

Additional investigation into a larger population group in South Africa, perhaps in differing school types, may be fruitful in order to gain additional knowledge on the subject across all socioeconomic strata. There does appear to be a paucity of South African published studies investigating DCD in the South African context, both for prevalence and in terms of scholastic performance and sporting participation. Further research into these and other life domains affected by DCD would be recommended to both raise awareness of this disorder and in order to best assist individuals affected by DCD, with the aim of optimising their long-term quality of life (6).

5.11 Conclusion

In summary, data was gathered from 69 children, aged from five to eleven years old, attending a primary school in the Eastern Cape province of South Africa. The children's coordination abilities, as well as other additional information, was gathered via the parental completion of the DCDQ'07, a standardised screening questionnaire and an additional data collection sheet,

respectively. The data was analysed and recorded in the results section and discussed in detail above.

The demographic data, which included details of the children's academic performance and sporting participation, as well as additional medical information and parent comments was discussed, with certain factors appearing to be associated with coordination difficulties in this cohort. These coordination difficulties appeared to potentially affect these children's academic performance and/or sporting participation to varying degrees. The results of the DCDQ'07 as an outcome measure, as well as the statistical analysis of correlations between the associated factors in this study for significance and strength of association was discussed.

The main aims, with the resulting implications, as well as the study's limitations, have been addressed. Lastly, recommendations for further research and clinical work have been suggested. The concluding chapter will summarise the main findings of this study with a focus on the objectives of investigating 'at risk' of DCD prevalence in this cohort and then to compare the 'at risk' of DCD children to those 'not at risk' of DCD in terms of their academic performance and sporting participation. Factors found to affect coordination in this cohort and how they may contribute to academic performance and sporting ability are also noted as potentially useful.

CONCLUSION

The main aims of this study were to add to the current knowledgebase of DCD, thereby attempting to assist in the management of children's academic performance and sporting participation within the local South African context. The study investigated the prevalence of DCD in a single primary school in the Eastern Cape in South Africa and how this impacted on academic performance and sporting participation. Data was gathered using a standardised coordination questionnaire, the DCDQ'07, which consists of three scales measuring areas of coordination difficulties, namely, control during movement; fine motor/handwriting and general coordination. An additional data collection sheet was also used to gather information.

Data was statistically analysed using Pearson's Correlation Coefficient Statistical Method to investigate for significant correlations that may affect academic performance and sporting participation within the cohort. Fisher exact T-tests were then used to compare children who screened 'at risk' to those 'not at risk' of DCD in terms of these factors and how they may affect the academic performance and sporting participation of the children 'at risk' of DCD specifically.

The conclusions of this study are summarised below:

The screened 'at risk' prevalence of DCD in this population was found to be 11.6% (n=69), compared to the actual/diagnosed global prevalence norms of 5-6%. This indicated that coordination problems such as DCD are present in this population group and require attention.

The ratio of 2.5:1 male to female children 'at risk' of DCD in this study, was found to be similar to the global norms of 2:1.

Factors shown to significantly correlate with coordination difficulties and postulated to affect academic performance were male gender and the repetition of a school grade.

Poor fine motor and handwriting skills specifically, were found to impact significantly on boys' academic performance. Children who had repeated a grade were also shown to have more difficulties in this coordination area and especially when having to control the amount of effort or pressure needed to write or draw compared to age-appropriate norms.

A child's need to repeat a grade may, in some instances, be explained by their poor coordination skills.

Difficulties in coordination often improve with age and normal development, whereas a diagnosed disorder in coordination such as in DCD, appears to remain for a much longer period, if not indefinitely.

Team sport participation which, in the majority of sports in this study involved ball skills, was shown significantly to affect sporting participation.

Boys also scored significantly lower in running speed and pattern compared to their same-age female counterparts.

When comparing children 'at risk' with those 'not at risk' of DCD, repeated grade was shown to significantly affect academic performance in the 'at risk' group.

Parental comments were noted to be a useful source of information and often related to the identified areas of concern.

Our findings confirm that children 'at risk' of DCD are prevalent in the school population and that early identification of this disorder is necessary to specifically address coordination skills deficits to improve academic performance and sporting participation in this population.

Additional research in the South African context would be useful to increase awareness of DCD amongst medical professionals, teachers and parents in order to continue to support children in their long term functional outcomes in all life domains.

