



UNIVERSITY OF
KWAZULU-NATAL™
INYUVESI
YAKWAZULU-NATALI

**COLLEGE OF
HEALTH SCIENCES**

**A STUDY OF THE EFFECTS OF EXERCISE THERAPY
ON THE COMORBIDITY OF ATTENTION DEFICIT
HYPERACTIVITY DISORDER (ADHD) AND DEVELOPMENTAL
CO-ORDINATION DISORDER (DCD)**

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**A Submission to the College of Health Sciences, University of KwaZulu
Natal, in fulfilment of the requirements for the Degree
PhD (Physiotherapy)**

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SUPERVISORS' PERMISSION FOR SUBMISSION

Ethical Clearance Approval Number: BFC 397/16

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A thesis submitted to the School of Health Sciences, University of KwaZulu-Natal, Westville Campus, for the degree of PhD Physiotherapy.

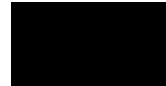
This thesis is presented in the format prescribed for submission via publication/manuscript route with the chapters written as a set of research publications; with overall introduction, literature review, methodology and summary and conclusions.

As the candidate's supervisors, we AGREE to the submission of this material for examination.



Dr T Nadasan

29 May 2019



A/Prof P. Govender

29 May 2019

DECLARATION

I, *Pamela Dawson*, declare that,

- (i) The research reported in this thesis, except where otherwise indicated, is my original research.
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DEDICATION

To my Mother, late Father, and my daughters.

Thank you for the love and support.



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All Praise and Glory be to our Mighty God!

I wish to express my sincere gratitude to the following individuals; for their valuable contribution and amazing support; offered to myself; during the completion of this thesis:

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TABLE OF CONTENTS

	<i>Page Number</i>
SUPERVISOR'S PERMISSION FOR SUBMISSION	I
DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	V
LIST OF TABLES	Viii
LIST OF FIGURES	Ix
LIST OF ABBREVIATIONS	X
GLOSSARY OF TERMS	Xii
ABSTRACT	Xiii
MANUSCRIPTS UNDER REVIEW	Xiv
PREFACE	Xv
CHAPTER 1 : INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	1
1.3 Purpose of the Study	2
1.4 Significance of the Study	2
1.5 Aim and Objectives of the Study	2
1.6 Hypotheses	3
1.7 Scope of the Study	3
1.8 Delineation of the Study	4
1.9 Conclusion	4
CHAPTER 2 : LITERATURE REVIEW	
2.1 Introduction	5
2,2 The Literature Review Strategy	5
2.3 The Comorbidity of ADHD and DCD	6
2.4 History of Comorbid ADHD and DCD	8
2.5 Neuroanatomy of Comorbid ADHD and DCD	8
2.6 Neurophysiology of Comorbid ADHD and DCD	10
2.7 Epidemiology of Comorbid ADHD and DCD	11
2.8 Etiology of Comorbid ADHD and DCD	12

2.9	Diagnostic Investigations used in Comorbid ADHD and DCD	15
2.10	Clinical Presentation of Comorbid ADHD and DCD	20
2.11	The Management of Comorbid ADHD and DCD	24
2.12	Conceptual Frameworks in the Design of the Exercise Intervention	31
2.13	How the Exercise Intervention differs to that used in similar studies	37
2.14	Conclusion	38

CHAPTER 3 : METHODOLOGY

3.1	Introduction	39
3.2	Research Design	39
3.3	Research Location	39
3.4	Phase 1: Prevalence Figures and Demographics of Comorbid ADHD and DCD	40
3.5	Phase 2: Design and Consensus of an Exercise Intervention for the Management of Comorbid ADHD and DCD	46
3.6	Phase 3: The Effect of an Exercise Intervention on the Comorbidity of ADHD and DCD	48
3.7	Data Management	52
3.8	Ethical Considerations	52
3.9	Conclusion	52

CHAPTER 4 : PREVALENCE OF THE COMORBIDITY OF ADHD AND DCD **53**

Manuscript 1		54
--------------	--	----

CHAPTER 5 : DESIGN AND CONSENSUS ON AN EXERCISE INTERVENTION, FOR THE MANAGEMENT OF COMORBID ADHD & DCD **64**

Manuscript 2		65
--------------	--	----

CHAPTER 6 : EFFICACY OF AN EXERCISE INTERVENTION IN MANAGING SYMPTOMS OF ADHD & DCD **78**

Manuscript 3		79
--------------	--	----

CHAPTER 7 : SYNTHESIS

7.1	Introduction	93
7.2	Alignment of Objectives to Study and Manuscripts	93
7.3	Limitations of the study	96
7.4	Significance of the study	96
7.5	Recommendations for further Studies	96
7.6	Conclusion	97

APPENDICES

<i>Appendix Ai</i>	Request for permission from the Department of Education	108
<i>Appendix Aii</i>	Permission granted from Department of Education	111
<i>Appendix B</i>	Request from School Principals	112
<i>Appendix C</i>	Invitation to Parents to Participate in the Research	115
<i>Appendix D</i>	Assent from Minor Child Participant	117
<i>Appendix Ei</i>	Modified Conners' Teacher Rated Questionnaire	118
<i>Appendix Eii</i>	Copeland Symptom Checklist	119
<i>Appendix F</i>	DCD Questionnaire : Parent	120
<i>Appendix G</i>	MABC-1 (2:7 to 8 years) – instruction and score sheet	128
	MABC-1 (3:9 to 10 years) – instruction and score sheet	131
<i>Appendix H</i>	Permission from Pearson Clinical	136
<i>Appendix I</i>	Consent from Experts for Delphi Process	139
<i>Appendix J</i>	Delphi Technique	140
<i>Appendix Ki</i>	First Draft of Exercise Intervention	143
<i>Appendix Kii</i>	Second Draft of Exercise Intervention	147
<i>Appendix Kiii</i>	Final Draft of the Exercise Intervention	154
<i>Appendix L</i>	Malpractice Insurance	158
<i>Appendix M</i>	Thesis Guidelines	161
<i>Appendix N</i>	Ethical Clearance (BREC)	168

LIST OF TABLES

Literature Review (Chapter 2)		
Table 2.1	The interpretation of scores of DCDQ-2007.	18
Table 2.2	Summary of the Publications reviewed in the development of the prototype of the Intervention	36
Methodology (Chapter 3)		
Table 3.1	Diagrammatical representation of the three phases of the multi-method research study	41
Table 3.2	Summarised Version of the Exercise Intervention	49
Manuscript 1 (Chapter 4)		
Table 1	Prevalence figures and demographics (gender, population group and ADHD subtype distribution) of comorbid ADHD and DCD.	58
Table 2	Cross-tabulation of gender with sub-type of ADHD and comorbid DCD	59
Table 3	Cross-tabulation of population group with sub-type of ADHD and comorbid DCD	59
Manuscript 2 (Chapter 5)		
Table 1	Summary of Publications reviewed in development of the exercise programme	68
Table 2	First draft of the Exercise Programme	70
Table 3	Summarised version of final draft of the exercise programme	73
Manuscript 3 (Chapter 6)		
Table 1	Summarised Version of the Exercise Intervention	84
Table 2	Wilcoxon Signed Rank Test Comparison of Group A to D, pre- and post-intervention scores	86
Table 3	Kruskal Wallis Test comparison of pre-intervention scores across Groups A, B, C and D	87
Table 4	Kruskal Wallis Test comparison of post-intervention scores across Groups A, B, C and D	87

LIST OF FIGURES

Literature Review (Chapter 2)

- Figure 2.1** Diagrammatical Representation of Neuroanatomical Areas which exhibit abnormal structure and function, in both ADHD and DCD (*Barkley; 2015*). 9
- Figure 2.2** International Classification of Function, Disability and Health (ICF) of ADHD and DCD (*Wilson; 2014*). 32

Methodology (Chapter 3)

- Figure 3.1** Map of provinces of South Africa. (*Research Gate.Net, 2018*) 40
- Figure 3.2** Controlled assignment of participants to one of four intervention groups, in phase three of the study. 48

Manuscript 2 (Chapter 5)

- Figure 1** Outline of the Delphi process employed in this study 67

Manuscript 3 (Chapter 6)

- Figure 1** Procedure and Allocation of Participants (n=112) according to CONSORT guidelines 85

LIST OF ABBREVIATIONS

ADHD	Attention Deficit and Hyperactivity Disorder
ADL	Activities of Daily Living
APA	American Psychiatric Association
ASD	Autism Spectrum Disorder
BOTMP	Bruininks Oseretsky Test of Motor Proficiency
BREC	Biomedical Research Ethics Committee
BRIEF	Behaviour Rating Inventory of Executive Function
BW	Backwards
CD	Conduct Disorder
CNS	Central Nervous System
CP	Cerebral Palsy
DCD	Developmental Co-Ordination Disorder
DCD-Q	DCD Questionnaire
DDK	Diadochokinesis
DSM	Diagnostical Statistical Manual
EEG	Electroencephalograph
EF	Executive Functions
FW	Forwards
GP	General Practitioner
ICF	International Classification of Function, Disability and Health
KZN	KwaZulu-Natal
LSEN	Learners with Special Educative Needs
MABC	Movement Assessment Battery for Children
MFNU	Motor Function Neurological Assessment
MMD	Minor Motor Dysfunction
MND	Minor Neurological Dysfunction
MPH	Methylphenidate (Ritalin)
MRI	Magnetic Resonance Imaging
ODD	Oppositional Defiant Disorder
OT	Occupational Therapy
PET	Positron Emission Topography
PI	Primary Investigator
RD	Reading Disorder

SA	South Africa
SLD	Specific Learning Disability
SMTB	Standard Motor Test Battery
SPECT	Single Photon Emission Computed Tomography
SW	Sideways
TEC	Task of Executive Control
UK	United Kingdom
USA	United States of America
VMI	Visual Motor Integration

GLOSSARY OF TERMS

Attention Deficit Hyperactivity Disorder (ADHD)

One of the most common childhood neurobehavioural disorders, affecting academic achievement, general well-being and social interaction (Reiff et al, 2011). Symptoms can be classified into three broad categories: Inattention, Impulsivity and Hyperactivity. To receive the diagnosis of ADHD, symptoms must be present before age 7, they must cause impairment in at least two settings and the child must exhibit at least six core symptoms (DSM V, 2013).

Developmental Co-ordination Disorder (DCD)

Defined as a discrete neurodevelopmental disorder (DSM V, 2013). To receive the diagnosis of DCD: motor skills are well below chronological age; clumsiness and slowness during motor tasks are present; onset of the condition is during early development; activities of daily living (ADL), academics, sports and leisure are all affected; any other medical or neurological impairment must be excluded (DSM V, 2013) (Nelson et al, 2015).

Comorbidity

In medicine, comorbidity is the presence of one or more diseases or disorders in co-occurrence.

International Classification of Function (ICF)

The International Classification of Function, Disability and Health is an international classification system of the health components of functioning and disability. It provides details on body structures, body function, personal factors, environmental factors, activity limitations and participation restriction. It describes and measures disability (Mahdi et al, 2018).

Delphi Technique

“This technique is a consensus method used in research to validate designs or generate ideas. It uses group interaction, via questionnaires amongst anonymous experts in their field. It uses a series of data collection and analysis, interspersed with feedback”. (McMillan et al, 2016).

Experts

In this study, the experts were involved in the validation of the exercise intervention designed. They consisted of physiotherapists, occupational therapists, paediatric neurologists and educational psychologists.

ABSTRACT

Background: *The literature suggests a high prevalence of comorbid ADHD and DCD in South Africa and worldwide. Specific figures of the suspected high prevalence are not available and the link between the two conditions are poorly understood. Medical treatment relies on neurostimulant drugs, which have little or no effect on the motor symptoms and have significant side effects. An intervention that addresses both motor co-ordination and attention/concentration impairments is essential in the overall management of children presenting with these comorbid conditions. This study aimed to document prevalence figures and demographic profile of children aged 8 to 9 years diagnosed with comorbid ADHD and DCD; and to design and develop and test efficacy of an exercise intervention that addresses symptoms of the comorbid conditions.*

Methodology: *The study was located at remedial units within mainstream schools in KwaZulu-Natal, South Africa. Children aged 8 to 9 years diagnosed with ADHD were assessed using the modified Conners' Teacher Rating Scale and the Copeland's Symptom Checklist, the Development Co-ordination Disorder Questionnaire (DCDQ) and the Motor Assessment Battery for Children, edition 1 (MABC-1). A three round Delphi technique assisted in the development of an exercise intervention. The efficacy of the exercise intervention was tested via a quasi-experimental study. Children that were assessed were divided into four groups namely: Group (A) that were administered neuropharmacological medication prescribed by a medical practitioner; Group (B) were exposed to the exercise intervention only; Group (C) included children on neuropharmacological medication that were exposed to the exercise intervention and Group (D) served as the control, receiving routine care. All participants were grouped, according to parental preference. Effectiveness of each intervention was assessed using Wilcoxon Signed Ranked Test. **Results:** 151 children were tested. 74% were diagnosed with comorbid ADHD and DCD. The male to female ratio was 2:1. The combined subtype of ADHD was most commonly diagnosed with comorbidity. Consensus on structure and content in an exercise intervention was achieved in three rounds of the Delphi technique. The programme comprised 12 exercises. ADHD scores were as follows: Group A and B showed significant deterioration in these scores, Group C demonstrated a significant improvement and Group D showed no significant change. Results of motor scores: Group A and D showed a significant deterioration, while Group B and C demonstrated a significant improvement. **Conclusions:** The combination of medication plus exercises are effective in addressing and improving the symptoms of comorbid ADHD and DCD in children aged 8 to 9 in KZN, SA. Practitioners are cautioned to screen children with ADHD for DCD, following which treatment should be administered to address symptoms of both conditions, hence, providing a more effective and holistic form of management.*

MANUSCRIPTS UNDER REVIEW

MANUSCRIPT 1 (Chapter 4)

Dawson, Nadasan & Govender (2019). Prevalence Estimations of the Comorbidity of Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Co-ordination Disorder (DCD) in children aged 8 to 9 years in KwaZulu-Natal, South Africa.

*Submitted to the **South African Journal of Child Health** (In Review)*

MANUSCRIPT 2 (Chapter 4)

Dawson, Nadasan & Govender (2019). Design and Consensus of an Exercise Programme for the Management of Comorbid Attention Deficit and Hyperactivity (ADHD) and Developmental Co-ordination Disorder (DCD)

*Submitted to the **African Journal of Health Sciences** (In Review)*

MANUSCRIPT 3 (Chapter 4)

Dawson, Nadasan & Govender (2019). A Quasi-Experimental Study testing the efficacy of an Exercise Intervention for the Management of Comorbid Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Co-Ordination Disorder (DCD)

*Submitted to **BMC Pediatrics** (In Review)*

PREFACE

The format of this thesis follows the guidelines for a PhD, via publication/manuscript format (*Appendix M*) within the College of Health Sciences, at the University of KwaZulu-Natal, Westville, South Africa. It includes the submission of research articles with introductory and summary chapters. The same process of planning, conducting the research and collating the results; as for a traditional thesis was followed. Due to the format followed, a large portion of background and methodology, discussed in the individual manuscripts, is also discussed in the introductory chapters: Chapter 1 (Introduction), Chapter 2 (Literature Review) and Chapter 3 (Methodology). Hence, there may be a fair amount of repetition. The manuscripts are presented in the format, as required by the journals, hence differences in style, font size, line spacing etc., to that required in the general format of the dissertation.

CHAPTER 1

INTRODUCTION

In this chapter, the background to the study, statement of the problem, and significance of the study, in addition to the aims, objectives and hypotheses are discussed. An outline of the content within each chapter is also supplied.

1.1 BACKGROUND

Attention Deficit and Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder affecting children and adults with persistent symptoms of inattention, hyperactivity and/or impulsivity (*DSM-V, 2013*). Epidemiological figures vary from 3 to 5% up to 6 to 10% of school-aged children (*Flapper, Houwen, Schoemaker, 2006*). In South Africa, the prevalence is approximated at 10% (*Vorster, Kem, Amod, Seabi, 2015*).

Developmental Co-ordination Disorder (DCD) is a chronic, neurological disorder affecting co-ordination, motor planning, Activities of Daily Living (ADL) and academic achievement (*DSM-V, 2013*). The prevalence of DCD varies from country to country, from 6% prevalence in the USA to a low 1.8% prevalence amongst children aged seven to eight years in the United Kingdom (*Lingham, Hunt, Golding, Jongmans, Emond, 2009*). The prevalence of DCD in SA remains largely unknown and a thorough search of the literature failed to yield relevant prevalence studies. Studies reveal that children with ADHD frequently experience motor impairments (*Fliers, Romelse, Vermeulen, Altinky, Buschgens, Paroone et al, 2010*). ADHD and DCD were found to exist in comorbidity in approximately 50% of cases (*Pearsall-Jones, Piek, Levy, 2010*). There is however a paucity of information in the literature on prevalence figures and demographics of the comorbidity of ADHD and DCD.

Generally, there is an inadequate treatment of motor problems in ADHD. Treatment of ADHD is commonly managed with neuropharmacological drugs, which do not adequately address the motor impairments, hence, the need for children with comorbid ADHD and DCD, to receive some form of rehabilitative exercises as well (*Fliers et al, 2010*).

1.2 PROBLEM STATEMENT

Studies show that children with ADHD frequently experience motor impairments (*Flapper, 2006; Fliers et al, 2010; Pienaar and du Toit, 2017*). However, the association between ADHD and motor impairments remains unclear, as does the extent of this association. Further

research is thus indicated in this area (*Fliers et al; 2010*). Treatment tends to rely on neuropharmacological drugs, which have little or no effect on the motor co-ordination symptoms, hence, the indication for an additional or alternative intervention (*Flapper et al, 2006; Pearsall-Jones et al, 2010*).

1.3 PURPOSE OF THE STUDY

The main purpose of the study is to contribute to the body of knowledge; by establishing the prevalence of comorbid ADHD and DCD. Additionally, it is to design and gain consensus on an exercise intervention; which can be used as an additional or alternative form of management of comorbid ADHD and DCD.

1.4 SIGNIFICANCE OF THE STUDY

There is a paucity of information on the diagnosis, the link between, the prevalence of and appropriate intervention for the comorbid conditions of ADHD and DCD, both worldwide and more specifically in SA (*Fliers et al, 2010*). Considering the above and the fact that the present form of management of comorbid ADHD and DCD, neuropharmacological medication, does not address the motor symptoms sufficiently and has significant side-effects (*Reiff, 2011*), the development of an alternative or additional form of management, such as an exercise intervention, will be of significant contribution. The significance of this study is thus, that it will contribute knowledge on the prevalence of comorbid ADHD and DCD to caregivers, such as physiotherapists and Occupational therapists. It will also guide practitioners to screen for comorbidity. If and when the exercise intervention is found to be effective, in the management of comorbidity, it may be added as an additional or alternative form of treatment of this comorbidity.

1.5 AIMS AND OBJECTIVES OF THE STUDY

The overall aim of the study is to contribute knowledge on the comorbidity of ADHD and DCD and to design and provide an exercise intervention; which can be used as an additional or alternative form of management of this comorbidity. This will be achieved by the following objectives presented as phases one, two and three:

Phase 1: To establish the prevalence estimations of the comorbidity of ADHD and DCD in children aged eight to nine, in KwaZulu-Natal, South Africa.

- To establish the inattention/cognitive baseline scores of children clinically diagnosed with ADHD.
- To establish motor baseline scores of these children, to confirm or exclude a diagnosis of DCD.

- To present a demographic profile on children diagnosed with comorbid ADHD and DCD (age, gender, population group, sub-type of ADHD).

Phase 2: To design and gain consensus of an exercise programme for the management of comorbid ADHD and DCD.

- To review/describe and appraise exercise interventions presently used for treatment of DCD and ADHD.
- To extract and develop exercises used at present for inclusion into the newly designed exercise intervention.
- To gain consensus from a panel of “experts” on items included within the exercise intervention.
- To present the final draft of the exercise intervention, following a rigorous validation process.

Phase 3: To determine the effectiveness of an exercise intervention on the comorbidity of ADHD and DCD.

- To determine the efficacy of exercise therapy on motor and inattention/cognitive symptoms of comorbid ADHD and DCD.
- To determine the efficacy of exercise therapy and neuropharmacological drugs on motor and inattention/cognitive symptoms of comorbid ADHD and DCD.

1.6 HYPOTHESES

- H_1 = A specific exercise intervention is effective in addressing the symptoms of comorbid ADHD and DCD in children aged 8 to 9 years in KZN, SA
- H_0 = A specific exercise intervention is **not** effective in addressing the symptoms of comorbid ADHD and DCD in children aged 8 to 9 years in KZN, SA.
- H_1 = A specific exercise intervention with children on neuropharmacological drug therapy, is effective in addressing the symptoms of comorbid ADHD and DCD in children aged 8 to 9 years in KZN, SA.
- H_0 = A specific exercise intervention with children on neuropharmacological drug therapy is **not** effective in addressing the symptoms of comorbid ADHD and DCD in children aged 8 to 9 in KZN, SA.

1.7 SCOPE OF THIS STUDY

This study aims to establish the prevalence figures of comorbid ADHD and DCD; amongst age eight to nine year old children, in remedial units at mainstream schools in KwaZulu-Natal, South

Africa. It also aims to design and gain consensus from a multi-disciplinary team of medical experts; on an exercise programme. It thirdly aims at testing the efficacy of this exercise programme, as an intervention on the management of comorbid ADHD and DCD.

1.8 DELINEATION OF THIS STUDY

The format of this thesis follows the guidelines for a PhD, via manuscript route, within the College of Health Sciences at the University of KwaZulu-Natal, Westville, SA. It is comprised of three papers under peer review; presented in Chapters 4, 5 and 6. The content of the thesis is outlined below.

Chapter 1: Introduction

Chapter 2: Overview of the Literature

Chapter 3: Overview of the Methodology: The research design and research setting are described. The methodology is divided into three phases; each phase discusses sample recruitment, sample size and sampling method. Full methodology is given and data collection and analyses are discussed.

Chapter 4: Manuscript 1: Prevalence estimations of the Comorbidity of ADHD and DCD in children; aged 8 to 9 years in KwaZulu-Natal, South Africa. Submitted to the South African Journal of Child Health. This consists of an introduction, full methodology, results, discussion and conclusions.

Chapter 5: Manuscript 2: The Design and Consensus of an Exercise Programme, for the Management of Comorbid ADHD and DCD. Submitted to the journal, African Health Sciences. This consists of an introduction, full methodology, all relevant tables, discussion and conclusions are included.

Chapter 6: Manuscript 3: A quasi-experimental study testing the efficacy of an exercise intervention, for the management of comorbid ADHD and DCD. Submitted to BMC Paediatrics. This consists of an introduction, full methods, results with relevant tables, and discussion and conclusions.

Chapter 7: Synthesis: The objectives are aligned to the outcomes; important conclusions are illustrated, strengths and limitations of the study are given and clinical significance of this information is supplied.

1.9 CONCLUSION

This chapter has served to introduce the topic, state the problem, supply the significance of the study; illustrate the hypotheses and outline all chapters of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides an overview of the literature; only that which is appropriate and relevant to this research study. There is extensive literature on ADHD and on DCD, separately: it is beyond the scope of this literature review to provide all this information, thus only literature/research appropriate to the **comorbidity** of these two conditions are discussed. The literature review is normally expected to be included in the introductory chapter; however, it is presented separately in order to present a strong overview of the available literature to defend the need for the study.

The purpose of the literature review is to identify and critically discuss the existing knowledge related to this study. Additionally, the methodologies, diagnostic tools and treatment protocols used by others, in similar studies were identified. The following topics are discussed:

- *The Comorbidity of ADHD and DCD.*
- *History of Comorbidity ADHD and DCD.*
- *Neuroanatomy of Comorbidity ADHD and DCD.*
- *Neurophysiology of Comorbidity ADHD and DCD.*
- *Epidemiology of Comorbidity ADHD and DCD.*
- *Etiology of Comorbidity ADHD and DCD.*
- *The Diagnostic Investigations used in Comorbidity ADHD and DCD.*
- *Signs and Symptoms of Comorbidity ADHD and DCD.*
- *Management of Comorbidity ADHD and DCD*
- *Conceptual Frameworks involved in the Design of the Exercise Intervention*

2.2 THE LITERATURE REVIEW STRATEGY

- Internet searches were undertaken, on Pubmed, Worldcat, and Medscape
- Search strings included the following:

(“Attention deficit disorder with hyperactivity”(MeSH Terms) OR (“attention”[All Fields] AND “deficit”[All Fields] AND “disorder”[All Fields] AND “hyperactivity”[All Fields] OR “attention deficit disorder with hyperactivity”[All Fields] OR (“attention” [All Fields] AND “deficit”[All Fields] AND “hyperactivity”[All Fields] AND “disorder”[All Fields] OR “attention deficit hyperactivity disorder”[All Fields] AND Developmental[All Fields] AND co-ordination[All Fields] AND (“disease” (MeSH Terms) OR “disease”[All Fields] OR “disorder”[All Fields] AND (“comorbidity” (MeSH Terms) OR “comorbidity”[All Fields])

AND (“attention deficit disorder with hyperactivity” [MeSH Terms] OR (“attention”[All Fields] AND “deficit”[All Fields] AND “disorder”[All Fields] AND “hyperactivity”[All Fields] OR “attention deficit disorder with hyperactivity”[All Fields] OR (“attention”[All Fields] AND “deficit”[All Fields] AND “hyperactivity”[All Fields] AND “disorder”[All Fields]) OR “attention deficit hyperactivity disorder”[All Fields] AND Developmental[All Fields] AND co-ordination[All Fields] AND (“disease”[MeSH Terms] OR “disease”[All Fields] OR “disorder”[All Fields])).

- Keywords included **ADHD, DCD, and Comorbidity of ADHD/DCD**.
- Dates of the searches were for a decade, from 2008 to 2019. Although the search was limited to 2008 until present, some articles prior to 2008 were also yielded.
- Three South African publications, researching ADHD and associated neuromotor co-ordination difficulties, were accessed. These were studies undertaken by *Pienaar and du Toit (2017)*; *Meyer and Sagvolden (2006)* and *Pila-Nemutandani, Pillay and Meyer (2018)*.
- Two unpublished South African theses were found. These included a study on minor motor difficulties (MMD) (*Kolesky, 2017*), and the other with motor difficulties (*Gritzman, 2011*). An additional SA publication dealt with DCD and the effect of an intervention on this condition (*Maharaj and Lalli, 2016*).

2.3 THE COMORBIDITY OF ADHD AND DCD

ADHD is described as one of the most common childhood neurobehavioural disorders. (*Barkley, 2015*; *Scharoun, Bryclen, Otipkova, Musalek, Lejcarova, 2013*; *Pearsall-Jones, Piek, Levy, 2010*; *Waternberg, Walsberg, Zul, Lerman-Sagie, 2007*; *Reiff, 2011*). It affects academic achievement, general well-being and social interaction. (*Reiff, 2011*; *DSM-V, 2013*; *Barkley, 2015*). To receive the diagnosis ADHD, symptoms must be present prior to the age of seven years, the individual must exhibit at least six core symptoms and these symptoms must cause some impairment in at least two settings, for example: school and home (*DSM-V, 2013*).

DCD is defined as a discrete disorder under the broader heading of neurodevelopmental disorders (*DSM-V, 2013*). Specific criteria for the diagnosis are required, namely:

- (1) Motor skills are well below the given chronological age.
- (2) Clumsiness, slowness and inaccuracy of motor performance exists.

- (3) Onset of the condition is during the early-developmental period.
- (4) Activities of Daily Living (ADL), academics, leisure activities, sport and play, are all affected.
- (5) All other mental, visual, auditory, intellectual or neurological impairment must be excluded, for example: cerebral palsy, muscular dystrophy and mental retardation (*DSM-V, 2013*).
- (6) There are no obvious dysmorphic features or neurological abnormalities (*Nelson, Jaskiewicz, Patakil, 2015*).

Movement/co-ordination disorders have been given many “labels” over the years: sensory integrative dysfunction; floppy infant syndrome (FIS); minor brain dysfunction (MBD); benign congenital hypotonia (BCH); clumsy child syndrome. At a meeting in Ontario in 1994, it was decided that DCD was the acceptable terminology to be utilised (*Nelson et al, 2015*).

Over the years, it has become obvious that children born with DCD have a high prevalence of symptoms associated with ADHD and those children diagnosed with ADHD, demonstrate motor/co-ordination symptoms, consistent with a DCD diagnosis (*Watemberg et al, 2007*). The rate of comorbidity between these two conditions was found to be 55.2% in a study completed by Watemberg in 2007, in Israel. Ninety-six children diagnosed with ADHD (by using the DSM IV (1994) criteria, neurological examination, educational and psychological evaluation, teacher and parent questionnaires) were recruited. They were tested for DCD using the Movement Assessment Battery for Children (MABC) and a diagnosis of DCD was confirmed in 53 children (55,2%). This was a methodologically strong, well thought-out study. Other studies found ADHD and DCD to co-occur in 50 to 60% of cases (*Blank, Engelsman, Wilson, Polatjako, 2011*) and 30 to 50% of cases (*Fliers et al, 2010; Stray, Stray, Iversen, Ruud, Ellertsen, Tonnessen, 2009*).

Three South African studies were located; which looked at motor co-ordination difficulties in children with ADHD (*Meyer et al, 2006; Pienaar and du Toit, 2017; Pila-Nemutandani et al, 2018*); *Meyer et al (2006)* explored fine motor skills in children with ADHD, however, prevalence rates were not given. *Pienaar et al (2017)* tested efficacy of different interventions on ADHD with motor co-ordination difficulties; again prevalence figures of comorbidity were not established or supplied. *Pila-Nemutandani et al (2018)* investigated gross motor skill difficulties in children with ADHD but prevalence figures were, once again, not furnished. This shows the need for this study; in which prevalence figures and demographics of the comorbidity of ADHD and DCD; in KZN, South Africa, were established and presented.

2.4 THE HISTORY OF COMORBIDITY OF ADHD AND DCD

Children with attention deficits, motor control difficulties and perceptual problems were “labelled” in the past as having “minor brain dysfunction” (MBD) (*Gillberg and Kadesjo, 2003; Flapper et al, 2006*). More recently, in the 1970’s, in Scandinavia the term **DAMP** became the accepted diagnostic terminology. The term DAMP is an acronym for Deficits of Attention, Motor Control and Perception (*Watemberg et al, 2007*). It is defined as a combination of ADHD and DCD and refers to children with inattention/impulsivity/hyperactivity, motor control problems, learning difficulty, speech problems and perceptual motor inadequacies (*Gillberg et al, 2003*).

In recent years, the comorbidity of ADHD and DCD has gained more focus than in the past 30 to 35 years; but this condition is still under-diagnosed, under-treated and under-researched. Only 50 published studies on comorbidity of ADHD and DCD were found over a 30-year period (*Gillberg, 2003*). This reveals the paucity of information on this topic and hence, the need for this study.

2.5 NEUROANATOMY OF COMORBID ADHD AND DCD

In a number of neurological studies undertaken on children with ADHD and children with DCD (separately); abnormal structure and function was revealed in the brain regions outlined below. Examples of such neurological investigations: Abnormal electrical activity revealed by electroencephalograms (EEG); reduced cerebral blood flow shown by single photon emission computed tomography (SPECT); diminished metabolism demonstrated by positron emission tomography (PET) and structural changes such as reduction in total volume and reduced cortical thickness displayed by magnetic resonance imaging (MRI) (*Kasperek, Theiner, Filove, 2015; Curatolo, D’Agati, Moavero, 2010; Biotteau, Chaix, Albarat, 2016*).

The Frontal and Prefrontal Regions: Located superiorly, anterior to the central sulcus of the brain. This area controls planning, problem-solving, language, attention, impulse control and memory (executive functions). The posterior portion of this part of the brain, the motor cortex, controls voluntary movement (*Goldberg, Ouellette, 2016; Fisch, 2017*).

The Cerebellum is located inferiorly to the hindbrain. It co-ordinates movement, controls posture and maintains balance. It is also involved in the control of speech (*Goldberg et al, 2016; Fisch, 2017*).

The Basal Ganglia are a group of structures situated deep within the white matter of the cerebral hemispheres. They include the caudate nucleus, putamen, globus pallidus, substantia nigra and the subthalamic nucleus. The functions of these structures are motor planning and control of

voluntary movement, learning of procedures, habit learning, eye movement, cognitive function (Goldberg *et al*; 2016; Fisch; 2017).

The Anterior Cingulate Cortexes are located on the medial aspect of each cerebral cortex; superior to the corpus callosum. Chief functions of these are control of emotion, memory, process learning and decision-making (Goldberg *et al*, 2016; Fisch, 2017).

The Corpus Callosum is a thick band of nerve fibres that connect the left and right hemispheres of the brain. The chief function of these is inter-hemispheric communication or bilateral integration (Goldberg *et al*, 2016; Fisch, 2017).

The Parietal Lobe is situated posteriorly to the central sulcus of the brain. Its chief function is sensorimotor, that is: recognising sensation and body position in space, predicting action and controlling executive functions (Goldberg *et al*, 2016; Fisch, 2017).

Thalamus: This is a small structure located above the brain stem. Its chief function is to relay motor and sensory signals to the cerebral cortex (Goldberg *et al*, 2016; Fisch, 2017).

The neurological areas described above are illustrated in Figure 2.1 below:

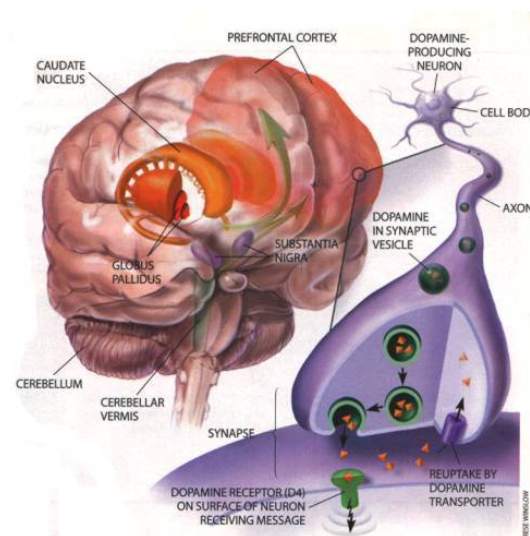


Figure 2.1 Diagrammatic Representation of Neuroanatomical Areas that exhibit abnormal structure and function in both ADHD and DCD (Barkley, 2015).

When other studies are explored the neuroanatomical areas seen to be implicated in comorbid ADHD and DCD, are very similar; with insignificant variations: In the review of *Pila-Nemutandani et al (2018)*, the following brain areas are seen to be implicated: lateral prefrontal cortex, dorsal anterior cingulate cortex, the caudate nucleus, putamen, cerebellum, temporo-parietal lobes and corpus collosum. These areas differ slightly from the areas reported on by *Stray et al (2009)*: frontal cortex, sensorimotor cortex, cerebellum, anterior cingulated cortex and the brainstem.

The above discussion provides evidence of common neuroanatomical features, in the neuroanatomy of children with ADHD and children with DCD.

2.6 NEUROPHYSIOLOGY OF COMORBID ADHD AND DCD¹

Scientists and researchers over the years have observed that concentration levels of certain neurotransmitter substances; in the blood and brain metabolites, are reduced in conditions such as ADHD and DCD (*Mandal; 2015; Ratey; 2016*). Neurotransmitter substances transport an electrical message, across the synapse, from one neurone to the next (*Mandal; 2015*). Of particular importance to ADHD and DCD are the following neurotransmitter substances:

Dopamine is produced chiefly by the basal ganglia although the midbrain and the hypothalamus are also responsible for this function. The chief functions of dopamine are motor control, memory, cognition and attention (*Mandal, 2015*).

Norepinephrine/Noradrenaline is produced by the post-ganglionic endings of the sympathetic nervous system (SNS) and the chief functions of this neurotransmitter is to increase attention and alertness. This substance also has a renal function (*Mandal, 2015; Melloni, Dox, Eisher, 1993*).

Endorphins are released by the pituitary gland during activities such as exercise and during laughter. The effects of endorphins are chiefly mood regulation and enhancing attention (*Melloni et al, 1993*).

Serotonin is mainly found in the gastrointestinal mucosa and in small amounts in the brain and blood platelets. This substance stimulates smooth muscles and its chief functions are mood regulation, memory and learning and metabolism (*Melloni et al, 1993*).

¹ All functions of the above four neurotransmitter substances have **not** been discussed, only the functions pertaining to ADHD and DCD have been reviewed.

Studies that have explored the levels of these neurotransmitter substances; in comorbid ADHD and DCD; confirm that which are discussed above: Dopamine levels are generally reduced and main functions of this neurotransmitter are motor control, cognitive function and control of impulsivity. Norepinephrine levels are also reduced and main functions of this substance, are impulse control and executive functions. Finally serotonin levels are reduced; serotonin being responsible for attention/focus and mood stabilisation (*Lange, 2018; Pila-Nemutandani et al, 2018; Fliers et al, 2010; Ng, Ho, Chan, Yong, Yeo, 2017; Den Heijer, Green, Tucha, Fuermaier, Koerts, Lange et al, 2015*).

The above outline of neurotransmitter substances levels, provides evidence of common physiological features in both ADHD and DCD.