APPENDICES

- Appendix 1: Parent/Guardian Study Information Form
- Appendix 2: Parent Informed Consent Form
- Appendix 3: Letter of request to Headmaster of Merrifield Primary School and College
- Appendix 4: Signed letter of permission from the Headmaster of Merrifield Preparatory School and College
- Appendix 5: Confidential participant Information Form
- Appendix 6: A 2-page Coordination Questionnaire (DCDQ07) redesigned without identifiers - Handed out to Parents/Guardians
- Appendix 7: A 2-page Coordination Questionnaire (DCDQ07) included in the DCD'07 Admin-scoring-02-02-2012 pdf – Not handed out to parents
- Appendix 8: Additional Data Collection Sheet
- Appendix 9: Protocol Approval
- Appendix 10: Ethical clearance certificate
- Appendix 11: Turnitin report



PARENT/GUARDIAN STUDY INFORMATION FORM

Study title: Prevalence of Developmental Coordination Disorder in a primary school in East London, South Africa

Dear Parent

I, Kerrin Raats, a Physiotherapist, am doing research on Developmental Coordination Disorder in primary school children in South Africa. Research is a process used in seeking new knowledge. In this study we want to determine the prevalence of Developmental Coordination Disorder in a South African primary school and to compare demographics and scholastic performance in this group of children in order to address this area of potential concern and thus attempt to improve outcomes.

Invitation to Participate: We are asking for your permission to include your child in a research study by means of a parent/guardian questionnaire. Complete confidentiality will be respected throughout the study.

What is involved in the study?

1. We would request that a parent/guardian informed consent form; a standardised parent questionnaire and an additional data collection sheet be completed and signed by you (see attached).
2. We would like to send home the forms to be completed at home and returned within a 2- week period.
3. The 2-page, 15-question, standardized screening questionnaire developed to identify coordination difficulties, which can affect fine motor skills; sports participation and functional abilities, is to be used. Information collected will be analysed and suggestions made to potentially improve child outcomes in these areas.

4. Completion of the questionnaire should take approximately 10 minutes;
5. Paper copies of the forms and an envelope will be sent to you. When completed, please return these forms in the sealed envelope to the school office for safe keeping in a locked post-box and for collection by myself only.

Risks of being involved in the study: No risks to participation in this study are foreseen.

Complete confidentiality will be respected throughout the study. Although I would have access to you and your child's details in order to follow-up with you, these details will be assigned a de-identifying study number to ensure that no person other than myself would have access to this data. The names of the participants will thus be protected and confidential. No personal information will be disclosed to other parties. It is not the intention of the study to cause any anxiety and so concerns regarding the questionnaire are welcome to be discussed with me via telephone or email prior to completion of the forms.

Benefits of being in the study: your participation in this study will add to the current knowledge around Coordination problems and specifically Developmental Coordination Disorder which has been shown to affect children and adults in the areas of fine motor skills; sports participation, and other social and functional outcomes. Screening of primary school children may prove to assist parents, teachers and health care professionals in early identification and intervention in areas of concern with may optimise the long-term outcomes of the child.

Please note that no direct benefit will be gained from participation in this study and that your participation is completely voluntary.

A follow-up feedback option will be given to all parent/guardian participants after the questionnaire has been completed.

Participation is voluntary, please note:

- that refusal to participate in the study or complete the questionnaire, will involve no penalty or loss of benefits to which you - the parent or your child is otherwise entitled; and

- that you - the parent may discontinue participation at any time without penalty or loss of benefits to which you or your child is otherwise entitled; and
- that there is no requirement to provide a reason for withdrawing and any data collected from such a person will in default be destroyed, unless you specifically consent to its retention.

There is to be no payment or cost associated with participation in this study.

Contact details of researcher/s:

Kerrin Raats, Principal Investigator Mobile: 082 924 7436 Email: kerryraats@gmail.com

Renate Strehlau, Primary Supervisor Mobile: 082 3218976 Email: renate.strehlau@wits.ac.za

Contact details of Human Research Ethics Committee administrator and chair –
for reporting of complaints / problems.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Parent/Guardian Study Information Sheet.