2.7 EPIDEMIOLOGY OF COMORBID ADHD AND DCD

Using the diagnostic criteria, as outlined in the *DSM V (2013)* prevalence rates of ADHD are between 7 to 10% worldwide. However some studies record lower prevalence rates of 3 to 6% (*Gillberg et al, 2003; Vysniauske, Verburch, Oosterlaan, Molendijk, 2016; Pienaar and du Toit, 2017; Pila-Nemutandani et al, 2018*). This does not seem to vary between socioeconomic levels and across various cultural groups (*Vorster, Kem, Amod, Seabi, 2015*). South African prevalence figures are recorded at approximately 10% (*Vorster, 2015, Barkley, 2015*) which is in agreement with the world prevalence rates. Following the diagnostic criteria outlined in the *DSM V (2013)*, world prevalence rates of DCD range from 5 to 8%, within age-group 6 to 12 years. This is slightly higher in the UK and USA, viz between 10 to 12%. Sweden records prevalence rates of 5 to 6%, whilst that of Australia is between 5 to 15% (*Nelson et al, 2015; Gritzman, 2011; Missiuna, Rivard, Bartlett, 2006*). A South African based DCD prevalence study was undertaken at seven mainstream schools within close proximity to the University of the Free State. In this study, 347 children (190 females and 157 males) aged 5 to 8 were tested using the Movement Assessment Battery for Children, 2nd edition (MABC-2). A prevalence of 6% DCD was established (*de Milander, Coetzee, Venter; 2016*). The study mentioned above did not show results of gender distribution of DCD. It is well recorded in a number of studies that males are more affected by ADHD and DCD, than females (*Barkley, 2015; Nelson et al, 2015; Murphey, Barkley, Bush; 2011; Morton, 2015*). An average ratio of 3 males to 1 female, having ADHD, is recorded by *Barkley (2015)*. *Nelson et al (2015)* reported on a study completed in the UK, on 7,000 children aged 7 to 8 years. This study found a male to female ratio having DCD, of 1,7 to 1. The year in which this study was completed was not given (*Nelson et al, 2015*). The *DSM-V (2013)* records a male to female ratio between 2 : 1 and 7 : 1 (*DSM-V, 2013; Lingham et al, 2009*). As can be seen from the above, a large number of studies report on prevalence figures of DCD and ADHD separately. However, few studies were found whereby prevalence figures of comorbid ADHD

and DCD are reported on: *Lange (2017)*, in a paper in the USA, on “*ADHD and Comorbid DCD: Implications and Recommendations for School Psychologists*”, states that DCD and ADHD are frequently comorbid. However, prevalence figures were not recorded (*Lange, 2017*). In a review completed in Sweden on “*Deficits in Attention, Motor Control and Perception (DAMP)*”, DCD is reported to co-occur in 50% of cases of children with ADHD and the male to female ratio of comorbidity is 3 to 5:1 (*Gillberg, 2003*). *Pearsall-Jones; (2010)* in Australia also states that a 50% rate of comorbidity of ADHD and DCD exists, but the publication was not based on calculation of this prevalence rate; it was predominantly to establish whether ADHD and DCD have shared etiology. Other papers written in the USA, Israel and Switzerland report a 50 to 60% prevalence of DCD amongst children with ADHD (*Barkley; 2015*) (*Watenberg et al, 2007; Kaiser, Schoemaker, Abaret, Geuze, 2015*). A study completed in Norway records a very high 44 to 84% rate of comorbidity (*Stray et al; 2009*). Of all related/appropriate South African publications located; 3 dealt with DCD only (*Peens, Pienaar, Nienaber, 2008; Maharaj and Lallie, 2016; de Milander et al, 2016*). One study investigated gross motor skill deficits in children with ADHD, whilst another explored fine motor skill problems in children with ADHD (*Meyer et al, 2006; Pila-Nemutandani et al, 2018*). Both studies did not, however, establish or supply general prevalence figures on comorbid ADHD and DCD. The sixth SA study located researched efficacy of various interventions on ADHD with associated neuromotor co-ordination difficulties but this study also failed to provide prevalence figures of comorbid ADHD and DCD (*Pienaar et al, 2017*). From the above, the large scatter in prevalence statistics and the paucity of information on prevalence figures and demographics of comorbid ADHD and DCD in South Africa in particular, is demonstrated. This shows the purpose and significance of Phase 1 of this three-part study.

2.8 ETIOLOGY OF COMORBID ADHD AND DCD

Neuroanatomy and neurophysiology anomalies are two underlying factors of DCD and ADHD etiology, as discussed earlier on in this chapter. These two factors are frequently discussed in numerous publications. The less frequently discussed etiological risk factors of ADHD recognised are discussed below:

Pre- and Peri-Natal Factors: Findings suggest that low birth weight, minor bleeding into the brain and prematurity; is frequently associated with ADHD (*Groen-Blokhuys, Middeldorp, van Beijsterveldt, Boomsma, 2011*). Exposure of the foetus to toxins, such as alcohol, maternal smoking and narcotic drugs; produces an elevated risk of ADHD according to some studies (*Rodriguez, Olsen, Kotimaa, Kaakinen, Moilanen, 2009*).

Familial and Genetic Factors: The evidence for a genetic heritability to ADHD is now well supported by four study-types: biological relatives; adoption studies; twin studies and molecular genetic studies (*Banaschewski and Backer; 2010*). One in every two children with “DAMP” have a sibling or a parent with the same condition (*Gillberg et al; 2003*).

Environmental Factors: Studies have shown that environmental issues may play a role in increasing the risk of ADHD. Examples of these are malnutrition, disease, trauma and toxins such as lead (*Nigg; 2006*).

Psychosocial Factors: Despite the large role genetic factors play in resulting in ADHD symptoms; the parents, family and social factors cannot be ignored (for example: family functioning, discipline measures, behavioural patterns and emotional problems) in predisposing to the development of symptoms of ADHD (*Nigg, 2006; Gillberg et al, 2003*). *Gillberg et al; (2003)* recognises pre- and peri-natal, familial and psychosocial factors as risk factors of DAMP whilst *Pearsall-Jones et al; (2010)* only discuss familial and pre/peri-natal factors as risk factors of children having attention and motor problems. DCD also has a number of etiological risk factors; these being outlined below:

Prematurity: Statistics indicate that extreme prematurity in infants, significantly increases the risk for developing DCD. This is because prematurity results in hypoxia which produces a disturbance to the formation of neuronal connections; during foetal development. This results in impaired cognitive ability, inattention, sensory and motor deficits. (*Nelson et al; 2015; Pearsall-Jones et al; 2010*).

Pregnancy Related Complications: Smoking during pregnancy can cause prematurity and complications which follow; discussed above. Oxygen supply to the foetus is reduced and this stunts growth and brain maturation. Maternal alcohol consumption stunts the growth of cells; brain cells in particular. Intake of narcotic drugs during pregnancy, can cause constriction of arterial blood vessels leading to micro-infarctions in the foetal brain. These factors all contribute to poor motor function and increased risk of DCD (*Gomez, 2015; Nelson et al, 2015*).

Familial and Genetic Factors: Studies completed have established a 47 to 69% chance of heritability of DCD (*Pearsall-Jones et al, 2008*). Other studies suggested that certain genes may contribute to the incidence of DCD, however these studies did not prove statistically significant (*Nelson et al, 2015*).

Environmental Factors: High levels of lead, anaemia and other deficiencies all seem to contribute to poor motor ability and increased risk of DCD (*Gomez, 2015; Gritzman, 2011*). *Blank et al; (2012)* discuss familial, environmental and psychosocial factors; viewed as risk factors of DCD.

2.8.1 Theories on Etiology of DCD

A number of theories have been derived; in an attempt to explain the etiology of DCD. These are briefly discussed below:

The Sensory Integration Theory demonstrates the inability to integrate information from various sensory origins (vestibular, visual and/or proprioceptive) which leads to poor motor planning and unsuccessful movement (*Nelson et al, 2015*).

The Dynamic Systems Theory states that the Central Nervous System (CNS) interprets sensory input; movement is selected based on current experience, memory of similar movements and external and internal environments (*Gritzman, 2011*).

The Neuronal Group Selection Theory recognises groups of functional cortical and subcortical neurons which exist in the CNS. Functional integrity depends on sensory input from proprioceptors, vision, alertness and from the memory experience. The reticular formation is activated and the resultant movement is planned. Deficits in the sensory/input information results in unsatisfactory movement (*Zwicker, Missiuma, Harris, Boyd, 2012; Nelson, 2015*).

The Automatisatation Deficit Hypothesis: Children with DCD do not have the ability to make motor skills automatic. This is possibly due to cerebellar involvement: the appropriate motor signal is matched to the sensory input. It was found that children with DCD have microscopic structural changes in sensory and motor pathways (*Zwicker et al, 2012*).

The Information Processing Theory looks at structural and functional constraints of the perceptual system. Immature myelination is seen on micro-imaging (structural) and great difficulty is experienced in movements becoming “automatic”; that is; the child depends more on cognition for movement (functional) (*Geuse, Jongmans, Schoemaker, 2001*).

In reviewing the literature above on the proposed etiologies of ADHD and DCD, several overlaps are identified. This provides evidence of partially shared etiology of ADHD and DCD and thus further verification of the link between these two conditions.

2.9 DIAGNOSTIC INVESTIGATIONS USED IN COMORBID ADHD AND DCD

As stipulated by the DSM-V (*American Psychiatric Association (APA), 2013*) in order to receive the diagnosis of ADHD; the individual must display at least six core symptoms of inattention/impulsivity/hyperactivity, before age of seven years, and these core symptoms must cause some impairment in at least two different environments; for example: home and school, and persist for at least one year (*Barkley, 2015*). There must be clear evidence of impairment in social, academic and/or occupational functioning. Symptoms cannot be better accounted for by any other mental disorder, for example: personality disorder or anxiety disorder (*DSM-V, 2013*).

Diagnosis is made by data collection (history, familial, social history, etc), a clinical evaluation (height, weight, pulse rate, blood pressure), rating scales such as Conners' Teacher and Parent rating scale and the Modified Copeland Symptom Checklist. Neuropsychological testing such as Intelligence Quotient and Conners' Continuous Performance Test 3rd edition (CPT-3), are also administered (*Conners, 2004-2016*). The CPT-3 is a "computerised task-oriented assessment of attention-related problems". It is used in individuals aged 8 and older. The test duration is 14 minutes, during which respondents are required to push the space bar when any letter of the alphabet appears other than the letter "X". Four dimensions of attention are measured: "Inattention, Impulsivity, Sustained Attention and Vigilance" (*Conners, 2004-2016*). Unfortunately few educational psychologists have access to this test, due to it being expensive to acquire. Diagnosis thus depends largely on rating scales mentioned previously which merit further explanation, since they will be used in this study to confirm the ADHD diagnosis.

2.9.1 The Modified Conners' Teacher Rating Scale

This rating scale has been used over the past 30 years. It was first introduced to test efficacy of neuropharmacological medication, as an intervention for children with behavioural disorders, in 1953, by Conners and Eisenberg (*Conners, Sitcrenios, Parker, Epstein, 1998*). It is used to test patients aged 6 to 18 and exists in 3 forms: a parent rating scale, a teacher rating scale and a self-report completed by the patient (*du Paul, Power, McGoey, Anastopoulos, 1998*). Reliability and validity of this scale were evaluated on a sample of 71 students, aged 5 to 17; geographical area and gender were not supplied. Parent and teacher ratings were obtained 4 weeks apart, each at a specific time of the day. The results showed adequate internal consistency, test-retest reliability and cross-informant agreement between parent and teacher (*du Paul et al; 1998*). It was concluded that the scales have adequate psychometric properties for the screening and assessment of ADHD (*Conners et al, 1998; du Paul et al, 1998*). The scale consists of 20 items/questions, each evaluated on a 4-point Likert scale: Not at all/0 – 0 points awarded, Just a little/1 – 0.5 point awarded, Pretty much/2 – 1 point awarded and Very much/3 – 1 point awarded. The first 10

questions refer to inattention e.g., disorganisation, distractibility; the next five questions refer to impulsivity e.g., interrupting, lacking inhibition, and the final five questions refer to hyperactivity e.g., fidgeting, restlessness. For questions one to 10 a total out of ten is derived from which a percentage is then calculated. The questions 11 to 15 and then 16 to 20; a total out of five each is derived; percentages are calculated from these. Percentages are interpreted in the following manner; If the child scores between 60 to 70%, a mild case of inattention/impulsivity/hyperactivity exists. If the score is greater than 70%; a moderate to severe case of inattention/impulsivity/hyperactivity, exists (*Conners et al, 1997*). Refer to **Appendix Ei** for a visual of the Conners’ Teacher Rating Scale.

2.9.2 Modified Copeland’s Symptom Checklist

Dr Edna D. Copeland, a child/clinical psychologist, began her major research and numerous publications around 1987. The Copeland Symptom Checklist for ADHD was designed to assist healthcare professionals in assessing whether a patient has symptoms of ADHD, to what degree and which areas of function are most affected. The checklist covers eight categories: “*Inattention, Impulsivity, Level of Activity, Noncompliance, Underachievement/Disorganisation/Learning Problems, Emotional Difficulties, Poor Peer Group Relationships and Impaired Family Relationships*” (*Copeland, 1987*). *Du Paul et al (1998)* evaluated reliability and validity of the Copeland Symptom Checklist in an epidemiological study of 1095 children diagnosed with ADHD by clinical interview. Gender and age-group of the children were not given and geographical area of where this study took place was not described. Results of four categories of ratings were compared: (1) Parents; (2) Teachers; (3) Parents or Teachers; (4) Parents and Teachers. The group having the greatest validity was group 4; where both parent and teacher ratings were completed/compared. The results of this study showed that this checklist has adequate validity, specificity and reliability. This proves its clinical usefulness in screening/confirming a clinical diagnosis of ADHD (*du Paul et al, 1998*). The checklist consists of a number of questions, under each of the 8 categories. Each item/question is evaluated on a 4-point Likert Scale: Not at all – 0 points, Just a little – 1 point, Pretty much – 2 points, Very much – 3 points. A percentage is calculated for each category, in the following manner:

$\frac{\text{Total score}}{\text{3 x number of items}} \times 100 = \%$

Percentages are interpreted in the following manner; If the score is 60% to 70% a mild case is diagnosed and if the score is greater than 70%, a moderate to severe case is diagnosed. For the purpose of this study only categories I to III were used; as these dealt with inattention, impulsivity

and level of activity (Hyperactivity); symptoms directly related to ADHD. Refer to *Appendix Eii* for a sample of the Copeland's Symptom Checklist.

A search of the literature investigating prevalence of the comorbidity of ADHD and DCD; revealed that the diagnosis of ADHD was **not** always confirmed. Tests used, other than Conners' or Copeland's (described above) were: The Disruptive Behaviour Disorder Rating Scale (*Pila-Nemutandani et al, 2018*); The Behaviour Assessment System for Children, Verbal fluency test; Kaufman Brief Intelligence Test (*Missuina et al, 2008*); Quick Neurological Screening Test 2, Visual Motor Integration Test 4, Disruptive Behaviour Scale (*Pienaar et al, 2017*); Van der Bilt rating scale (*Southammakosane et al, 2015*). It was found that the Conners' rating scale was the test most frequently used, to confirm an ADHD diagnosis.

Having discussed how a diagnosis of ADHD is confirmed, the investigations completed to make a diagnosis of DCD will now be discussed. According to DSM-V (*APA, 2013*), the criteria for the diagnosis of DCD is marked impairment in motor function; which impairs academics and activities of daily living (ADL) and is not due to any other medical, genetic, developmental or mental condition (*DSM-V, 2013*). This diagnosis is confirmed by the use of:

- *The Developmental Co-ordination Disorder Questionnaire (DCDQ,2007; Wilson, 2007).*
- *Movement Assessment Battery for Children, first or second edition (MABC-1; 1992 or MABC-2; 2007) (Henderson and Sugden, 1992; Henderson and Henderson, 2007).*
- *The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) first edition (Bruininks, 1978) and the 2nd edition known as the Bruininks-Oseretsky Test (BOT-2) (Bruininks and Bruininks; 2005).*

A large percentage of publications, involving diagnosis of DCD, utilise the MABC-1 or MABC-2. It is by far the more common motor test administered (*Peens et al, 2007; Gritzman, 2011; Pienaar et al, 2017*). Hence the decision of the researcher (PI) to use this test in the present study. This test supplies a **quantitative** score. The researcher felt that a **qualitative** score was also essential, hence, the use of the DCD-2007 (*Henderson et al; 2007 and Wilson, 2005*). A discussion of these two tests follows.

2.9.3 The Developmental Co-ordination Disorder Questionnaire (DCDQ-2007)

The original version of this questionnaire was first published in 1999. After several years of widespread use and translations into several other languages, a second study to review the questionnaire was commenced in 2004. This resulted in the current questionnaire, known as the DCDQ-2007 (*Wilson, 2005*). The questionnaire begins with the demographics of the respondents;

particular chronological age and consent. The questionnaire consists of 15 items; grouped into three parts: Control during movement, fine motor and handwriting, general co-ordination (*Wilson; 2007*). Total score for the 15-item version, ranges from 16 to 75. It has a mean of 61,79 with a standard deviation of 10.21. A maximum of five points are awarded for each of the above. Scoring is as per Table 2.1.

Table 2.1 The Interpretation of the Scores of the Developmental Co-ordination Disorder Questionnaire (DCDQ-2007)

Age Group	DCD Suspected	Probably not DCD
5 years to 7 years 11 months	15 → 46	47 → 75
8 years to 9 years 11 months	15 → 55	56 → 75
10 years to 15 years	15 → 57	58 → 75

The test is used on children aged five years to 15 years. It has a high internal consistency ($\alpha = 0.94$) and an overall sensitivity of 85% and specificity of 71% (*Wilson, 2007*). Refer to *Appendix F* for an example of the DCDQ 2007.

2.9.4 The Movement Assessment Battery for Children

The first MABC-1 was developed in 1992 by *Henderson and Sugden*. This was revised by *Henderson et al (2007)* and published as the MABC 2nd Edition or MABC-2. The MABC-2 was administered to 1172 children in the UK to obtain norms. The primary aim of this test is identification of children having motor difficulties. The test focuses on three areas: manual dexterity; eye-hand co-ordination; and balance. This test is most commonly used in identification of children with DCD (*Henderson et al, 2007*). MABC-2 has three age appropriate sections, for three age bands; 3-6 years, 7-10 and 11-16, all measuring similar motor skills. It consists of eight subtests, described below. MABC-1 is comprised of four age bands: (1) Four to six years; (2) seven to eight years; (3) nine to ten years; (4) eleven to twelve years.

Manual Dexterity

- Speed and confidence of movement of each hand
- Co-ordination of 2 hands in a single task
- Eye-hand co-ordination, for example; writing

Eye-Hand Co-ordination

- Ability to catch a moving object
- Ability to aim accurately at a target

Balance

- Static: maintaining balance while remaining in one area/position
- Dynamic: maintaining balance while moving from one point to another slowly
- Dynamic: maintaining balance while moving from one point to another, with speed.

Raw scores are converted to standard scores and percentiles are calculated, for the MABC-2. Both the MABC-1 and MABC-2 “have excellent test-retest reliability of 0.75 for all age groups and fair to good construct and concurrent validity. The specificity seems to be good and the sensitivity fair to good”. Limitations of use of the MABC-1 and 2, is that there is a lack of research on the discriminant validity of the test and attention problems may interfere with performance during testing (*Henderson et al, 2007*). The MABC has not been standardised for South African context, so we are unsure of its cultural suitability. However, it has been used in a number of South African studies, for example: *Peens et al (2007)*, and other researchers did not state any limitations with using the motor test and did not recommend that it needs to be standardised for use in SA. (*Gritzman, 2011; Pienaar et al, 2017; Kolesky, 2017; Maharaj and Lallie, 2016*) to mention just a few. It was felt that the age bands of the MABC-2 were too broad for the age-group, 8 to 9 years, being investigated in this study and it was thus decided that MABC-1 would be used. This was scored as follows: A total Motor Impairment Score is derived from the eight subtests.

- Scores of under 10.5 The child does not have DCD
- Scores of 10.5 to 14 The child has borderline DCD
- Scores of 14.5 or greater The child definitely has DCD.

(Henderson et al; 2007).

Refer to ***Appendix G*** for a sample of the instructions and score-sheet of MABC-1.

Publications located where prevalence of DCD was investigated and the comorbidity of ADHD and DCD was explored, were found to **not** always use the above two tests described. Other tests used were: Assessment of Participation and enjoyment (*Morton, 2015*); Twistbox, finger-tap, foot-tap (*Scharoun et al; 2013*); Groningen Motor Observation Scale (*Fliers et al, 2010*); Maze Co-Ordination Task, Grooved Pegboard Test (*Meyer and Sagvolden, 2006*); ADL Scale (*Lingham et al, 2009*); Motor Function Neurological Assessment (*Stray et al, 2009*); Assessment of Motor Co-Ordination and Dexterity (*Cardos, Magalhaes, Rezende, 2014*). The most commonly used tests were however, the DCDQ and the MABC.

The above has provided an outline of clinical diagnostic criteria for each condition (ADHD and DCD) as set out in the *DSM-V (APA, 2013)* and described the tests administered to confirm a

diagnosis of each condition, separately. It thus follows that the diagnosis of comorbid ADHD and DCD would be confirmed by combining the above two sets of tests. A summary of this follows:

To Diagnose Comorbid ADHD and DCD

- Clinical diagnostic criteria by a clinician
- Conners' Teacher or Parent Rating Scale
- Copeland's Symptom Checklist for ADHD
- Developmental Co-Ordination Disorder Questionnaire (DCDQ)
- Movement Assessment Battery for Children (MABC-1/2)

This study used the above five-point summary to diagnose comorbidity in that children clinically diagnosed with ADHD (identified by the teachers) were tested using the Conners' teacher rating scale (pre-intervention), the DCD-Q, the MABC-1 (pre and post-intervention) and the Copeland's Symptom Checklist (post-intervention). This ensured accurate diagnosis and sound methodology for purposes of this investigation.