PARENT/ GUARDIAN INFORMED CONSENT FORM

Prevalence of Developmental Coordination Disorder in primary school children in East London, South Africa

1. I have been given a Parent/Guardian Study Information Form which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no direct benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

Contact details:

Kerrin Judy Raats, Principal Investigator, telephone no. 082 924 7436, or by e-mail at kerryraats@gmail.com

Dr Renate Strehlau, Supervisor, on telephone no. 082 321 8976, or by e-mail at Renate.Strehlau@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no.011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z. Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of child: _____

Name of parent/ guardian: _____

Signature of parent/ guardian: _____

Date: _____ Place signed: _____

Appendix 3:

35 Stanmore rd
Nahoon
East London
5241
Date: 07/06/2018

The Headmaster
Merrifield Preparatory School and College
PO Box 15681
Beacon Bay
5205

Attention: Dr Hartley

Re: Permission requested for participation in Master's study

Dear Dr Hartley

Thank you for considering my request regarding my Master's study proposal as discussed yesterday.

In summary of our conversation, I am currently employed by the Department of Education as a Physiotherapist at Parkland Special School in East London and am studying towards a Master of Science (Med)(Child health Neurodevelopment) degree through the University of the Witwatersrand via Coursework and Dissertation.

My request to undertake a study at Merrifield Preparatory School and College is proposed as follows:

- A standardised parent questionnaire, which is a useful screening tool for coordination difficulties, would be send out to the parents of children from the ages of 5 to 10 years old for voluntary completion by the parents of these children. This would give confidential feedback to me as the Physiotherapist undertaking the study to ascertain if there may be a potential risk area in the child's fine motor, gross motor or functional activities where coordination is required. Typically, children who struggle with these areas may find scholastic fine motor activities and sport participation challenging and although they often manage, do not always performing optimally in these areas. The diagnosis of Developmental Coordination Disorder (DCD) is being shown to be present in approximately 5-10% of the normal, intellectually-able population. I would not want to create anxiety in the parents of the children who decide to participate in the survey and

therefore no diagnostic labelling would be mentioned on the questionnaire which simply screens children for coordination difficulties. A carefully worded cover letter would accompany the questionnaire to avoid anxiety and explain the focus of the study.

- Teachers would need to be consulted regarding this request and be in agreement as to its usefulness for their pupils.
- If permission is granted and the questionnaires are thus completed, follow-up feedback would then be given individually via either telephonic discussion or setting up of a private meeting with each parent to discuss any areas of concerns, suggestions or simply to answer any questions that the parent may have. No obligations are required of the parent and sensitivity would be paramount to avoid anxiety in either the parent or the child.
- Although, according to academic research procedures, participants would require their names to appear on the questionnaire, confidentiality would be respected and names would not be disclosed in the Dissertation write-up or to any other person without parental permission. Secure record keeping and ethical practice would be strictly adhered to according to WITS ethical clearance standards and professional HPCSA guidelines.
- I would not be benefitting financially from conducting this research, as I am no longer working in a private capacity and would only suggest referring to a suitable professional, should there be an indication that this would assist the child. This would be in consultation with the parent and always their decision.
- I feel that this would be useful as a study to look at the prevalence of DCD or coordination difficulties in a normal school environment and that this would also potentially benefit the children, parents and staff at the school in terms of awareness and options for assistance.

I would appreciate your ongoing consideration and opinion in this regard.

Thank you.

Yours sincerely

Kerrin Raats

Physiotherapist

Appendix 4:

35 Stanmore rd
Nahoon
5241
East London
Date: 25/07/2018

The Headmaster
Merrifield Preparatory School and College
PO Box 15681
Beacon Bay
5205

Attention: Dr Hartley

Re: Permission to conduct a Master's study at Merrifield Preparatory School and College

Dear Dr Hartley

I hereby officially request your permission to conduct a Master's study on Developmental Coordination Disorder at Merrifield Preparatory School and College as discussed previously.

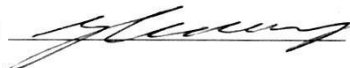
I would appreciate your signing the agreement below if this is still in order and kindly emailing this back to me for submission for my ethical clearance application to The University of the Witwatersrand.

Thank you again for your support in this endeavour.