2.10 THE CLINICAL PRESENTATION OF COMORBID ADHD AND DCD

2.10.1 Signs and Symptoms of ADHD

Research has repeatedly identified three core symptoms, which are thought to characterise ADHD: Inattention, Impulsivity and Hyperactivity (*Barkley; 2015; DSM-V; 2013; Vorster et al; 2015*). From these three core symptoms, three subtypes of ADHD are identified: Inattentive type, Hyperactive-Impulsive type and the Combined type; with all three core symptoms exhibited (*Nigg, 2006; DSM-V, 2013; Meyer et al, 2006*). These three core symptoms are further illustrated below:

Inattention: forgetfulness, carelessness, losing things, not listening, disorganisation, inability to follow instruction, reduced executive function, unfinished tasks, lacks ability to initiate activity, easily distracted, reduced mental flexibility (*DSM-V, 2013; Meyer et al, 2006; Barkley, 2015*)

Hyperactive-impulsive: fidgeting, lacks executive inhibition, restlessness, excessive activity, excessive talking, acting impulsively, interrupting, inability to adapt to change, touching, requires increased stimulation (*DSM-V, 2013; Meyer et al, 2006; Barkley, 2015*).

Combined Type: at least six symptoms of inattention and 6 symptoms of hyperactivity-impulsivity are experienced (*DSM-V, 2013; Meyer et al, 2006; Barkley, 2015*).

Other than the three core symptoms discussed above, a host of additional symptoms have been identified: gross and fine motor co-ordination, balance, motor planning and execution, memory, verbal fluency and language, emotional regulation. Deficits of executive function are included among these additional symptoms. Four important executive functions are recognised (*Barkley, 2015; Martinussen, Hayden, Hogg-Johnson, 2005; Meyer et al, 2006; Murphey et al, 2001*).

- Non-verbal working memory (retaining information for later use)
- Verbal working memory (vocalising thoughts)
- “Self-Regulation of Affect” (Inhibition of initial emotional response)
- “Reconstitution” (planning and problem-solving for goal-directed behaviours)

All publications located and reviewed; seemed to agree with the three core symptoms of ADHD, as well as additional symptoms of this condition.

2.10.2 Signs and Symptoms of DCD

The child with DCD is described by *Zwicker et al (2012)*, as being slow to complete tasks and generally lacking co-ordination. ADL such as dressing, fastening and unfastening zips and buttons, tying shoe-laces and using a knife and fork; all present a challenge. School related, fine motor activities such as writing, cutting and drawing are affected. Gross motor activities are also affected, for example: running, jumping, throwing, catching, hopping and balance (*Zwicker et al, 2012; Dawson and Puckree, 2006*). Physical impairments of a child with DCD are well described by *Missiuna et al, 2009*. The child is clumsy and experiences difficulty with gross motor and fine motor skills, throwing and catching present a problem, as do activities which involve use of both sides of the body; that is: bilateral integration. Poor balance and poor postural control (reduced muscle tone and core stability) are often exhibited during movements (*Missiuna et al, 2009*). *Nelson (2015)* describes DCD to be characterised by symptoms of reduced muscle tone, gross and fine motor skill deficits; lowered muscle power, inability to integrate sensory information and motor planning deficits. In contrast, *Morton (2015)* reviewed the secondary signs and symptoms of DCD, such as reduced participation in sports, deficient ADL, impaired academic performance, decreased fitness level, obesity, cardiovascular disease and compromised endurance. *Vaivre-Douret, Lalanne, Ingster-Moati, Boddaert, Cabrol, Dufier et al (2011)* focused more on the fine motor aspects: bi-manual dexterity, synkinesis, manual dexterity, DDK, oro-facial praxia, EF, slowness, handwriting, hypotonia, VMI, visuo-spatial difficulties and constructional tasks.

Pearsall-Jones et al (2010), reviewed the literature on the clinical presentation of DCD: developmental delays, precision in reach and grasp, fine motor manipulation, reduced interaction with environment, motor deficits, static and dynamic balance complications, clumsiness, reduced muscle tone and sensory integrative problems. The secondary symptom deficits were discussed by *Missiuna et al (2009)*; these being: reduced physical activity and social interaction, poor academic performance, risk for obesity, vulnerability to being teased, low self-esteem, poor emotional well-being, language and speech difficulties. Finally, *Blank et al (2011)* gave a brief description of primary and secondary symptoms of DCD: gross motor and fine motor deficits; high prevalence of comorbidities, impaired performance of ADL, reduced academic achievement and general diminished participation.

The above provides a detailed description of the clinical presentation of DCD. (*Nelson, 2015; Morton, 2015; Vaivre-Douret et al, 2011; Pearsall-Jones et al; 2010; Missiuna et al, 2009; Blank et al, 2011*).

2.10.3 Sub-types of DCD

In order to identify subtypes of DCD, “cluster analyses” are completed. This involves deriving a number of scores from various motor and perceptual tests, viz: “visual-perceptual, visual-motor, manual dexterity, kinaesthetic acuity, balance and running speed”. Participants are grouped into subtypes on the basis of profiles formed from all of these scores (*Visser, 2003*).

In a study on 43 children with DCD, aged five to 15 years; *Vaivre-Douret et al (2011)* identified three main subtypes of DCD, namely: (i) **Ideomotor**: predominantly difficulty with quick response, motor action, (ii) **Visual-spatial**: predominantly sensory difficulty and (iii) **Mixed dyspraxia**: both motor and sensory difficulty. This study added further understanding of DCD, however, due to the heterogenous nature of this condition, studies on subtypes are not conclusive and methods need refinement (*Vaivre-Douret et al, 2011; Visser, 2008*).

2.10.4 Comorbid Conditions of ADHD and DCD

Studies have proved that a number of conditions exist in comorbidity with ADHD. These include:

- Oppositional Defiant Disorder (ODD)
- Conduct Disorder (CD)
- Anxiety and Mood Disorder
- Tic Disorders, Tourette’s, Autism
- Cognitive and Language problems

- Impaired school performance
- Motor Development problems. This occurs in approximately 60% of cases, the most common of all the comorbid conditions.

(Barkley, 2015; Nigg, 2006; Kaiser et al., 2015)

Studies also highlight a number of conditions which co-exist with DCD; as listed below:

- Language impairment
- Specific Learning Disability (SLD)
- Autism Spectrum Disorder (ASD)
- Reading Disorder (RD)
- Developmental Dyslexia
- ADHD. This occurs in 50 to 60% of cases, the most common of all the comorbid conditions.

(Nelson et al, 2015; Visser, 2003; Zwicker et al, 2012; Ghanizadeh, 2010).

As can be seen from the above, ADHD and DCD are two of the most common childhood disorders, commonly occurring in comorbidity; in approximately 50 to 60% of cases *(Visser, 2003; Nigg, 2006; Pearsall-Jones et al, 2008).*

Comorbidity suggests that symptoms of ADHD and DCD described above are “shared” and can thus be summarised as listed hereunder.

- Inattention
- Hyperactive-Impulsive Symptoms
- Memory Deficits
- Psycho-emotional Disturbances
- Language Impairment
- Sensorimotor Deficits
- Balance Deficits
- Motor Planning Abnormalities
- Difficulty with certain ADL
- Academic Difficulties
- Sports and Leisure Deficits

The following studies provide evidence of shared symptoms of DCD and ADHD: Parents of 122 children with ADHD were interviewed with questions from the DCD-Questionnaire (DCD-Q).

Problems of handwriting and fine motor skills were mainly reported. Gross motor and balance problems did not seem to feature as much (*Ghanizadeh, 2010*). Approximately half of all children with DCD suffer from symptoms of ADHD. A sample of 110 children were selected, 32 with DCD, 30 with comorbid DCD and ADHD and 48 controls. All children were between 12 to 13 years of age. Step count and activity energy expenditure were measured, using accelerometry. Conclusions drawn: amongst the males, step count was significantly lower than the controls, in the groups with DCD and comorbid DCD and ADHD. However, amongst the females; step count was lower than the controls in the DCD group only; with it being higher in the ADHD/DCD group. The explanation for this is that the hyperactivity of ADHD overrides the hypoactivity of DCD (*Baerg, Caorney, Hay, Rempel, Mahlberg, Faught, 2011*). From the above, it can be concluded that holistic management of the child with comorbid ADHD and DCD is needed; that being an intervention which address cognitive attention and sensorimotor deficits. These interventions have been discussed in the following section.

2.11 THE MANAGEMENT OF COMORBID ADHD AND DCD

The management of ADHD will first be outlined; followed by that of DCD. Thereafter management of comorbid ADHD and DCD will be discussed.

2.11.1 The Management of ADHD

This takes the form of pharmacological and non-pharmacological treatment, the latter including: (1) behaviour modification therapy; (2) cognitive behaviour therapy; (3) psycho-education, (4) neuro-feedback, (5) exercise and diet. Behaviour modification therapy is parent-directed and/or classroom-based. Cognitive behaviour therapy trains the patient to plan more systematically and have a more goal-directed approach to ADL. Psycho-education teaches the patient how to manage their condition. Neuro-feedback is a computer-based exercise which scores the level of attention during a given task. There is some evidence that physical activity and dietary control may be beneficial to patients with ADHD. There is a paucity of research on the effects of non-pharmacological treatment of ADHD, **more research is indicated in this area**; which is of significance to this study (*Bennett, Brown, Craver, Anderson; 1999; Wodka, Mark-Mahone, Blanker, 2007; Barkley, 2015*).

Pharmacological management entails administration of a number of neuropharmacological drugs. Non-stimulants, Atomoxetine such as Strattera are used but stimulant methylphenidate (MPH) such as Concerta, Ritalin and Adderall are more commonly used. These are described as dopamine and norepinephrine re-uptake inhibitors. This means that they block the dopamine and norepinephrine transporters thereby increasing the availability of dopamine and norepinephrine

within the synaptic space (Barkley, 2015; Mandal, 2015). Dopamine and norepinephrine are key neurotransmitters for prefrontal cortex functioning, which controls attention, behaviour, emotion, motivation and memory. By modulating neurotransmission, they reduce motor hyperactivity and distractibility and enhance well co-ordinated voluntary movement (Mandal, 2015). Dosage varies from 5mg up to 60mg. They are available as immediate release, sustained release and extended release. Short-term and long-term side effects are as follows: Short-term: Nervousness, insomnia, loss of appetite, weight loss, abdominal pain, headaches, nausea, dry mouth, euphoria, dizziness, increased sweating, tic-like movements. (Barkley, 2015). Long-term: Blood pressure changes, pulse rate changes, cardiac arrhythmias, future risk of substance abuse, cerebrovascular accident (stroke), heart attack, sudden death, psychiatric problems, suicidal thoughts (Barkley, 2015). Withdrawal symptoms include tiredness, crankiness, panic attacks, extreme hunger, depression and nightmares. Treatment is symptomatic and a cure for ADHD does not exist. (Bennett et al, 1999; Bart et al, 2015; Barkley, 2015).

2.11.2 The Management of DCD

Several approaches are utilised in the improvement of motor performance in DCD and intervention is most commonly administered by physiotherapists and occupational therapists. Wilson (2005) reviewed current trends in 2005 in intervention on DCD. A more recent publication of a good synopsis of all interventions was not procured.

Normative Functional Skills Approach: This approach is based on normal development and the cognitive theory. It is task-orientated and utilises age-relevant motor and functional skills. This approach is “**top-down**” starting with the child identifying the goal for action then planning the movement then carrying out the plan and finally evaluating the outcome of the action. This treatment, based on a blend of normal development and cognitive theory, is referred to as Cognitive Orientation to Daily Occupational Performance (CO-OP) (Wilson, 2005). Examples of goals are cutting, dressing, writing, shoelace tying, bike-riding. Generally, 12 sessions are given; one instructor/therapist to one child (Polatajko and Mandick, 2004; Nelson et al, 2015).

General Abilities Approach: This approach is based on sensorimotor functions providing a platform for future motor and intellectual development. Sensory integration therapy underlies this approach and attempts to deal with problems of integrating sensory information and motor planning deficits. (Deficit orientated). The approach is described as “**bottom-up**” and aims to activate faulty sensory systems. Sensory Integration Training seems to yield “poor treatment outcomes” and is thus currently infrequently used (Wilson, 2005). Examples of techniques used are: visual-motor integration (drawing a figure of eight); bilateral co-ordination (playdough with

two hands); cutting (circles, spirals); eye-hand co-ordination (ball activities); midline crossing (joining dots); gross motor (jumping into hoops on the floor) and fine motor (posting pennies) (Polatajko et al, 2004; Wilson, 2005).

Neurodevelopmental Therapy: This approach is based on neuromaturation and acquisition of motor milestones. Treatment is aimed at achieving age appropriate motor milestones; inhibiting primitive reflexes; normalising muscle tone; improving postural control, facilitating normal patterns of movement, improving sensory function and enhancing gross and fine motor co-ordination. It is mainly used for management of C.P. muscular dystrophy and other such conditions and is found to be slightly limiting; as an intervention with DCD. (Wilson, 2005; Nelson et al, 2015)

Dynamical Systems Approach: This approach focuses on the interaction between multiple systems, that is: perceptual and motor. Development is seen as the **child** (with multiple systems) interaction with the **task** and negotiating the constraints of the **environment**. Intervention is task-specific and focused on quality of movement. The process of task-specific training: (a) The child selects an appropriate task, (b) the therapist attends to certain elements (for example: throwing – preparation, backswing, propulsion, follow-through, timing, force, etc.) and (c) visual and verbal prompts are given. **Repetition** is a key element of this approach. Examples of tasks: Throwing and catching; reach and grasp, walking, jumping, hopping. One disadvantage is that generalisation of skills does not seem to occur (Wilson, 2005; Polatajko et al, 2004; Nelson et al, 2015; Smits-Engelsman, Blank, van der Kaay, Wilson, 2013).

Cognitive Neuroscience Approach: This approach is based on an understanding that motor skills develop as a result of brain-behaviour interactions. It is described as “**top-down**”; is task and process-orientated and focuses on motor imagery and motor timing deficits. Tasks are normally functional. Treatment is based on CO-OP. (See (i) Normative Functional Skills Approach). The process of Cognitive Neuroscience Training: (a) Children observe six motor skills, (b) they are then asked to “replay” the skill in their mind, followed by imagining themselves performing the skill, (c) the motor skill is then physically rehearsed together with a mental rehearsal, (d) the child is encouraged to “see” and “feel” the movement. This approach seems to facilitate feed-forward, prediction or outcomes and ability to plan. The skill is repeated until mastered (Wilson, 2005; Missiuna et al, 2006; Smits-Engelsman et al, 2013). Examples of motor skills/tasks: running, throw-catch, hopping, jumping, bike-riding, writing, eating using cutlery. The advantage of this approach is that motor skills are maintained for longer than other approaches. There is limited research on whether motor skills acquired are generalised to other contexts (Wilson, 2005).

Kinesthetic Approach: This approach is based on sensory or information processing. It uses vestibular stimulation and kinesthesia, such as rolling, skipping and jumping. It is task-specific. This approach also uses fine motor and eye-control. Examples of some exercises: copying movement of a finger or upper limb without the child looking at their own upper limb/hands, standing on tip-toes with the eyes closed, alternate biceps curls with the eyes closed, line-walking, balance on one leg, throwing and catching, fastening clothes-pegs to paper. There is insufficient literary support for use of this approach in clinical practice currently (*Peens et al, 2007; Wilson, 2005*).

Water-based Programme: This approach uses the principles of total body co-ordination and the factor that water slows down movement thereby producing continuous movement. Water-based exercise enhances proprioception and reduces anxiety; due to fun/playful nature of programmes (*Joubert, 2004*). Exercises included are aimed at improving co-ordination, balance, strength, agility, visual-motor skills and swimming skills and style. The result of a study submitted for a Master's Degree at University of Port Elizabeth was that water-based activities had a significant positive effect on motor proficiency of the experimental/intervention group (*Joubert, 2004*).

Treatment Administered for DCD in other Publications: *Maharaj and Lallie (2016)* administered a gross motor skills programme, comprised of widely varied exercises working on core stability, muscle strength, balance and gross motor co-ordination. This was administered for 8 sessions; to a group of 6 to 12 year old children diagnosed with DCD. The intervention yielded a 6.46% improvement in MABC scores. However, MABC scores were repeated immediately after the intervention; the 6 month re-test period having **not** elapsed. *Peens et al (2008)*, completed a study on 7 to 9 year old children with DCD, whereby the children were divided into 4 intervention groups: (1) motor; (2) self-concept; (3) psychomotor; and (4) control group. Group (1) and (3) received the following motor programme: kinaesthetic training, sensory-integration therapy, vestibular stimulation (rolling/skipping/hopping/jumping), fine motor activities, eye control and ball skills. The two groups receiving the motor intervention showed the most significant improvement; at first and second post-intervention testing. A physiotherapy-led gross motor skills programme was administered to 7 to 10 year old children with DCD, for 10 weeks. This consisted of throwing at targets, catching, gross motor skills, balance and muscle toning exercises (weight-bearing). The effect of this intervention was a significant improvement in participation intensity and motor performance (*Morton, 2015*). Considering various approaches described above and noting advantages and disadvantages of each, it can be concluded that there is insufficient evidence in the literature to suggest the gold standard intervention for the management of DCD. This is possibly due to the heterogeneous nature of DCD. The synopsis of

the available literature described above seems to suggest that multilevel-approach, task-specific, functionally based motor interventions yield the best results (*Wilson, 2005*).

2.11.3 The Management of Comorbid ADHD and DCD

ADHD and DCD exist in comorbidity in approximately 50 to 60% of cases with shared etiology and symptoms (*Visser, 2003; Nigg, 2006; Pearsall-Jones et al, 2008*). It follows thus that interventions designed/administered should address symptoms of **both** conditions. *Fliers et al (2010)*, conducted a survey on motor problems in 235 children with ADHD. Only half the children affected by motor problems attended physiotherapy. It was concluded that there was a general under-treatment of motor problems in co-morbid ADHD and DCD, a significant deduction pertaining to this study. Numerous studies have tested the efficacy of MPH and other neuropharmacological drugs, on motor co-ordination problems experienced in ADHD:

Studies testing the effects of neuropharmacological medication on comorbid ADHD/DCD

Bart et al (2015) tested the effect of Methylphenidate (MPH) on motor performance in children with co-morbid DCD and ADHD. Parents of 18 children of average age 8.3 years were interviewed to clinically diagnose ADHD. The MABC was administered to them to diagnose DCD. On separate days, MABC was administered whilst the children were under the influence of MPH and then whilst not on medication. Significant improvement in all motor sub-tests was noted, except static balance test. The conclusion drawn was that MPH improves motor proficiency by 33% (*Bart et al, 2015*). The sample size in this study was small and statistical significance is thus questionable. *Flapper et al (2006)* tested the effects of MPH on fine motor skills in children with comorbid ADHD/DCD. They found that the medication improves speed and accuracy of fine motor skills and ameliorates inattention (*Flapper et al, 2006*). The effect of neurostimulant drugs on motor performance in children with comorbid ADHD and DCD, remains unclear. Forty-nine children, all medically naive; average age 8,4 years were selected for a study. The MABC and Visual Motor Integration (VMI) tests were administered at diagnosis and after three months of daily MPH. Motor skills, after MPH, improved significantly but in only 55.1% of the cases. The author concluded that there is still a need for these children to attend rehabilitation; hence the need for this study. (*Brossard-Racine et al, 2012*). An extensive search of the literature **did not reveal any specific exercise/rehabilitation intervention to treat the symptoms of comorbid ADHD and DCD**, hence the significance of this study.