Yours sincerely

Kerrin Raats
Physiotherapist

I, Dr Hartley, the Headmaster of Merrifield Preparatory School and College grant my permission for the above-mentioned Mrs Kerrin Raats, Physiotherapist, to conduct a study at Merrifield Preparatory School and College as previously discussed.

Name: GUY HARTLEY Signature: 
Date: 26/7/2018 Place: MERRIFIELD, EAST LONDON

CONFIDENTIAL

Participant study no: _____ **Date form completed:** _____

Child's Name: _____

Date of birth: ____/____/____ **Age at time of study:** _____y _____m

Parent/Guardian name: _____

Parent/Guardian contact no(s): _____

Parent/Guardian email(s): _____

Please note:

The above information is strictly confidential and will not be disclosed to any other parties besides Kerrin Raats, the Principal Investigator. It will not be accessible and will be secured in a locked database. Only a participant study number will appear on the attached Questionnaire and Additional Data Information sheet to ensure confidentiality.

Thank you for participating in this study.

COORDINATION QUESTIONNAIRE (REVISED 2007)

TO BE COMPLETED BY CHILD'S PARENT/GUARDIAN

Participant study number: _____

Today's Date: _____

Child's age group (tick applicable): **5y-7y11m** _____ **8y-9y11m** _____ **10y-15y** _____

Most of the motor skills that this questionnaire asks about are things that your child does with his or her hands, or when moving. A child's coordination may improve each year as they grow and develop. For this reason, it will be easier for you to answer the questions if you think about other children that you know who are the same age as your child.

Please compare the degree of coordination your child has with other children of the same age when answering the questions.

Circle the one number that best describes your child. If you change your answer and want to circle another number, please circle the correct response twice.

If you are unclear about the meaning of a question, or about how you would answer a question to best describe your child, please call: Kerrin Raats at 082 924 7436 for assistance.

Not at all like your child 1	A bit like your child 2	Moderately like your child 3	Quite a bit like your child 4	Extremely like your child 5
---------------------------------------	----------------------------------	---------------------------------------	--	--------------------------------------

1. Your child throws a ball in a controlled and accurate fashion.

1 2 3 4 5

2. Your child catches a small ball (e.g., tennis ball size) thrown from a distance of 6 to 8 feet (1.8 to 2.4 meters).

1 2 3 4 5

3. Your child hits an approaching ball or birdie with a bat or racquet accurately.

1 2 3 4 5

4. Your child jumps easily over obstacles found in garden or play environment.

1 2 3 4 5

5. Your child runs as fast and in a similar way to other children of the same gender and age.

1 2 3 4 5

6. If your child has a plan to do a motor activity, he/she can organize his/her body to follow the plan and effectively complete the task (e.g., building a cardboard or cushion "fort," moving on playground equipment, building a house or a structure with blocks, or using craft materials).

1 2 3 4 5

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cont. over

page

7. Your child's printing or writing or drawing in class is fast enough to keep up with the rest of the children in the class.

1 2 3 4 5

8. Your child's printing or writing letters, numbers and words is legible, precise and accurate or, if your child is not yet printing, he or she colours and draws in a coordinated way and makes pictures that you can recognize.

1 2 3 4 5

9. Your child uses appropriate effort or tension when printing or writing or drawing (no excessive pressure or tightness of grasp on the pencil, writing is not too heavy or dark, or too light).

1 2 3 4 5

10. Your child cuts out pictures and shapes accurately and easily.

1 2 3 4 5

11. Your child is interested in and likes participating in sports or active games requiring good motor skills.

1 2 3 4 5

12. Your child learns new motor tasks (e.g., swimming, rollerblading) easily and does not require more practice or time than other children to achieve the same level of skill.

1 2 3 4 5

13. Your child is quick and competent in tidying up, putting on shoes, tying shoes, dressing, etc.

1 2 3 4 5

14. Your child would never be described as a "bull in a china shop" (that is, appears so clumsy that he or she might break fragile things in a small room).

1 2 3 4 5

15. Your child does not fatigue easily or appear to slouch and “fall out” of the chair if required to sit for long periods.