Studies testing the effects of physical activity on comorbid ADHD/DCD: Watemberg et al (2007) completed a study on the prevalence of DCD in children with ADHD and the effect of physical therapy on the comorbid condition. A total of 55.2% of children with ADHD tested positive for

DCD and this percentage was comprised mainly of the inattentive and combined type of ADHD. The children who tested positive for both conditions were randomly assigned to an intervention group and a non-intervention or control group. The intervention group received perceptual motor training, sensory integration therapy, kinaesthetic training and neurodevelopmental therapy for four weeks, during a summer vacation. The results showed enormous improvement in motor performance in the intervention group (*Watemberg et al, 2007*). However, the attention/cognitive scores were **not** tested thus improvement in these (possibly due to the exercises) could not be established. This study also did not provide the specific exercise intervention utilised. Few studies have tested effects of exercises on ADHD. In a study completed by *Ziereis and Jansen (2015)* the effects of physical activity (PA) on executive function (EF) and motor performance, in children with ADHD, were tested. A working memory test and the Movement Assessment Battery for Children (MABC) were used to obtain pre-intervention scores, on 43 children, aged 7 to 12, with ADHD and motor ability deficits. The children were divided into three groups: namely, (1) specific exercise intervention (fine motor)/balance and ball, components of the MABC), (2) specific sport and (3) control group. After 12 weeks of PA; the working memory test and the MABC were repeated to obtain post-intervention scores. Significant improvement in the two outcome measures were recorded in both experimental groups and slight improvement in the control group. The conclusion made was that PA has a positive effect on EF in children with ADHD and can thus be used as an alternative or complementary non-pharmacological treatment of ADHD (*Ziereis et al, 2015*). The sample size in the above study was perhaps a bit small and the outcome measures were repeated too soon. This may have negatively impacted on the statistical accuracy. *Ratey (2016)* considered an exercise programme as an alternative intervention, his rationale being that exercises regulate the brain's dopamine, norepinephrine and serotonin levels. These chemical substances enhance focus and attention, improve co-ordination, memory and movement. Endorphins released during exercises enhance the mood and reduce stress. *Vysniauske et al (2016)* completed a meta-analysis on the effects of physical exercise on functional outcomes in the treatment of ADHD. The authors discuss that up to 30% of children do not respond positively to neuropharmacological drugs and are frequently unable to tolerate the side-effects. They conclude that exercise has a significant effect on both motor skills and EFs in children with ADHD. They state: "If the effects of exercise for ADHD are better substantiated in the future, we might be looking at a powerful complementary or alternative treatment" (*Vysniauske et al, 2017*). The limitation with this meta-analysis is that the exercise intervention administered, in each study reviewed, was **not** outlined fully, exercises were not described and the structure of the programme not discussed. Two systematic reviews which looked at the management of ADHD with exercises were located. Exercises were described very broadly as cycling, treadmill, various sports, yoga, ergometry horse-riding and board games. Only one

publication by *Banaschewski et al (2010)*, outlined an exercise programme: proprioception, postural control, resisted exercises and balance activities. The authors concluded that moderate to intense aerobic exercises and/or cardio and non-cardio exercise regimes; have a beneficial effect on academics, cognition EF's and other symptoms of ADHD (*Den Heijer et al, 2016; Ng et al, 2017*).

Studies testing the effects of a combination of medication and physical activity on comorbid

ADHD/DCD: The aim of a study completed by *Pienaar and du Toit (2017)*, in South Africa, was “to examine the efficacy of different ADHD treatment methods in the improvement of core symptoms of ADHD, as well as associated motor co-ordination difficulties”. Ninety five Grade 1 and two children in three schools, were identified by the teachers, for displaying disruptive behaviour. The children were assigned to one of five groups: (1) medication; (2) neuromotor programme; (3) “sharper brain” programme; (4) control with ADHD; (5) control without ADHD. The following four tests were administered to obtain pre- and post-intervention scores: (1) MABC, (2) Quick Neurological Screening Test 2 (QNST-2), (3) Developmental Test of Visual Motor Integration and (4) Disruptive Behaviour Scale. The children in the medication intervention group had already been placed on medication by medical practitioners. The neuromotor intervention group received exercises having a vestibular and kinaesthetic input, balance exercises, fine motor, eye-hand co-ordination and visual skills exercises were also administered. Details of the precise exercise programme, number of repetitions etc., were not supplied (*Pienaar et al, 2017*). The “Sharper Brain” programme intervention group, received cognitive instructions from a computer-based programme that aims at producing a calming effect and improving focus, alertness and concentration. Interventions occurred over a nine-week period, frequency of administration of various interventions was **not** recorded. Results and conclusions: All interventions had a significant effect on improving symptoms of ADHD but the same was **not** seen with neuromotor symptoms. There seems to thus be no “gold standard” treatment for ADHD with motor difficulty. It was suggested that further research designs a more effective and specifically outlined motor treatment programme(*Pienaar and Du Toit,2017*), which this study has perhaps achieved.

Summary of significant factors with respect to the management of comorbid ADHD/DCD

- Motor problems are generally undertreated in comorbid ADHD and DCD (*Fliers et al; 2010*).
- Neuropharmacological drugs are effective in addressing motor problems of comorbid ADHD and DCD (*Bart et al, 2015; Brossard-Rucine, Shevell, Snider, Ageraniotti,*

Maynemer, 2012; Watemberg et al, 2007), although these drugs have significant side-effects (*Barkley, 2015*).

- Physical Activity is effective in enhancing cognitive and executive function of ADHD (*Ziereis et al, 2015*).
- Exercises regulate neurotransmitter substances which enhance focus/attention, improve memory and control movement and co-ordination (*Ratey, 2016*).
- Exercises could be a significant alternative or complementary intervention in ADHD (*Vysniauske et al, 2016*).

It follows from the above that optimum management of comorbid ADHD and DCD should be neuropharmacological drugs and a good exercise intervention. However, noting the significant side effects of neuropharmacological medication; if an exercise programme could be used as an alternative intervention; this would present as a significant contribution to what seems to be a commonly occurring comorbid condition. Hence; the importance of Phase two of this study; the design and consensus on an exercise intervention.

2.12 CONCEPTUAL FRAMEWORKS INVOLVED IN THE DESIGN OF AN EXERCISE INTERVENTION FOR COMORBID ADHD AND DCD

The literature reveals a general inadequate treatment of motor problems in ADHD (*Fliers et al, 2010*). Methylphenidate (MPH), commonly known as Ritalin/Concerta and other such neurostimulants; only produce a significant improvement in motor problems of comorbid ADHD and DCD; in 50 to 55% of cases. Rehabilitation exercises are thus necessary (*Brossard-Racine et al, 2012*). Two studies tested the effect of various interventions (motor in particular) on cognitive and motor symptoms of comorbid ADHD and DCD. Significant improvement was found in **both** motor and cognitive symptoms in one study and significant improvement in cognitive symptoms only in the second study (*Ziereis et al, 2015; Pienaar et al, 2017*). Specific exercise interventions were **not** given; type of exercises were briefly mentioned: fine motor, balance, eye-hand or ball skills, vestibular and kinaesthetic sense. Hence, the significance of this part of the literature review, in providing rationale for the choice of exercises included in the motor intervention, used in this study.

Five important conceptual frameworks were involved in the design of the exercise intervention. These are described below.

2.12.1 International Classification of Function, Disability and Health (ICF)

ICF is an international classification of health and disability across different cultures and settings. This was officially endorsed by the World Health Organisation (WHO) in 2001, as the international standard to describe and measure health and disability. This provides a standardised assessment of function and environmental influences on any given condition, in a number of settings. In 2007, a Child and Youth version of the ICF was designed; this is called the ICF-CY (Mahdi et al, 2018). ICF provides detailed classification on components of body function (physiological), body structures (anatomical), activities (task execution), participation (life situations) and environmental factors (physical and social). These symptoms and their implications are well illustrated by the International Classification of Function, Disability and Health (ICF) (Refer to Figure 2.2).

BODY STRUCTURES	BODY FUNCTIONS	ACTIVITY LIMITATION
Reduced in total brain volume Reduced in cortical thickness Structural changes to frontal cortex/cerebellum, basal ganglia, parietal lobe. Microdamage. Maturational	Reduced Dopamine, Norepinephrine, Endorphins, Serotonin. Control of motor, memory, attention, planning, inhibition, alertness.	Reduced academic advancement Impaired learning Unable to sit upright Unable to concentrate/focus Impaired speech Impaired reading Impaired writing quality and speed Impaired cutting
PERSONAL FACTORS	COMORBID ADHD & DCD	Unable to dress independently (slow, disorganised, cannot manage buttons/zips) Difficulty with eating (poor use of cutlery, messy, leaning on table) Difficulty with grooming and hygiene Clumsiness Lethargy/fatigue Reduced speed and endurance Reduced eye-hand/eye-foot co-ordination Reduced balance Reduced gross motor skills
Genetic Cognitive Emotional Physical Gender Age (Facilitate or constrain)	Inattention/Impulsivity/Hyperactivity Deficit in EFs Reduced MP and muscle tone Impaired gross and fine motor co-ordination Static and dynamic balance deficit Visual – motor problems Core stability and postural problems Bilateral and sensory integration problems Motor planning deficits and clumsiness	PARTICIPATION RESTRICTION ADL – Self-care/Home life Schooling : Writing/Reading : Task Organisation : Academics Sports Social & Leisure
	ENVIRONMENTAL (CONTEXTUAL) FACTORS	
	<u>Physical Environment</u> Different expectations at home and school. <u>Social Environment</u> Low socioeconomic = ↑ risk. <u>Implementation</u> Rehab (Neuroplasticity) MDT.	

Key: ADL: Activities of Daily living; MDT: Multidisciplinary Team; Activity Limitation: A dimension of health preventing performance of a usual activity. Participation Restriction: Problem experienced by an individual, which inhibits involvement in life situation. MP: Muscle Power, EF: Executive Functions

Figure 2.2 International Classification of Function, Disability and Health (ICF) of ADHD and DCD

2.12.2 Symptoms/Motor Difficulties in Comorbid ADHD and DCD

These were previously discussed under “clinical presentation of comorbid ADHD and DCD. Hereunder is a summary of the symptoms of these comorbid conditions:

- Inattention, Impulsivity and Hyperactivity.
- Deficits in executive functions: memory, language, planning and inhibition.
- Reduced muscle tone and muscle power.
- Impaired gross and fine motor co-ordination.
- Static and dynamic balance deficit.
- Visual motor problems (eye-hand, eye-foot).
- Postural anomalies and poor core stability.
- Bilateral and sensory integration problems.
- Motor planning deficits and clumsiness.
- Secondary manifestations include academic difficulties, sporting and leisure problems, difficulty with performance of ADL and reduced cardio-respiratory fitness
(Missiuna et al, 2009; Pearsall-Jones et al, 2010; Vaivre-Douret et al, 2011; Visser, 2003; Meyer et al, 2006; Barkley, 2015; Martinussen et al, 2005; Murphey et al, 2001)

These symptoms are well illustrated by ICF; above (Figure 2.2)

The exercise intervention designed in this study, for the management of comorbid ADHD and DCD, included one or more exercises, to cater for each symptom as shown below:

- Inattention, Impulsivity and Hyperactivity
Exercises needing focus/attention: balance exercises/ball skills finger-thumb opposition.
- Deficits in executive functions: memory, language, planning and inhibition
Exercises requiring planning/inhibition: balance/ball skills/starjumps/jump-hop sequences.
- Reduced muscle tone and muscle power:
Weight-bearing and strengthening: sit-ups/bridges/wheelbarrow.
- Impaired gross and fine motor co-ordination
Gross motor: crawling/toe-walking/jumping/starjumps.
Fine motor: Diadechokinesis/Opposition

- Static and dynamic balance deficit
Balance exercises: four-point kneel balance/half-kneeling balance/hopping.
- Visual motor problems (eye-hand; eye-foot)
Ball skills: mainly throwing, catching and kicking/jumping over an object.
- Postural anomalies and poor core stability
Sit-ups/bridges/four-point kneeling balance.
- Bilateral and sensory integration problems
Four-point kneeling balance/crawling/starjumps.
- Motor planning deficits and clumsiness
Crawling/ball skills/wheelbarrow/starjumps/jumping and hopping games.

2.12.3 Neuroanatomy and Neurophysiology

As previously discussed, neurological studies undertaken on children with ADHD and children with DCD (separately); revealed the same structural and functional details; in both conditions (Kasperek et al, 2015; Curatolo et al, 2010). This shows the neuroanatomical link between the two conditions and provides evidence that the two conditions should be treated simultaneously. Researchers over the years have noted that concentration levels of neurotransmitter substances, in the blood and brain metabolites, are reduced in both ADHD and DCD (Mandal, 2015). These substances are chiefly dopamine, norepinephrine, serotonin and endorphins (Melloni et al, 1993). Exercise regulates the concentration levels of these four substances in the brain and these chemical substances are responsible for enhancing focus, attention, memory, movement and co-ordination (Ratey, 2016). The above explanation provides the rationale for the use of an exercise intervention in the management of comorbid ADHD and DCD.

2.12.4 Effects of Physical Exercise in relation to Comorbid ADHD and DCD

The effects of physical exercises can be divided into the more familiar and the less familiar effects: The more well-known effects include improvement in overall fitness, reduction of obesity, cardiovascular enhancement, prevention of bony demineralisation improving muscle strength and co-ordination and a general feeling of well-being (Den Heijer et al, 2016). The less-familiar effects of exercises are on psychological and cognitive functions. Improvement in executive functions (EF) were most noticeable after exercises needing cognitive engagement, focus, attention and motor planning (Best, 2010). As previously discussed it is thought that concentration

of neurotransmitter substances (dopamine, norepinephrine, serotonin and endorphins) is regulated by physical exercises. These chemical neurotransmitters enhance focus, attention, memory, movement and co-ordination (*Ratey, 2016*). Cognitive enhancement may also be related to increased blood flow to the entire brain, in particular to the prefrontal cortex; which largely controls executive functions (memory, language, inhibition, planning) (*Den Heijer et al, 2016*). Short-term exercises enhance cognitive function immediately whereas long-term exercises improve cognitive function more permanently through “morphological brain changes and improved cardio-respiratory functioning” (*Best, 2010*). Long-term exercises were also found to promote cerebellar development and hence, improvement in co-ordination and balance (*Best, 2010*). It was the beneficial effects of physical exercises on the cognitive/psychological functions (amongst other factors), discussed above, that underpinned the design of the exercise intervention, used in this study as an intervention for the management of comorbid ADHD and DCD. In particular, exercises which require focus, attention and motor planning were included, as these **significantly** enhance cognitive/psychological functions (*Best, 2010*). Examples of such exercises: four-point kneeling balance, half-kneeling activities, ball skills, starjumps, fine motor opposition and diadochokinesis (DDK).

2.12.5 Motor interventions administered (in other publications) to address cognitive and motor difficulties of ADHD and DCD

In a systematic review on the effects of physical exercise on cognition and behaviour in children and adults with ADHD, *Den Heijer et al (2015)* collated information on type of exercises, frequency, duration, short-term and long-term effect on symptoms (*Den Heijer et al, 2015*). This information was well presented in a complex tabular format. The researcher has simplified and reconstructed these tables, to determine type of exercises that yield the **best** outcomes on cognitive symptoms of ADHD, in order to include these exercises in the intervention used in this study, to address symptoms of comorbid ADHD and DCD. In addition to the above; a summary of exercise interventions administered to children with DCD and the effect of the exercises on the symptoms; is also supplied in Table 2.2.

The exercises outlined in publications reviewed, illustrated in Table 2.2, were included in the exercise intervention designed for use in this study, as an intervention for the management of symptoms of comorbid ADHD and DCD.

Table 2.2 Summary of the Publications reviewed in the development of the prototype of the intervention

Author	Country	Year	Exercises	Duration & Frequency of Exercises	Age (in years)	Outcomes E = Excellent M = Moderate P =Poor
Smith et al	USA	2013	Hopping Running (Vigorous)	30 mins. Daily Daily 8 weeks	5-9	E Motor and Inhibition improved
Ziereis & Jansen	Germany	2015	Ball skills Manual dexterity Balance (Moderately vigorous)	60 mins. 1 per week 12 weeks	7-12	E Motor and Executive Functions improved
Mckune et al	Australia	2003	Running Jumping (Vigorous)	60 mins. 5 days/week 5 week	5-13	E Both Attention and Motor improved
Kang et al	Korea	2011	Running Rope-jumping Goal-directed throwing	90 mins. x 2/week 6 weeks	7-9	M Only motor improved
Verret et al	Canada	2012	Aerobic muscular + motor skills	45 mins. x 3/week Duration unspecified	7-12	E ADHD symptoms improved
Pienaar et al	South Africa	2017	Vestibular and kinaesthetic input Balance exercises Eye-hand co-ordination Fine motor activities Visual skills	9 Weeks 37 minute sessions ? Number of sessions per week not recorded	7-12	Significant improvement in visual-motor integration
Kolesky	South Africa	2017	Cardiovascular training Strengthening Balance Bilateral Co-ordination Throw and catch Visual motor	30 mins. x 3/week 8 weeks	4-14	Significant improvement in BOT-2 scores. Percentages were not specified.
Maharaj & Lallie	South Africa	2016	Trampoline Strengthening (Push-ups/sit-ups) Ball skills Throwing & catching Balance (wobble boards) Jumping in/out Bilateral co-ordination (Starjumps) Large ball activities	30 mins. x 1/week 8 weeks	6-12	6,46% improvement in MABC scores
Peens et al	South Africa	2008	Vestibular and kinaesthesia (rolls/jumps/toe-walking/skipping/hopping balance on 1 leg) Ball skills Fine Motor activities Eye control exercises + Psycho-Motor Intervention + Self-Concept enhancing	30 mins. x 2/week 8 weeks	7-9	31% (*) improvement in MABC scores * seems unusually high
Morton	Dublin	2015	Balance (superman) Ball skills, throw-catch Gross Motor (line-walk/hopping) Ball rolling up the wall Strengthening (Wheelbarrows/crabwalk)	1 hour x 1/week 10 weeks	7-10	5 to 7% improvement in MABC

Note: Only studies investigating participants of appropriate age group (age 8 to 9 and 11 months) and using free, active exercises with use of simple, minimal equipment were reviewed.

2.13 HOW THE EXERCISE INTERVENTION IN THIS STUDY DIFFERS TO THAT USED IN SIMILAR STUDIES

In a review of 72 publications, where efficacy of interventions to improve motor performance in children with DCD were tested; it was found that task-orientated interventions and motor-trained therapies yielded strong treatment effects (*Smits-Engelsman et al, 2012*). This is why the intervention used in this study, comprised mainly of motor-trained exercises and a few task-orientated exercises. Other strengths of the intervention used in this study, are as discussed hereunder:

Content and Design: The initial draft of the exercise programme was designed; with careful consideration for the five conceptual frameworks, previously discussed: ICF, Neuroanatomy and Neurophysiology, Symptoms/Motor and other difficulties in comorbid ADHD and DCD, Effects of Exercises in relation to ADHD and DCD and Motor Interventions used (in other publications) to address cognitive and motor difficulties of ADHD and DCD. The programme was then put through a stringent three-phase modified Delphi validation process; whereby neuropaediatricians, educational psychologists, occupational therapists and physiotherapists, who comprised an expert panel, gave their opinions on the programme, which was subsequently accordingly altered. Of all the interventions reviewed, none were found that had been put through as stringent a validation process. An exercise (or a number of exercises) was included for each symptom of comorbid ADHD and DCD. Exercises which require focus, attention and motor planning were included in order to address symptoms of ADHD.

Duration of Programme: Refer to Table 2.2, where details of ten exercise interventions are supplied. The average duration of these ten interventions was 50 minutes, hence, the decision by the researcher to have one hour classes. Sixty minute classes yielded significant improvement in most cases (*Mckune et al, 2003*).

Frequency: The average frequency was calculated in the same manner as the duration, described above. Average frequency was twice per week. However, the researcher was unable to deliver 2 sessions a week, as the school principals expressed their concerns about the interruption to the school day, of the participants. Thus, one session a week was delivered. When a comparison was made between various studies, whether an intervention was administered once a week or five times per week, the outcomes were both described as “a significant improvement” (*Smith et al, 2013; Mckune et al, 2003*).

Duration of the course of management: The average duration of the course of exercise classes given was calculated in the same manner as the duration, described previously. The average was calculated at eight weeks; which is precisely the length of time for which the researcher administered the exercise interventions.

Group Therapy: Therapy/exercises in a group has many advantages: psycho-social, motivational, accountability, provision of a little competitive edge and group therapy has shown significant improvement on symptoms of DCD (*Wilson, 2014*). The exercise intervention was delivered to small groups of five to seven participants.

Repetition: The exercises in the motor intervention were repeated each week. This was due to the principle of neuroplasticity: a skill taught repetitively can become learnt and improved, such as a motor skill (*Nahum, Lee, Merzenich, 2013*).

To summarise how the exercise intervention used in this study differs from those used in other studies; the content was selected with strong consideration to conceptual frameworks. These exercises were put through a stringent consensus process, as was the structure of the programme. Duration and frequency were calculated by finding the average of previous similar studies, which had yielded significant improvement. The decision to use group therapy and repetition of exercises, was supported by the literature. This exercise intervention should thus prove to be effective in reducing symptoms of comorbid ADHD and DCD.

2.14 CONCLUSION

This literature review has presented an overview of all the facets of comorbid ADHD and DCD; namely: history, epidemiology, etiology, investigations, symptoms and management. Certain portions of this literature may need to be repeated in Chapters 4, 5 and 6; the manuscript chapters. The following Chapter 3 will now give a full outline of the methods used in this study.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodology that was utilised in this study. It provides a background and rationale for the selected study design and describes the research setting. The study population, recruitment and sampling method and sample sizes are described, including the selection criteria for participants in this study. The design of the intervention is discussed and data collection and analyses are described. To conclude, ethical considerations are highlighted.

3.2 RESEARCH DESIGN

This multi-method research study design was implemented in three-phases, and included: (1) A cross-sectional study generating prevalence estimates of the comorbidity of ADHD and DCD. (2) Use of a three-round modified Delphi technique; where the design and consensus of an exercise programme for the management of comorbid ADHD and DCD; was completed. (3) A quasi-experimental design; where the efficacy of an exercise intervention for the management of comorbid ADHD and DCD was tested. The study was designed in a manner which ensured that all ethical rules were strictly adhered to. Tests used that were widely known and proven to be both valid and reliable. Researcher bias was eliminated by double-blinding: the researcher was blinded to which participants were on medication and which were not. Also, a research assistant administered post-intervention tests. Transferability was achieved by the nature of the research design ensuring that results could be generalised to other settings for example, a different age group. Triangulation was achieved by three different people assessing the child, namely: parent, teacher and therapist

3.3 RESEARCH LOCATION

The study was located in KwaZulu-Natal (KZN), one of nine provinces in South Africa, as illustrated in Figure 3.1.



Figure 3.1 Nine Provinces of South Africa (*ResearchGate.net, 2018*)

KwaZulu-Natal has a high prevalence of poverty, unemployment, HIV/AIDS and TB. Clinics and state-run hospitals are heavily burdened by the large numbers of people who are critically ill. The first phase of the study occurred at mainstream², co-educational³ schools with remedial units⁴ and / or Learners with Special Education Needs Classes (LSEN) and at the researcher’s private physiotherapy practice, located in Waterfall, a suburb in KZN.

3.4 PHASE 1: PREVALENCE ESTIMATION OF THE COMORBIDITY OF ADHD AND DCD IN CHILDREN, AGED 8 TO 9 YEARS IN KWAZULU-NATAL, SOUTH AFRICA

3.4.1 Research Design

The first phase of this study established statistics on prevalence and demographics of children with comorbid ADHD and DCD. It looked at “statistical occurrence within a specialized subgroup, united by some commonality” (*Healy et al; 2011*). By virtue of this definition, the research design that best describes this phase of the study, is a Cohort Design. Cohort designs are classified as open (size of the study population is not constant) or closed (number of study participants remains constant). Hence, this phase having a closed Cohort research design which all participants joined an eight week intervention. Once the eight week programme had begun, new participants could not join, hence, the advantage of a closed Cohort design.

² A mainstream school is a school or academy, which is not a special school.

³ A co-educational school is a system of education where males and females are educated together.

⁴ Remedial education is intended for children with learning difficulties and / or special needs

Table 3.1 Phases of this multi-method research study

	Phase 1	Phase 2	Phase 3
Summarised Title of Phase	Prevalence and Demographics of Co-morbid ADHD and DCD	Development of the Exercise Intervention	Testing Efficacy of the Exercise Intervention.
Ethics	Permission/consent from all gatekeepers.	Permission/consent from all gatekeepers	Permission/consent from all gatekeepers.
Design	Closed Cohort Research Design	Delphi Technique	Quasi Experimental Study
Research Location	KZN, South Africa	Durban, South Africa	KZN, South Africa
Population of the study	Remedial units or LSEN classes at mainstream schools.	Clinicians in private practice/special needs schools and lecturers having knowledge in ADHD/DCD or both.	Remedial units or LSEN classes at mainstream schools.
Recruitment of Participants	Invitation to all children, complying with inclusion/exclusion criteria.	Consents to clinicians described above, complying with inclusion criteria.	All children found to have comorbid ADHD/DCD from Phase 1.
Selection Criteria	All children aged 8 to 9, in LSEN class/remedial unit, recently diagnosed with ADHD.	Experts with knowledge/experience of ADHD/ DCD. Willingness/time to participate.	As for Phase 1 but only children diagnosed with comorbid ADHD/DCD from Phase 1.
Sampling Techniques	Stratified random sampling	Purposive expert sampling	Blocked random sampling
Sample	Children aged 8 to 9 diagnosed with ADHD	Physiotherapists Occupational Therapists, Educational Psychologist, Neuropaediatricians	Children aged 8 to 9 diagnosed with comorbid ADHD /DCD
Sample Size	n=151	n=17	n=112
Data Collection	Conners' DCDQ MABC-1	3 Stage Delphi: 9-point Likert Polar questions	Copeland's DCDQ MABC-1
Data Analysis	Data captured into Excel spreadsheet, imported into SPSS version 25 and demographics calculated	70 to 100% A-Priori threshold	Wilcoxon Signed Rank Test to test improvement/ regression in each intervention group

KZN: KwaZulu-Natal, LSEN: Learners with Special Education Needs, DCDQ: DCD Questionnaire, MABC: Movement Assessment Battery for Children

3.4.2 Population of the Study

The target population for this phase included all the mainstream schools, in KZN, having remedial units or LSEN classes. The accessible population, however (all mainstream schools, with remedial units and LSEN classes in KZN), comprised 23 mainstream schools. The principals of all 23 schools were contacted to obtain permission to conduct the study at the various schools. Four of these 23 schools gave a positive response timeously and thus, formed the study population.

3.4.3 Recruitment of Participants

The educational psychologists and / or teacher heading the remedial units / LSEN classes who had consented to participate in the research, were given invitations to pass on to the parents of all children, meeting all the selection criteria. Upon receiving the consent from the parent and assent from the child, the child was included as a participant. An invitation for screening of children with diagnosed ADHD, clearly outlining all inclusion and exclusion criteria (discussed later). Once the consent and assent had been completed, the child was included as a participant.

3.4.4 Selection Criteria

The following selection criteria were used for the children in this phase of the study.

Inclusion Criteria

- Children aged eight to nine years, of any gender and of any ethnic group.
- Children who attended a remedial unit or were in an LSEN class, at a primary mainstream school, in KwaZulu-Natal, South Africa.
- Children who had been diagnosed with ADHD, by clinically accepted standardised evaluation, as stipulated by the *DSM-V (2013)*.
- Children who had been diagnosed recently (within 3 months) and had not yet initiated therapy, other than neuropharmacological medication.

The researcher's original intention was only to include treatment-naive (medication and therapy) children in the study, but found that this was not feasible, as most children were medicated, soon after diagnosis of ADHD was confirmed.

Exclusion Criteria

- Any child diagnosed with any other neurological, psychiatric, sensory integration, orthopaedic or genetic problem, was excluded from this study, for example: Muscular

Dystrophy, Down Syndrome, bipolar disorder, autism, spina bifida, personality disorder, mental retardation, auditory processing.

3.4.5 Sampling Technique

Stratified, random sampling was applied to recruit and select children for this phase of the study.

3.4.6 Sample Size

The sample size was calculated by doing a preliminary investigation with 15 schools (out of 23 schools identified) with remedial and/or LSEN classes, in KZN, SA. Results revealed an average of 15 children per school; aged eight to nine years, recently diagnosed with ADHD. Hence the researcher aimed at a preliminary sample size of $n = 225$ (15×15).

3.4.7 Data Collection Tools

The following instruments were utilised to confirm the diagnosis of ADHD and to diagnose DCD.

- (i) Modified Conners' Teacher Rating Scale
- (ii) DCD Questionnaire
- (iii) MABC-1

The scores derived from these instruments, were used to calculate the prevalence of comorbidity and to present a demographic profile of children with comorbid ADHD and DCD. These data collection instruments have been described in the previous Chapter, but important points will be highlighted, hereunder, for ease of reference:

(i) Modified Conners' Teacher Rating Scale

Description: This scale is a four-point Likert scale (0,1,2,3) used on individuals aged six to 18; to derive scores on inattention, impulsivity and hyperactivity.

Administration: Teachers were requested to rate children on 20 items; whilst the children were NOT on neuropharmacological medication.

Scoring: The four-point Likert scale is scored as follows: Not at all / 0 = 0 point awarded; Just a little / 1 = 0.5 point awarded; Pretty much / 2 = 1,0 point awarded; Very much / 3 = 1,0 point awarded. From the first 10 questions (inattention) a total out of ten was derived and a percentage calculated. For questions 11 to 15 (impulsivity) and questions 16 to 20 (hyperactivity), a total out of five each was derived, from which percentages are calculated. Percentages were interpreted

as follows: Scores between 60% to 70% = mild case of inattention/impulsivity/hyperactivity and scores 70% or greater = moderate to severe case of inattention / impulsivity / hyperactivity.

This test was used to confirm and score an ADHD diagnosis.

Validity and Reliability: De Paul et al, (1998) showed “adequate internal test- retest reliability and cross-informant agreement” of this instrument. This study concluded that this rating scale had adequate psychometric properties for the screening of ADHD (Conners’ et al, 1998; de Paul et al, 1998).

(ii) DCD Questionnaire

Description: This questionnaire consists of 15 items, associated with movement and co-ordination. Maximum of 5 points are awarded for each item. This test is used on children aged 5 to 15 and is a parent-rated questionnaire

Administration: Parents were asked to rate children on 15 items; whilst their child is **not** on medication.

Scoring: Scoring was as follows for purposes of this study: 8 years to 9 years 11 months: 15 to 55 points: DCD diagnosis suspected; 8 years to 9 years 11 months: 56 to 75 points: probably **not** a DCD diagnosis; (Refer to **Appendix F** for a sample of the DCDQ).

Validity and Reliability: This instrument has a “high internal consistency (alpha = 0.94) and an overall sensitivity of 85% and specificity of 71%” (Wilson; 2007).

(iii) Movement Assessment Battery for Children, Edition 1 (MABC-1)

Description: The primary aim of this test is identification of children having motor difficulties. It focuses on three main areas: manual dexterity, eye-hand co-ordination and balance. MABC-was developed in 1992 and MABC-2 in 2007. MABC-1 is comprised of four age bands: (1) age band one: age four to six years, (2) age band 2: age seven and eight years, (3) age band 3: age nine and ten years, (4) and age band 4: age 11 and 12 years. MABC-2 is comprised of three age bands : age band one: age three to six years, age bank two: seven to ten years and age band three: 11 to 16 years. The researcher thus decided to use the MABC-1 for this study; as it was felt that age bands of MABC-2 were too broad.

Administration: This test was administered by the primary researcher or research assistant, during school hours in the morning. Participants took the test while off neuropharmacological medication.

Scoring: Total scores derived from the eight subtests were interpreted as follows: Scores under 10.5= child does **not** have a DCD diagnosis. Scores from 10.5 to 14 = child has **borderline** DCD. Scores from 14.5 or greater = child has a **definite** DCD diagnosis (*Henderson et al, 2007*).

Validity and Reliability: Both MABC-1 and MABC-2 “have excellent test-retest reliability of 0.75 for all age-groups and fair to good construct and concurrent validity. The specificity seems to be good and the sensitivity fair to good.” (*Henderson et al, 2007*).

3.4.8 Data Collection Process

3.4.8.1 Pilot Study and Results

A pilot study was conducted on twenty children fulfilling the inclusion criteria following ethical approval and informed consent and assent. These children were not included in the main study. Of the 20 children assessed, 15 tested positive for co-morbid ADHD and DCD, a prevalence of 75%. Gender: 14 males and 6 females were assessed. All 6 females tested positive for co-morbidity, whilst 9 males tested positive. Average age of 15 participants testing positive for both conditions was 8.67 years. Ten out of 15 children who tested positive for co-morbidity, had the combined type of ADHD (inattention, impulsivity and hyperactivity) and the rest had the inattentive type of ADHD. The results of this pilot study yielded 100% validity, with no missing statistics. This indicated that the researcher could proceed with the main study.

3.4.8.2 Main Study Data Collection Process

Scores from the Modified Conners’ Teacher Rating Scale; the DCDQ and the MABC-1 were collected; to determine comorbidity of ADHD and DCD. If the participant was diagnosed with comorbidity; the gender, age in years and months and the population group demographics were tabulated.

3.4.9 Statistical Analysis

Demographic data of each child diagnosed with comorbid ADHD and DCD, was entered onto an Excel spreadsheet. This data was imported into a statistical package SPSS version 25, which calculated prevalence of comorbidity, mean age, gender ratios, population ratios and ratios on the subtype of ADHD. These demographics were presented in tabular form.

3.5 PHASE 2: DESIGN AND CONSENSUS OF AN EXERCISE PROGRAMME FOR THE MANAGEMENT OF COMORBID ADHD AND DCD

3.5.1 Research Design

The second phase of the study included the design and consensus on an exercise intervention by experts namely: physiotherapists, occupational therapists, educational psychologists and neuropaediatricians. The study design included use of a modification of the Delphi Technique, a “structured multistage group interaction” (*McMillan et al, 2016*). The initial prototype of an exercise intervention and a series of statements pertaining to the exercises, were sent to a group of ‘experts’ (listed above). Respondents rated statements on a 9-point Likert scale as well as a polar questionnaire (yes/no answers), in three stages. The exercise intervention continued through each stage until 70% to 100% consensus was reached on all aspects of the exercises included in the programme. This Delphi Technique is useful in developing guidelines with health professionals, hence the advantage of this technique for this phase of the study (*McMillan et al, 2016*).

3.5.2 Population of the Study

The target population included all clinicians in private practice or special needs schools and academics and researchers , having sound knowledge in ADHD, DCD or both.

3.5.3 Recruitment of Participants

In Round one fifteen experts in South Africa were located by using the Internet, Medpages and by word of mouth. These experts needed to comply with the selection criteria outlined below. Upon receiving consent from the expert, who had met the selection criteria, he/she was included on the panel of experts, for consensus of the exercise intervention. In Round two and subsequently Round three experts were recruited from special needs schools in and around the suburb of Durban, in South Africa. Experts needed to either be practising physiotherapists or an occupational therapists and comply with the selection criteria outlined below.

3.5.4 Selection Criteria

The panel of experts who validated the exercise intervention designed in Round one, needed to comply with the following expertise criteria:

- Knowledge and/or clinical experience with neuropaediatrics/ADHD/DCD.
- Willingness and sufficient time to participate.
- Effective communication means/skills
- Recent publications were an advantage

Experts participating in Round two and subsequently Round three needed to comply with the following criteria:

- A minimum of three years working in the field of paediatrics.
- Clinical experience in the treatment of ADHD, DCD, or both.
- Willingness and time to participate.
- Effective communication means/skills.

3.5.5 Sampling Technique

Purposive expert sampling was used.

3.5.6 Sample Size

Fifteen experts (clinicians and/or lecturers in the fields of physiotherapy, occupational therapy, educational psychology and neurodevelopmental paediatrics) in South Africa were initially located. Seven of these professionals responded and consented to being included on a panel of experts to provide consensus on the exercise intervention designed in this research. These professionals formed the panel of experts in the first round. A further 10 professionals constituted the expert panel in the second and third round of this modified Delphi technique, and they were clinicians at two special needs schools in and around Durban.

3.5.7 Data Collection

The initial prototype of an exercise intervention, together with an information package, was sent to all experts, who consented to participation. The experts needed to rate a series of fifteen statements pertaining to the exercise programme, on a 9-point Likert scale. In the second round questionnaire, each aspect of the intervention was described, appropriate literature to support that aspect was given and one or two polar questions (yes/no) were asked about each item. The second round questionnaire was delivered to Physiotherapists and Occupational Therapists at two special needs schools in Durban. A final document was drafted and e-mailed to the experts who had responded to the second phase. Consensus was obtained on all aspects of the exercise intervention, after the third round. Final draft of the exercise programme was produced. (Refer to Appendices under K for samples of all the drafts of the exercise intervention)

3.5.8 Statistical Analysis

Consensus was determined by a 70% to 100% *a-priori* threshold agreement given the small sample size. Statements where $\geq 70\%$ consensus was **not** reached, were addressed and appropriate changes were made to the exercise programme, to produce the second round questionnaire.

3.6 PHASE 3: TESTING THE EFFICACY OF AN EXERCISE INTERVENTION ON THE COMORBIDITY OF ADHD AND DCD

3.6.1 Research Design

The third experimental phase of the study entailed assigning children to one of four groups, according to treatment preference. As a result, a randomised controlled trial could not be used. It would have been unethical to request for parents of the children to alter a treatment programme that they had already been enrolled in, in order to randomly allocate them to an intervention group. The advantage of a *quasi-experimental design* is that it is used in cases where randomization is difficult or impossible, as is in the case of this study. The assignment of participants to one of four intervention groups was controlled, according to the treatment that child was already on or the treatment intervention that was selected and preferred by the parent of the child (Figure 3.2).

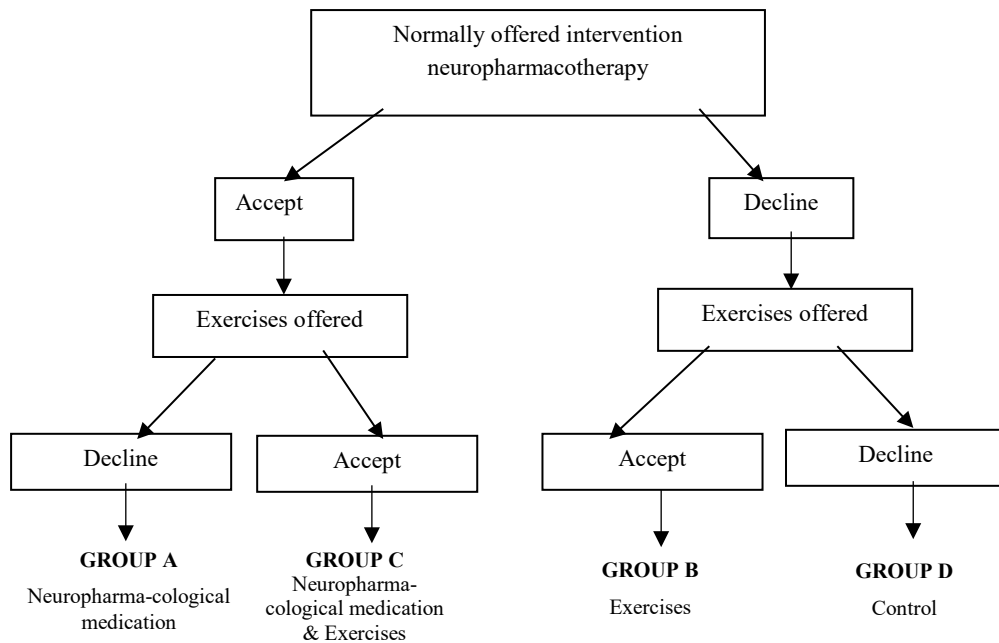


Figure 3.2 Controlled assignment of Participants to one of four intervention groups in phase three of the study

Group B (Exercises only) and Group C (Medication and Exercises) received an exercise intervention designed in phase 2 for 8 weeks once per week. A summary of this is provided below. These exercise classes were administered to small groups of five to seven children.