1

2

3

4

5

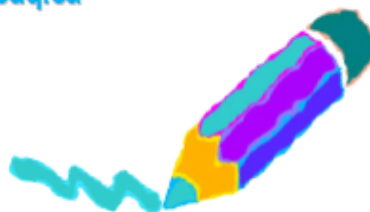
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Thank you

THE DEVELOPMENTAL COORDINATION DISORDER QUESTIONNAIRE 2007® (DCDQ'07)

www.dcdq.ca



B.N. Wilson, M.Sc., OT(C) and S.G. Crawford, M.Sc.
Calgary, Alberta, Canada

BN Wilson 2007®

March 2012

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Center for Child, Family and Community Research

Wilson, B.N., Crawford, S.G., Green, D., Roberts, G., Aylott, A., & Kaplan, B. (2009).
Psychometric Properties of the Revised Developmental Coordination
Disorder Questionnaire. *Physical & Occupational Therapy in Pediatrics*,
29(2):182-202.

COORDINATION QUESTIONNAIRE (Revised 2007)

Name of Child: _____

Today's Date:

Person completing Questionnaire: _____

Child's Birth:

Relationship to child: _____

Child's Age:

Year	Mon	Day

Most of the motor skills that this questionnaire asks about are things that your child does with his or her hands, or when moving.

A child's coordination may improve each year as they grow and develop. For this reason, it will be easier for you to answer the questions if you think about other children that you know who are the same age as your child.

Please compare the degree of coordination your child has with other children of the same age when answering the questions.

Circle the one number that best describes your child. If you change your answer and want to circle another number, please circle the correct response twice.

If you are unclear about the meaning of a question, or about how you would answer a question to best describe your child, please call _____ at _____ for assistance.

Not at all like your child	A bit like your child	Moderately like your child	Quite a bit like your child	Extremely like your child
1	2	3	4	5

- Your child *throws a ball* in a controlled and accurate fashion.

1	2	3	4	5
---	---	---	---	---
- Your child *catches* a small *ball* (e.g., tennis ball size) thrown from a distance of 6 to 8 feet (1.8 to 2.4 meters).

1	2	3	4	5
---	---	---	---	---
- Your child *hits* an approaching *ball* or *birdie* with a bat or racquet accurately.

1	2	3	4	5
---	---	---	---	---
- Your child *jumps* easily *over* obstacles found in garden or play environment.

1	2	3	4	5
---	---	---	---	---
- Your child *runs* as fast and in a *similar* way to other children of the same gender and age.

1	2	3	4	5
---	---	---	---	---
- If your child has a *plan* to do a motor *activity*, he/she can organize his/her body to follow the plan and effectively complete the task (e.g., building a cardboard or cushion "fort," moving on playground equipment, building a house or a structure with blocks, or using craft materials).

1	2	3	4	5 (OVER)
---	---	---	---	----------

	Not at all like your child 1	A bit like your child 2	Moderately like your child 3	Quite a bit like your child 4	Extremely like your child 5
7.	Your child's printing or <i>writing</i> or drawing in class is <i>fast</i> enough to keep up with the rest of the children in the class.				
	1	2	3	4	5
8.	Your child's printing or <i>writing</i> letters, numbers and words is <i>legible</i> , precise and accurate or, if your child is not yet printing, he or she <i>colors and draws</i> in a coordinated way and makes pictures that you can recognize.				
	1	2	3	4	5
9.	Your child uses appropriate <i>effort</i> or tension when printing or writing or drawing (no excessive <i>pressure</i> or tightness of grasp on the pencil, writing is not too heavy or dark, or too light).				
	1	2	3	4	5
10.	Your child <i>cuts</i> out pictures and <i>shapes</i> accurately and easily.				
	1	2	3	4	5
11.	Your child is interested in and <i>likes</i> participating in <i>sports or active</i> games requiring good motor skills.				
	1	2	3	4	5
12.	Your child learns <i>new motor tasks</i> (e.g., swimming, rollerblading) easily and does not require more practice or time than other children to achieve the same level of skill.				
	1	2	3	4	5
13.	Your child is <i>quick and competent</i> in tidying up, putting on shoes, tying shoes, dressing, etc.				
	1	2	3	4	5
14.	Your child would <i>never</i> be described as a " <i>bull in a china shop</i> " (that is, appears so clumsy that he or she might break fragile things in a small room).				
	1	2	3	4	5
15.	Your child does <i>not fatigue easily</i> or appear to slouch and "fall out" of the chair if required to sit for long periods.				
	1	2	3	4	5

Thank you.

COORDINATION QUESTIONNAIRE (DCDQ'07): SCORE SHEET

Name: _____ Date: _____

Birth Date: _____ Age: _____

	Control During Movement	Fine Motor/ Handwriting	General Coordination
1. Throws ball			
2. Catches ball			
3. Hits ball/birdie			
4. Jumps over			
5. Runs			
6. Plans activity			
7. Writing fast			
8. Writing legibly			
9. Effort and pressure			
10. Cuts			
11. Likes sports			
12. Learning new skills			
13. Quick and competent			
14. "Bull in shop"			
15. Does not fatigue			

TOTAL $\frac{/ 30}{\text{Control during Movement}}$ + $\frac{/ 20}{\text{Fine Motor/ Handwriting}}$ + $\frac{/ 25}{\text{General Coordination}}$ = $\frac{/ 75}{\text{TOTAL}}$

For Children Ages 5 years 0 months to 7 years 11 months

15-46 indication of DCD or suspect DCD
 47-75 probably not DCD

For Children Ages 8 years 0 months to 9 years 11 months

15-55 indication of DCD or suspect DCD
 56-75 probably not DCD

For Children Ages 10 years 0 months to 15 years

15-57 indication of DCD or suspect DCD
 58-75 probably not DCD

Administration and Interpretation of the DCDQ'07

Overview

The *Developmental Coordination Questionnaire (DCDQ)* is a parent report measure developed to assist in the identification of Developmental Coordination Disorder (DCD) in children. Parents are asked to compare their child's motor performance to that of his/her peers using a 5 point Likert scale. It provides a standard method to measure a child's coordination in everyday, functional activities. As reported in 2000¹, the internal consistency of the DCDQ is high and the results from discriminant function analyses were appropriately strong for a screening tool.

Developmental Coordination Disorder is a DSM-IV² diagnosis. An indication of DCD based on the score of the DCDQ fulfills the requirement for Criterion B of this diagnosis. However, the questionnaire cannot be used alone for this purpose. Diagnosis must be made based on the results of several reports and tests. The questionnaire is labeled "The Coordination Questionnaire" to avoid parents becoming concerned that a medical condition is being diagnosed.

The DCDQ'07 presented here is considered to have stronger psychometric properties than the 2000 version because it was developed with a population-based sample and has a larger age range³. The research took place between 2004 and 2006, involving 287 typically developing children, as well as 232 children who were reported to have motor coordination difficulties or who were more likely to have DCD. This revised version is appropriate for use with children ages 5 to 15.

The DCDQ'07 consists of 15 items, which group into three distinct factors. The first factor contains a number of items related to motor control while the child was moving, or while an object was in motion, and is labelled "Control during Movement". The second factor contains "Fine Motor and Handwriting" items and the third factor relates to "General Coordination". These factor scores alone do not provide an indication of whether the child may have DCD. However, when the scores of each of the factors are examined relative to the scores of the other factors and are then compared with formal and informal assessment results, support for the identification of particular motor strengths and challenges a child is experiencing may be provided.

Prior to Administration

Before copying for clinical or research use, it is recommended that a name and phone number be written into the space on the first page so that parents can call if they have questions about the meaning of an item. This contact person should be knowledgeable about the condition of DCD, or know who to refer the question to if questions of this nature arise. The validity of the results will be increased if parents have the opportunity to clarify the intent of an item.

It is recommended that the 2 page questionnaire be copied double sided. The Score Sheet on the 4th page should be kept separate from the questionnaire itself. It is not recommended that parents be given the Score Sheet.

Respondents

This questionnaire was developed for parents, as parents know their children the best and can reliably report developmental problems. In addition, only the data from parent report was used to develop the scoring system. This DCDQ is therefore intended to be used with parents. However, some clinicians and researchers are experimenting with having both parents (or one parent and the child's primary teacher) complete it. Sometimes two or more respondents have completed the questionnaire separately, but in other situations they have conversed while completing one form. Subjectively, the results appear to be satisfactory but no one has yet studied this approach.