Table 3.2 Summarised Version of Exercise Intervention

Exercises	Repetition	Effect
<i>Abdominal crunches with knees bent. Hold 10 secs.</i>	5 reps	Core stability, posture.
<i>Bridges with knees bent. Hold 10 secs</i>	7 reps	Core stability, posture, influence of muscle tone.
<i>Four-point kneeling. Raise opposite UL/LL. Hold 10 secs</i>	x 3 R / L x 3 L / R	Core stability, balance, proprioception, bilateral integration, focus/attention, influence of muscle tone.
<i>Crawling forwards, backwards, and sideways</i>	4m in each direction	Core stability, bilateral integration, gross motor, proprioception, influence of muscle tone, motor planning.
<i>Ball throwing and catching (23cm ball) whilst in half-kneeling</i>	x 10 in the air x 10 with a bounce	Eye-hand co-ordination, motor planning, balance, posture, focus/attention.
<i>Half-kneeling balance Hold 10 seconds</i>	x 3 – R leg raised x 3 – L leg raised	Balance, gross motor, function, focus/attention.
<i>Wheelbarrow activity</i>	4m forwards 4m backwards	Weight on shoulder girdle to enhance fine motor, core strengthening. Influence of muscle tone.
<i>Toe-walking forwards and backwards</i>	4m forwards 4m backwards	Balance, gross motor, posture.
<i>Jumping or hopping over an object (hoop)</i>	6 hoops. Different combos x 3	Gross motor, eye-foot co-ordination, balance, motor planning, sensory integration.
<i>Star jumps</i>	x 10	Gross motor, eye-hand and eye-foot, motor planning, integration, endurance.
<i>Diadochokinesis: Quick door knob action, palm up and palm down</i>	10 x 2	Eye-hand co-ordination, Fine motor.
<i>Opposition: Quick opposition of thumb to each finger</i>	x 2 each hand x 1 both hands together	Eye-hand, fine motor, focus/attention.

3.6.2 Population of this Study

The population included children aged eight to nine years in a remedial unit; recently diagnosed with ADHD and testing positive for comorbid DCD. These children had either begun treatment on neuropharmacological medication or had alternatively declined intervention.

3.6.3 Recruitment of Participants

The participants recruited in phase one were tested for comorbid ADHD and DCD. If they tested positive for both conditions, they were recruited to be included in this third phase of this study.

3.6.4 Selection Criteria

The selection criteria used for the children in this part of the study were as follows:

- Children aged eight to nine years of any gender, of any ethnicity who were attending a remedial unit or LSEN class; at a primary mainstream school, in KwaZulu-Natal, South Africa.

- Children who had been diagnosed with ADHD by clinically accepted standardised evaluation; this diagnosis having been confirmed by the Modified Conners' Teacher Rating Scale. Additionally, a diagnosis of DCD having been made by the use of the DCDQ and MABC-1.
- Children who had been diagnosed with the above conditions within three months and were therapy naive, other than neuropharmacological medication.

3.6.5 Sampling Technique

Participants in Phase one, who tested positive for comorbid ADHD and DCD, were allocated into the four intervention groups as illustrated previously, according to the process described below: Parents of children who were diagnosed with co-morbid ADHD and DCD, were asked to choose the course of intervention that they would like, for their minor child: Those who opted for the standard/most commonly used intervention (medication), were asked by the researcher, if they would agree to an exercise programme for the child, in addition to medication (Group C). Those declining exercises, constituted the medication only group (Group A). Those parents opting out of neuropharmacological medication, were offered the exercise therapy. Those accepting, constituted the exercise only group (Group B). Those parents declining exercises plus medication, constituted the control group (Group D). Children assigned to different intervention groups as discussed above; is termed blocked random sampling.

3.6.6 Sample Size

The sample size for this phase was calculated as follows: Based on the article by *Flapper et al;* (2006); in which the median manual dexterity score for children/participants **not** on neurostimulant medication was 9.8 (range 5.0 to 15.0) compared to the children on medication with a score of 8.3 (range 0.0 to 12.0). Our hypothesis of significant change in this measurement of 1.0 points is based on this above-published article. With a power ($1 - \beta$) of 0.80 and testing at α of 0.05; the sample size required to detect a difference in median scores (9.8 versus 7.3) is 35 children/participants per group. A total sample size of 140 for phase three was thus the aim.

Group A	-	Neuropharmacological drugs
Group B	-	Exercise intervention
Group C	-	Both A and B
Group D	-	No intervention : Normal activity

3.6.7 Data Collection

Scores derived from the following three tools, were used as post-intervention scores in **phase 3**:

The Modified Copeland’s symptom checklist (discussed below)

DCD Questionnaire (discussed in phase 1)

MABC-1 (discussed in phase 1)

The Modified Copeland’s Symptom Checklist

This checklist was designed to assess whether patients have ADHD and to what degree. It also establishes the co-occurrence of other behavioural/learning disorders. *Du Paul et al (1998)* completed a study; from which conclusions were made that this checklist has adequate validity, specificity and reliability; proving its usefulness as a screening tool to confirm a diagnosis of ADHD (*du Paul et al, 1998*). Not at all – 0 point, Just a little – 1 point, Pretty much – 2 points, Very much – 3 points. A percentage is calculated for each category, in the following manner:

$\frac{\text{Total points scored}}{\text{Number of items x3}} \times 100 = \quad \%$ <p>(Maximum score)</p>

The checklist consists of a number of questions, in 8 categories. For this study, only the first three categories were used: Inattention, Impulsivity and Level of Activity (Hyperactivity). A comparison of the Conners’ rating scale and the Copeland’s Checklist, reveals that both rating scales “derive information on certain behavioural, social and academic issues in children and to confirm a diagnosis of ADHD” (*Conners, 1998*); *Copeland, 1987*). These tests can thus be used interchangeably, so the Conners’ was used to establish ADHD pre-intervention scores and the Copeland’s to establish post-intervention scores, in phase 3. This was to prevent teachers from simply replicating information given on the pre-intervention scale (Conners’) and the post-intervention scale (Copeland) (Refer to Appendix Eii for a sample of this test). Blinding was ensured by the parents completing the post-intervention DCDQ, without referring to the pre-intervention DCDQ. Double blinding was achieved by the research assistant administering the post-intervention MABC-1. The pre-intervention MABC-1 had been administered by the researcher.

3.6.8 Statistical Analysis

Demographic variables and evaluation baseline measures (T_0) along with measures at T_1 after 5 to 6 months break from initial scores; (as per requirement of the MABC) were entered into an MS Excel spreadsheet. Subsequently, the spreadsheet was imported into SPSS version 25 for analysis. Comparison of pre- and post-intervention ADHD scores and motor scores were done

using the Wilcoxon Signed Ranked test. Kruskal Wallis and Mann Whitney U tests were computed to identify significant group differences.

3.7 DATA MANAGEMENT

All raw printed data, motor skills tests, DCD questionnaires etc. was kept at the researcher's residence. Electronic raw data was stored on the researcher's PC and/or the statistician. Only the statistician and the researcher had access to the raw data, and the printed data. The raw data will be kept for the period of five years as stipulated by BREC, at which point it will then be shredded by the researcher.

3.8 ETHICAL CONSIDERATIONS

The following ethical considerations, were strictly adhered to (*Declaration of Helsinki, 1964*).

- *Beneficence*: The researcher ensured that participants benefitted from the screening and exercise intervention. Control group participants were given exercise classes on completion of the research.
- *Justice*: The researcher respected a participant's right to withdraw from the study, refuse to participate and/or miss an exercise class.
- *Confidentiality*: The participants were all assigned a number.
- *Honesty*: The researcher was honest in testing, analysing and interpreting results. The researcher considered all ethical, legal and regulatory norms and standards of the country, province and department in carrying out this research. This was done by applying to the appropriate authorities: BREC, KZN Education Department, school principals, heads of remedial units and any other gatekeepers.
- *Non-maleficence*: The exercise intervention was non-invasive, comprised of normal developmental gross motor skills, which did not place participants at any risk.

3.9 CONCLUSION

Having discussed the research design, methodology, sampling strategies, data collection and analysis utilised in testing the hypotheses and illustrating the purpose of the study; the following three chapters proceeds with the manuscripts detailing the outcomes of the three phases of this study. Due to this format, there may be a repetition of some aspects of the methodology, in each of the following chapters, which was unavoidable based on the nature of the submission.

CHAPTER 4
MANUSCRIPT 1

Prevalence Estimations of the Comorbidity of Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Co-ordination Disorder (DCD) in children aged 8 to 9 years in KwaZulu Natal, South Africa

Authors: PMT Dawson, T Nadasan & P Govender
Journal: South African Journal of Child Health
Status: In Review

An observational closed cohort study was undertaken; with 151 children, aged 8 to 9 years, attending a remedial school, in KZN, SA. The children were clinically diagnosed with ADHD. Conners' teacher rating scale was administered to confirm the ADHD diagnosis. The DCDQ and MABC-1 were administered to confirm a comorbid diagnosis of ADHD and DCD. Demographics of comorbidity were recorded.

PREVALENCE ESTIMATIONS OF THE COMORBIDITY OF ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) AND DEVELOPMENTAL CO-ORDINATION DISORDER (DCD) IN CHILDREN, AGED 8 TO 9 IN KWAZULU-NATAL, SA

ABSTRACT

Background: Children diagnosed with ADHD often encounter motor co-ordination difficulties. Little has been documented about the prevalence of the comorbidity of ADHD and DCD; both in South Africa and globally. **Objectives:** The purpose of this study was to establish the prevalence and demographics of comorbidity of ADHD and DCD at five sites located within three districts of KwaZulu-Natal, South Africa. **Methods:** A descriptive observational study was undertaken with one hundred and fifty one children aged 8 to 9 years, both males and females from all four population groups in KwaZulu-Natal, South Africa. The children were clinically diagnosed with ADHD and had received some remedial intervention. Children with any other conditions and/or receiving therapy were excluded. The Conners' teacher rating scale, the DCD Questionnaire and the Movement Assessment Battery for Children were administered to confirm the comorbidity of ADHD and DCD. Scoring followed the guidelines for each of the instruments. Data were captured onto MS Excel and analysed using SPSS v25 with frequency tables and percentages in addition to cross tabulations. **Results:** A 74% prevalence of comorbidity and a male to female ratio of 2:1 was established. The combined sub-type of ADHD was most commonly affected by comorbidity with DCD. **Conclusion:** From the relatively high prevalence figures; it appears that an association between ADHD and DCD exists. Children with ADHD should therefore be assessed for motor skills deficiency and offered appropriate interventions.

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a highly prevalent neurodevelopmental disorder with worldwide prevalence figures of seven to ten percent and characterised by three core symptoms, namely, inattention; impulsivity and hyperactivity. These symptoms are impaired in social, academic and occupational settings.^[1-2] Developmental Co-ordination Disorder (DCD) is a neurodevelopmental disorder characterised by delayed motor skills development. The onset is early and affects academic achievement, activities of daily living (ADL), sport and leisure. International prevalence figures of DCD range from five to 15%.^[1,3-5] In addition to the three core symptoms of ADHD, impairments in co-ordination, balance, motor planning and executive function have been identified in children diagnosed with ADHD.^[6-10] Symptoms of DCD include reduced muscle tone and muscle power, impaired gross and fine motor co-ordination, balance deficits, visual-motor problems, poor core stability, bilateral and sensory integration problems, postural anomalies and motor planning deficits.^[3-5] The condition of ADHD is associated with a

host of comorbid conditions, the most commonly occurring comorbidity being motor developmental problems, which occur in 60% of cases.^[6-9] A number of conditions co-exist with DCD, the most commonly occurring of these being ADHD, which occurs in 50 to 60% of cases.^[3,11-14] Based on the available literature, ADHD and DCD exist commonly in comorbidity.^[15] However prevalence in the context of South Africa has not been determined. This study attempted to establish prevalence figures and demographics of children aged eight to nine years with comorbidity of ADHD and DCD.

LITERATURE REVIEW

Children with ADHD often experience motor co-ordination deficits.^[1] Fliers et al^[16] conducted a study in the Netherlands on 486 children, aged 5 to 18 years, diagnosed with ADHD. Parents completed a DCD questionnaire (DCDQ) after which the Groningen Motor Observation Scale was administered to all participants. Results revealed a 33% prevalence of comorbidity of ADHD and DCD. This prevalence figure was similar in both genders and motor problems were most commonly identified in the inattentive type of ADHD.^[16] Waternberg et al^[15] completed a study in Israel where the Movement Assessment Battery for Children (MABC) was administered to 96 children with ADHD. Children were aged between 6 to 12 years. Test results revealed that 53 children had DCD, and a 55.2% prevalence of comorbid ADHD and DCD was found. Comorbidity was most prevalent in the inattentive type of ADHD followed closely by the combined type.^[15] Three South African (SA) studies^[8,17-18] were located; the first of which tested 528 children, aged six to nine years, diagnosed with ADHD in seven ethnic groups on three fine-motor tests. Prevalence figures were not recorded, there was no difference found in the prevalence between males and females and the sub-type of ADHD most affected was the combined type.^[8] The second study tested efficacy of treatment methods for ADHD with associated motor difficulties; but did not establish prevalence figures and demographics of the comorbidity of ADHD and DCD.^[17] The third and most recent SA study, tested 160 children (80 with ADHD and 80 controls) aged seven to 13 years, with several gross motor skills. Children with ADHD displayed poorer scores in all motor tasks than the control group^[18] Once more, demographics describing this comorbidity were not outlined. The paucity of information on prevalence figures and demographics of comorbid ADHD and DCD, worldwide and in SA, in particular, is evident. There is neuroanatomical evidence to suggest that ADHD and DCD occur in comorbidity, in that the following areas of the brain control **both** motor and executive/cognitive functions, namely, frontal region, cerebellum, basal ganglia and thalamus.^[3,6,19,20] Levels of neurotransmitter substances such as dopamine, norepinephrine and serotonin, are also considered to be reduced in **both** ADHD and DCD.^[3,6,19,20]

ADHD is presently diagnosed by general practitioners (GP), paediatricians and educational psychologists. Children are often managed with neuropharmacological drugs. Often these children are also not screened for motor or co-ordination deficits and hence the intervention for these deficits are not provided. Clearly, the association between the two conditions needs to be explored, in order to provide a more holistic approach to management of the children presenting with these conditions.

METHODS

Study Method: This study was a descriptive observational study to determine the prevalence of co-morbid ADHD and DCD. Demographics such as average age, gender, population group figures and sub-type of ADHD were recorded.

Population, Recruitment and Sampling Procedures: The participants were primary school children, aged 8 years to 9 years 11 months, from any population group; who attended a remedial class, in mainstream schools. All mainstream schools; with remedial units or Learners with Special Education Needs (LSEN) in KwaZulu-Natal, South Africa were invited to participate in the study (N=23). The school became a study site; once the principal had signed consent. The final sample consisted of children from four mainstream schools, and one private practice that had children feed in from mainstream schools with remedial classes. Children included in the study were recently clinically diagnosed with ADHD, within a maximum of three months of being recruited into the study. Children having started neuropharmacological medication were included, as it is unethical to discontinue this treatment. Children having any other neurological, psychiatric, orthopaedic, intellectual or genetic disorders were excluded from the study. Any child having started any form of therapy, was also excluded from the study. Parental consent and child assent was received one hundred and fifty one children from the five sites for participation in the study.

Data Collection Tools: The Modified Conners' Teacher Rating Scale^[21] was used to confirm the diagnosis of ADHD. This scale is used on children aged 6 to 18 years and consists of 20 items. Teachers were requested to rate children when not on any neuropharmacological medication. Each item is rated on a 4-point Likert scale and scored as follows:

- Not at all (0) [0 points awarded]
- Just a little (1) [0.5 point awarded]
- Pretty Much (2) [1 point awarded]
- Very Much (3) [1 point awarded]

The first 10 items relate to inattention. The next 5 items relate to impulsivity and the final 5 items relate to hyperactivity. Percentages are calculated for each core symptom, and are interpreted as follows: 60% to 70% [mild case of inattention/impulsivity or hyperactivity]. Greater than 70% [moderate to severe case of inattention/impulsivity/hyperactivity]. From these percentages; 3 sub-types are identified: Inattentive, Hyperactive-Impulsive or Combined (Inattention/Impulsivity/Hyperactivity).

The DCDQ is a parent-rated questionnaire, used to identify DCD in children aged 5 to 15 years. It consists of 15 motor/co-ordination items rated on a 5-point Likert scale and provides a measure of co-ordination in daily functional activities.^[22] The total was interpreted as follows, for children within the age band of 8 years to 9 years 11 months:

- 15-55 points [DCD]
- 56-75 points [Not DCD]

The Movement Assessment Battery for Children - version 1 (MABC-1)^[23] was used to derive a quantitative assessment of DCD. The MABC-1 was used as the researcher felt it to be more appropriate to age 8 to 9 years, with age-bands not being as wide as MABC-2^[23]. The test has eight items, which focus on three main areas, namely, manual dexterity, eye-hand co-ordination and balance. This test was administered by the researcher or a research assistant. Prior to testing, both researcher and research assistant tested the same children, independently, in order to ensure that scores were similar. These tests were administered on children who were not participants. This ensured inter-rater reliability. Total scores were interpreted as follows:

- Motor score under 10.5 [Not a DCD diagnosis]
- Motor score > 10.5 [DCD Diagnosis]

DCDQ and MABC-1 have concurrent validity and thus ability to diagnose DCD.^[22,23]

Procedure: Teachers and parents of the children recruited for this study were orientated and provided with guidance on how to complete the Conners' Teacher Rating Scale and the DCDQ respectively. The MABC-1 was administered by the first author, during school hours, in a classroom or therapy room that was conducive to testing of gross motor skills. None of the participants were on neuropharmacological drug therapy, at the time of testing. On the basis of a child having all three tests being positive; they were classified as having comorbid ADHD and DCD. Prior to commencement of the main study, a pilot study was conducted on 20 children. The testing procedure followed the same protocol as for the main study. The pilot was useful in that confirmed the clinical diagnosis of ADHD with use of the Conners' teacher rating scale. DCDQ scores were also confirmed by scores derived from the MABC-1.

Statistical Analysis: Demographic data were entered onto an Excel spreadsheet and this was imported into a Statistical Package for Social Sciences (SPSS) version 25. Average age was determined by using the mean and standard deviation. These statistics were represented in tabular form. A Shapiro-Wilk Test was used to test the data for normality. Frequency tables and percentages were used to determine prevalence of comorbidity, gender distribution, population group percentages (SA Asian, SA Black, SA Coloured, SA White) and ADHD sub-type (inattentive/hyperactive-impulsive/combined) figures of comorbidity. Cross-tabulations of gender and population group with sub-type of ADHD were also done.