When the perspective of two adults gives a more complete or more accurate evaluation of the child's motor performance, this practice is likely to increase the validity of the score. However, it must be remembered that the scores were developed solely on parent response, so if the respondents have divergent opinions on the child's performance, or if the two forms have very different scores, the parent's score should be the one reported. The fact that others who know the child score the items differently can be noted, but it would be inappropriate to use the score of a teacher or coach alone (for example) in interpreting the results of the DCDQ.

Time to Complete

The DCDQ usually takes parents about 10-15 minutes to complete. As much as possible, arrange for the parent completing the questionnaire to do so in a non-distracting environment.

Administration - Written or Verbal

The DCDQ was designed to be self-administered by parents. In the reference sample of the development of the original DCDQ, however, parents were given the choice of completing a paper version of the questionnaire independently or of completing it over the phone while reading a paper copy along with the interviewer. In the study for the revised *DCDQ'07*, most parents completed a paper copy independently but a small proportion completed it with an occupational therapist following administration of the standardized motor tests. Either method of completion is acceptable.

Missing Items

When the questionnaire is completed or returned, review it for missed items or items where more than one item is circled. Ask the parent who completed it for clarification. Note: a total score can only be calculated if all items are scored. Missing one score will prevent you from obtaining a total score and having an indication of DCD or not.

If the parent does not know how to grade an item, or has not seen their child in a particular activity, ask them if there is anyone else who would know (e.g., the other parent, a caregiver, a teacher or a coach). You may inquire if the parent can make arrangements to ask that person, or if they will give you permission to do so.

Computing the Chronological Age

Enter the date that the DCDQ was completed and the child's Date of Birth (D.O.B.) on the first page of the questionnaire. Compute the chronological age by subtracting (first) the days, then the month and finally the year of birth. For example, if the questionnaire was completed on March 21, 2007, and the child was born on February 2, 2000, the child's chronological age would be calculated as shown in the first table:

	Yr	Mon	Day
DCDQ completion	2007	03	21
Child's D.O.B.	2000	02	02
Chronological age	7 yrs	1 mon	19 day

	Year	Month	Day
DCDQ completion	2007 2006	14 02	51 21
Child's D.O.B.	2000	06	28
Chronological age	6 years	8 month	23 days

If the day of the month in which the child was born is larger than the day of the month of questionnaire completion, add 30 days to the day of testing and subtract one month from the month of testing. Similarly, if necessary, a month of testing can be borrowed by adding 12 months to the month of testing and subtracting one year from the testing year, as shown above in the table on the right.

Computing a Total Score

Re-enter the numbers circled for all items of the questionnaire onto the Score Sheet (4th page).

Total each column to compute the 3 Factor Scores, and add all Factor Scores to compute a Total Score. *Double check your addition.*

Interpretation of Scores on the DCDQ

Using the child's chronological age at the time the questionnaire was completed, find the appropriate age grouping on the left column of the table below. Scan across that row to find the range of scores which the child's score falls within. This range will indicate whether the child's score is an "Indication of, or Suspect for, DCD", or "Probably not DCD".

Age Group	Indication of, or Suspect for, DCD	Probably not DCD
5 years to 7 years 11 months	15 - 46	47 - 75
8 years 0 months to 9 years 11 months	15 - 55	56 - 75
10 years 0 months to 15 years	15 - 57	58 - 75

Reporting of DCDQ`07 results

As outlined above, the DCDQ cannot be used alone to identify DCD. When using the questionnaire in a verbal or written report about a child, the terms "indication of possible DCD", "suspect for DCD", or "probably not DCD" should be used, as this test alone cannot be used to diagnose DCD.

Sensitivity and Specificity

It is sometimes desirable, especially when a diagnosis is not clear, to report the sensitivity and specificity of the test scores. The most accurate predictive values of the DCDQ`07 are reported in the table below according to the different age ranges. If overall values for the questionnaire are required, however, the overall sensitivity is 84.6% and the specificity is 70.8%.

Age Group	Sensitivity and Specificity
5 years to 7 years 11 months	Sensitivity=75.0% Specificity=71.4%
8 years 0 months to 9 years 11 months	Sensitivity=88.6% Specificity=66.7%
10 years 0 months to 15 years	Sensitivity=88.5% Specificity=75.6%

The purpose of a screening instrument is to identify whether a child has a particular condition. Rarely is a screening tool alone 100% accurate in identifying all children with a condition while at the same time not falsely identifying any children who do not. When evaluating a screening tool such as the DCDQ`07, the degree of accuracy in identifying children with possible DCD (sensitivity) must be compared to the accuracy in correctly identifying children who do not have the condition (specificity). This "trade off" is common to all diagnostic tests because when one of these predictive values increases, the other decreases. By design, the DCDQ`07 is most accurate in identifying children who may have DCD. It may identify children who do not have the condition, but further motor testing should reveal whether DCD is indeed present.

References

1. Wilson BN, Kaplan BJ, Crawford SG, Campbell A, Dewey D. (2000) Reliability and validity of a parent questionnaire on childhood motor skills. *Am J Occup Ther* 54(5): 484-493.
2. American Psychiatric Association (2000) *DSM-IV-TR. Diagnostic and Statistical Manual of Mental Disorders*, 4th Ed. text revision. American Psychiatric Association, Washington, DC, USA.
3. Wilson, B.N., Crawford, S.G., Green, D., Roberts, G., Aylott, A., & Kaplan, B. (2009). Psychometric Properties of the Revised Developmental Coordination Disorder Questionnaire. *Physical & Occupational Therapy in Pediatrics*, 29(2):182-202.

Additional Data Collection Sheet

(Fill in, tick or circle where appropriate)

Please complete the Coordination Questionnaire (see previous 2 pages) and then the Additional Data Collection Sheet below.

Note: All information disclosed will be treated **confidentially** and will **not** be disclosed to **any** other parties (see Study Information Sheet).

Participant study no:

Gender of child: Male / Female

Tick the age group of the child at the time of the study:

5y-7y 11m:

8y-9y 11m:

10y-15y:

Number of children in family: _____

This child is: first born/second born/third born/other: _____

Current grade: _____ **Grade/s repeated:** Yes / No **Which grade repeated?** _____

Academic performance (term average, level 1-7):

1-3(<50%) __ **4-5(50-69%)** __ **6-7(>70%)**__

Does your child participate in any sport? Yes / No

If yes, which sport: _____

Sporting participation: **Good**_____ **Fair**_____ **Challenging**_____

Diagnosed medical conditions: **Tick if applicable** **Receiving medication/intervention (specify)**

ADD/ADHD

Visual problems

Hearing problems

Genetic conditions

**Developmental
problems**

Other disabilities

(state diagnosis)

Prematurity <36w

General Parental/ Guardian

concerns: _____

**Would you like to be contacted with the results of the questionnaire and possible
recommendations if deemed necessary: Yes / No**

Thank you for your time and participation in this study

Appendix 9:



Empilweni Services and Research Unit,
Rahima Moosa Mother and Child Hospital

Private Bag X20, Newclare, Johannesburg, South Africa, 2112
• Tel: +27(0)11 470 9214 •



Renate Strehlau, MBBCh, DCH, DipHIV, MSc
Department of Paediatrics and Child Health
Faculty of Health Sciences
University of the Witwatersrand
Rahima Moosa Mother and Child Hospital
Cnr Fuel and Oudtshoorn Street
Coronationville, 2112
Johannesburg
South Africa

11 October 2018

Dear Protocol Assessment Committee, Department of Paediatrics

Re: Corrections made to the satisfaction of the supervisor

I hereby confirm that Kerrin Judy Raats (student number: 1972380), registered for the degree MSc (Med) Child Health Neurodevelopment has completed the required changes to her protocol entitled: Prevalence of Developmental Coordination Disorder in a Primary School in East London, South Africa.

I am satisfied that the student has addressed all the issues identified and discussed during the protocol review committee meeting.

Yours faithfully

Renate Strehlau

Liezel Cilliers



R14/49 Mrs Kerrin Raats

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)**CLEARANCE CERTIFICATE NO. M180912**

NAME: Mrs Kerrin Raats
(Principal Investigator)
DEPARTMENT: Paediatrics
 Merrifield Preparatory School and College, East London

PROJECT TITLE: Prevalence of developmental coordination disorder in a primary school in East London, South Africa

DATE CONSIDERED: 28/09/2018

DECISION: Approved Unconditionally

CONDITIONS:

SUPERVISOR: Dr Renate Strehlau

APPROVED BY: 
 Doctor CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 16/11/2018

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore be due in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).



Principal Investigator Signature

06/12/2018

Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

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