Ethical Considerations: The Biomedical Research Ethics Committee of the University of KwaZulu-Natal, approved the study. (BFC397/16). The Department of Education in KwaZulu-Natal also approved the study. Consent was sought from the school principals and parents and assent was obtained from the participants.

RESULTS

A total of one hundred and fifty one children were tested. Of these, 112 (n=74%) participants tested positive for all three tests and were subsequently diagnosed with comorbid ADHD and DCD (Table 1). Of these 74 male children (n=66%) were diagnosed with comorbid ADHD and DCD and 38 female children (n=34%) were diagnosed with comorbidity with a male:female ratio of 2:1. Of the children presenting with co-morbidity, 4.5% were South African Asian children, 49% were South African Black children, 6.3% South African Coloured children and 40.2% South African White children. Table 1 refers.

Table 1 Prevalence figures and demographics (gender, population group and ADHD sub-type distribution) of comorbid ADHD and DCD

<i>Measure</i>	<i>Details</i>	<i>No. of comorbid cases (A)</i>	<i>Total Tested (B)</i>	<i>A/B=%</i>	<i>A/112=%</i>
Prevalence of comorbidity	- -	112	151	74,0	-
Gender	Males	74	103	71,0	66,0
	Females	38	48	79,0	34,0
		112	151		
Population Group	Asian	5	5	100,0	4,5
	Black†	55	74	74,0	49,0
	Coloured	7	9	78,0	6,3
	White	45	63	71,0	40,2
		112	151		
ADHD Subtype	Inattentive	47	-	-	42,0
	Hyper-Imp*	2	-	-	1,8
	Combined	63	-	-	56,2
		112			

*Hyperactive-Impulsive Type

†Black – Black African

Of the 112 participants diagnosed with comorbid ADHD and DCD, 42% children presented with the inattentive type of ADHD, 1.8% had the hyperactive/impulsive type and 56.2% had the combined type. Mean average age of children diagnosed with comorbidity was 8,8 years [range 7.8 years to 9.9 years] with a standard deviation of 0.6. The cross-tabulation revealed a greater percentage of males presenting with combined sub-type of ADHD (38.4%) followed by inattentive type (26.8%); as compared to females (Table 2). SA Black children presented more frequently with ADHD as opposed to the other population groups (49.1%). Of these, 24.1% presented with the inattentive sub-type of ADHD more frequently than the combined type (23.2%). South African White children presented more frequently with the combined type (25.9%) than the inattentive type (14.3%). Table 2 and 3 refers.

Table 2 *Cross tabulation of gender with sub-type of ADHD and comorbid DCD*

Gender	Type of ADHD			Total (N/%)
	Inattentive (N/ %)	Hyperactive-Impulsive (N/%)	Combined (N/%)	
Male	30 (26,8)	1 (0,9)	43 (38,4)	74 (66,1)
Female	17 (15,2)	1 (0,9)	20 (17,8)	38 (33,9)
Total	47 (42,0)	2 (1,8)	63 (56,2)	112 (100,0)

Table 3 *Cross tabulation of population group with subtype of ADHD and DCD*

Population Group	Type of ADHD			Total N (%)
	Inattentive N (%)	Hyperactive-Impulsive N (%)	Combined N (%)	
Asian	3 (2,7)	0 (0,0)	2 (1,8)	5 (4,5)
Black†	27 (24,1)	2 (1,8)	26 (23,2)	55 (49,1)
Coloured	1 (0,9)	0 (0,0)	6 (5,3)	7 (6,2)
White	16 (14,3)	0 (0,0)	29 (25,9)	45 (40,2)
Total (%)	47 (42,0)	2 (1,8)	63 (56,2)	112 (100,0)

†Black African

DISCUSSION

The purpose of this paper was to establish the prevalence of the comorbidity of ADHD and DCD as well as to present demographics of this comorbidity. As illustrated in the results, a 74% comorbidity was estimated. This figure is higher than the figures presented in the current available literature. For example, a prevalence of comorbidity of 55.2% was indicated in a study sample in Israel^[15] with a 50% prevalence in Australia^[24] and 33% in children in a study completed in the Netherlands.^[16] Possible reasons for the large scatter in statistics: include the variability in the sample size from 96^[15] to 151 (in this study) to 486 children.^[16] Additionally, these studies,^[15-16; 24] which are the only similar studies that have been located that provide **actual** prevalence percentages, were published between eight to ten years ago. What has changed over the time that

has elapsed, from when these studies were completed, is that modern technology has caused children to play less and be more indoors, engaging in more sedentary activities. This may have contributed to the higher prevalence rates in this study.

Prevalence figures of the 3 SA studies ^[8,17-18] found are not provided here; as these were not outlined within individual publications. Another reason for the higher prevalence established in this study would potentially be in the fact that three instruments were administered; in order to confirm the existence of the comorbidity; whereas other studies utilised: DCDQ and Groningen Motor Observation Scale; MABC alone, testing of Fine Motor Skills and testing of Gross Motor Skills. A combination of 3 or more tests did not appear to be utilised. This study revealed a greater number of males diagnosed with comorbid ADHD and DCD than females; in a ratio of two males to one female. The previous studies that established co-morbidity cited no gender differences in the prevalence figures.^[8,16] A number of literary sources supports the findings of this study, in which more males are affected by ADHD, DCD and by implication the two conditions, in comorbidity.^[1,3,6,21]

This study established that the highest percentage of children with comorbidity was 49% amongst the Black African children and the lowest percentage were amongst the SA Asian children, with just 4,5%. However, when looking at each population group separately, the SA Asian children had the highest percentage with five out of five children diagnosed with comorbid ADHD and DCD. This disparity in the statistics can be attributed to the fact of the small sample of SA Asian children recruited in this study. The same disparity for SA Coloured children who had participated in this study. Both the previous SA studies completed on the comorbidity of ADHD and DCD, did not provide population group prevalence figures.^[8,17]

This study established that, of the three sub-types of ADHD, the combined sub-type (inattention, impulsivity and hyperactivity) occurs most commonly with DCD, in comorbidity. This finding is not supported by the prior two studies, which established that the inattentive sub-type of ADHD most commonly displays symptoms of DCD.^[15,16] Meyer however, completed a study in South Africa and also found the combined subtype of ADHD to coexist most commonly with DCD.^[8]

The cross-tabulation that highlighted more males presenting with both inattentive and combined sub-types of ADHD; with comorbid DCD; is supported by the available literature; that a male to female ratio of comorbidity of 2:1 seems to exist.^[8] The cross-tabulation that revealed a larger proportion of Black Africans presenting with the inattentive sub-type and a larger proportion of

white Africans; with the combined sub-type; has not been previously indicated in available literature. A paucity of literature on comparative ethnic group figures thus remains.

A strength of this study was that the ADHD diagnosis was not only confirmed by a Conners' Teacher-rating scale but was also provided as a clinical diagnosis (either confirmed by a paediatrician, psychologist or psychiatrist). Similar studies in SA did not confirm an ADHD diagnosis that had been clinically made.^[8,17,18] A second strength was that DCD was diagnosed with both the DCD Questionnaire and MABC-1 which demonstrate concurrent validity.^[22,23] No similar studies found, assessed DCD using both of these instruments. Watemberg et al^[15] and Bart et al^[25] used the MABC alone, whilst Pearsall-Jones^[24] utilised a less well-known motor test, the McCarron Assessment and Neuromuscular Development (MAND) and Stray et al^[26] used the Motor Function Neurological Assessment (MFNU). A study in the Netherlands used both the DCDQ and the Groningen Motor Observation Scale; both qualitative measures.^[16] A third strength of this study was that all demographic information on children diagnosed with comorbid ADHD and DCD, was presented, namely: prevalence, gender distribution, mean age, population figures and sub-type of ADHD. Other similar studies either did not illustrate prevalence figures, did not establish population group statistics or did not discuss the most commonly affected subtype of ADHD.^[8,16,17,24, 25,26]

CONCLUSION

This study provided significant statistics and demographics on the comorbidity of ADHD and DCD, in three districts of KwaZulu-Natal, South Africa. Such statistics have previously not existed. These figures may assist clinicians in the planning and provision of services for these children. Given these findings, evaluation of children with ADHD should include assessment of motor skills and children with motor problems or DCD; should be screened for symptoms of ADHD. The association between ADHD and DCD; established in this study; suggests that assessment and intervention should focus on symptoms of inattention/impulsivity/hyperactive as well as motor co-ordination symptoms.

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CHAPTER 5
MANUSCRIPT 2

Design and Consensus of an Exercise Programme for the Management of Comorbid Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Co-ordination Disorder (DCD)

Authors: PMT Dawson, T Nadasan & P Govender
Journal: African Health Sciences
Status: In Review

A modified three-round Delphi technique assisted in gaining consensus on an exercise programme that could be utilised as an adjunct to the management of comorbid ADHD and DCD. Seventeen experts including physiotherapists, occupational therapists, educational psychologists and neurodevelopmental paediatricians, were involved in reaching consensus on content and structure of an exercise programme. After three rounds, consensus was reached, the result of which has produced a rigorous programme of exercises which could assist in management of comorbid ADHD and DCD.

DESIGN AND CONSENSUS OF AN EXERCISE PROGRAMME FOR THE MANAGEMENT OF COMORBID ATTENTION DEFICIT AND HYPERACTIVITY DISORDER (ADHD) AND DEVELOPMENTAL CO-ORDINATION DISORDER (DCD)

ABSTRACT

Background: Children diagnosed with ADHD frequently encounter motor co-ordination difficulties. Physical exercises have significant benefits, including physical, emotional and educational. These enhance concentration, self-regulation, cognitive skills, co-ordination and balance. Thus, exercises have the potential to minimise the symptoms of ADHD and DCD in comorbidity. **Objective:** To develop and gain consensus on a structured exercise programme for the management of comorbid ADHD and DCD, in children aged 8 to 9 years. **Method:** A modified three round Delphi process assisted in gaining consensus on an exercise programme, which was initially guided by available theory, literature and clinical experience of the first author. Seventeen experts, including physiotherapists, occupational therapists, educational psychologists and neuropaediatricians were included in the study. **Results:** Consensus on structure and content in the programme was achieved in three rounds. The programme comprises 12 exercises. Required equipment is listed, including repetitions of each exercise, and the effect of each exercise. **Conclusion:** The development and consensus on an exercise intervention to assist in the management of comorbid ADHD and DCD is presented. These exercises have the potential to improve core stability, strengthen muscles, improve balance, influence muscle tone, enhance gross and fine motor co-ordination, and improve proprioception and enhance focus and attention.

KEYWORDS

Physical exercises; Neurotransmitters; Attention Deficit and Hyperactivity Disorder (ADHD); Developmental Co-ordination Disorder (DCD); Medical experts

INTRODUCTION

Children diagnosed with attention deficit hyperactivity disorder (ADHD) display three core symptoms of inattention, impulsivity and hyperactivity.¹ Additionally, they display other symptoms such as deficiencies of executive functions, including memory, language, inhibition, planning, and motor co-ordination difficulties.^{2,3,4} Despite the fact that motor difficulties are experienced by 30 to 50% of children diagnosed with ADHD⁵ little attention is given to the comorbidity of ADHD and developmental co-ordination disorder (DCD) in clinical practice as compared to psychiatric comorbidities.⁵ Motor difficulties significantly impact activities of daily living (ADL) and should thus be addressed to ensure good quality of life and functional independence in children.⁵ Physical exercises have commonly known effects of improving overall

fitness, reduction of obesity, cardiovascular enhancement, prevention of demineralisation, improvement of muscle strength and co-ordination and enhancement of a general feeling of well-being.^{2,6} The less commonly known effects of physical exercises is that they regulate the levels of neurotransmitters and hormones, such as dopamine, serotonin, norepinephrine and endorphins^{2,4,7-9}. Regulation of these in turn, have the effect of enhancing focus, attention, memory, movement and co-ordination.^{2,4,7-9}

It thus follows that physical exercises may be used as an adjunct in the intervention of comorbid ADHD and DCD. Most studies that were accessed on physical exercises in comorbid ADHD and DCD included programmes that were not comprehensively outlined.^{2,10-11} Two studies tested efficacy of physical exercises on symptoms of children with ADHD and motor problems. In both cases only broad outlines of the exercise programmes were provided, for example, vestibular, kinaesthetic, balance, fine-motor and visual skill exercises.^{4,8} The duration of each session; number of sessions, frequency and group dynamics were not clearly illustrated.^{4,8} Whilst numerous studies on the effects of neuropharmacological drugs on ADHD and associated motor co-ordination difficulties exist; there is a paucity of literature on the effects of physical exercise on comorbid ADHD and DCD. This gap in the literature provided the impetus for this study which was to design and gain consensus on an exercise programme, with detail on content and structure. It is essential to elicit the opinion of clinical medical experts and incorporate this into the design of such an exercise programme; as the tacit knowledge of practitioners are considered valued in knowledge creation. Hence a hybrid Delphi process was suitable in obtaining expert input and consensus, and reducing author bias, in an area which is lacking in literary input and evidence.¹² The purpose of this paper is to report on the consensus from physiotherapists, occupational therapists, educational psychologists and neuropaediatricians on an exercise programme, that could potentially assist practitioners in a more holistic approach to the management of comorbid ADHD and DCD.

METHODS

This study followed an eight-step process using a three round hybrid Delphi technique in the development and consensus on an exercise intervention for comorbid ADHD and DCD.

Recruitment and Sampling of Experts for Round One

Participants were recruited from the clinical disciplines of paediatric neurology, educational psychology, occupational therapy and physiotherapy as these are clinicians involved in the management of both ADHD and DCD. A systematic method was used to identify the medical “experts” using the Internet, Medpages and word of mouth. Inclusion criteria for selection of these

experts included (i) knowledge and/or clinical experience with neuropaediatrics/ADHD/DCD, (ii) willingness and sufficient time to participate and (iii) effective communication skills. The Delphi process was preceded by the initial draft of the exercise programme being generated; with reference to the theory on physical exercises⁶, an extensive literature review, including systematic reviews and clinical trials^{2,4,8,10,11} and clinical experience of the first author. Table 1 illustrates the literature reviewed that contributed to the development of the initial programme and Table 2 depicts the first prototype of the exercise programme.

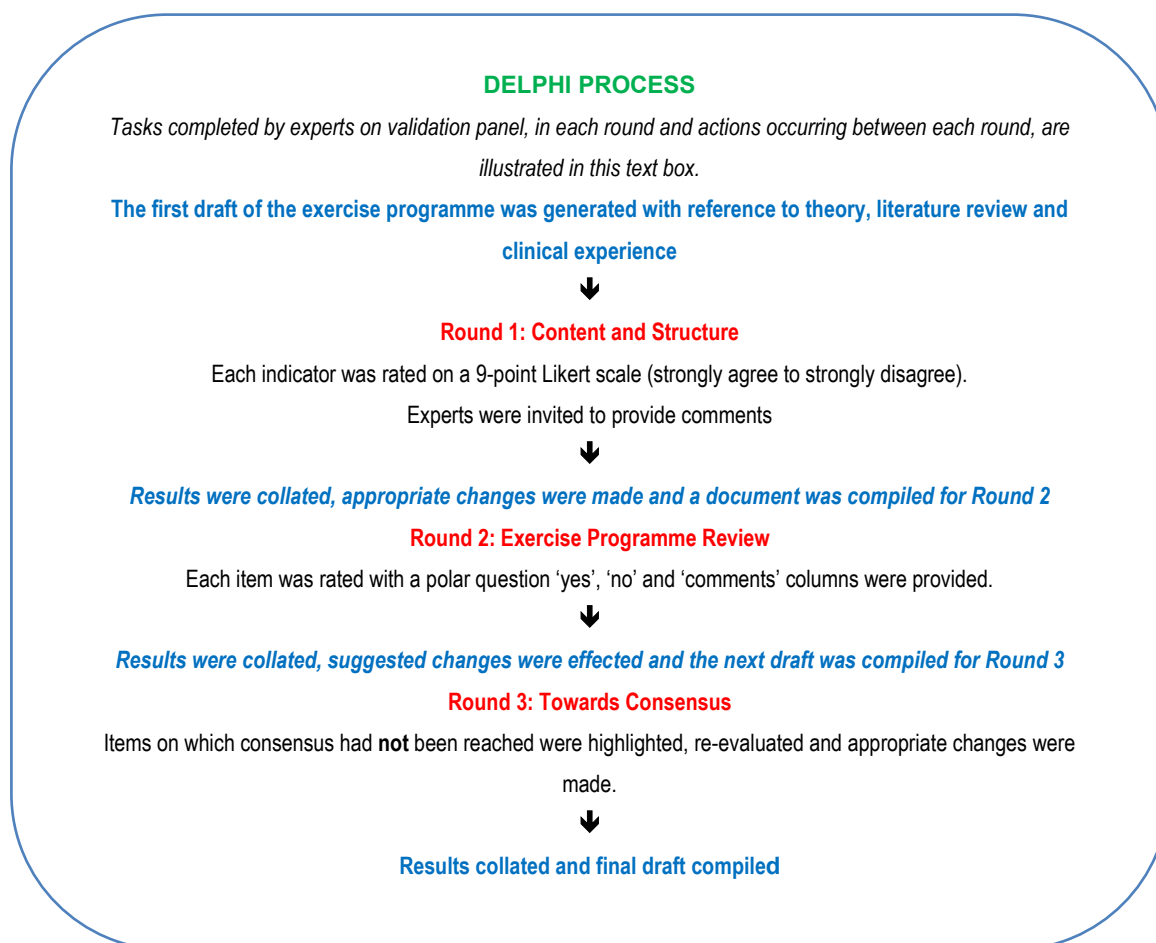


Figure 1 Outline of Delphi Process employed in this study

Table 1 Summary of Publications reviewed for initial draft of exercise intervention⁵

AUTHOR	COUNTRY	YEAR	EXERCISES	DURATION & FREQUENCY OF EXERCISES	AGE (in years)	OUTCOMES E = Excellent M = Moderate P =Poor
Smith et al ²²	USA	2013	Hopping Running (Vigorous)	30 mins. Daily Daily 8 weeks	5-9	E Motor and Inhibition improved
Ziereis & Jansen ¹⁸	Germany	2015	Ball skills Manual dexterity Balance (Moderately vigorous)	60 mins. 1 per week 12 weeks	7-12	E Motor and Executive Functions improved
Mckune et al ⁹	Australia	2003	Running Jumping (Vigorous)	60 mins. 5 days/week 5 week	5-13	E Both Attention and Motor improved
Kang et al ²³	Korea	2011	Running Rope-jumping Goal-directed throwing	90 mins. x 2/week 6 weeks	7-9	M Only motor improved
Verret et al ²⁴	Canada	2012	Aerobic muscular + motor skills	45 mins. x 3/week Duration unspecified	7-12	E ADHD symptoms improved
Pienaar et al ⁴	South Africa	2017	Vestibular and kinaesthetic input Balance exercises Eye-hand co-ordination Fine motor activities Visual skills	9 Weeks 37 minute sessions ? Number of sessions per week not recorded	7-12	Significant improvement in visual-motor integration
Kolesky ¹⁹	South Africa	2017	Cardiovascular training Strengthening Balance Bilateral Co-ordination Throw and catch Visual motor	30 mins. x 3/week 8 weeks	4-14	Significant improvement in BOT-2 scores. Percentages were not specified.
Maharaj & Lallie ¹⁴	South Africa	2016	Trampoline Strengthening (Push-ups/sit-ups) Ball skills Throwing & catching Balance (wobble boards) Jumping in/out Bilateral co-ordination (Star jumps) Large ball activities	30 mins. x 1/week 8 weeks	6-12	6,46% improvement in MABC scores
Peens et al ¹⁸	South Africa	2008	Vestibular and kinesthesia (rolls/jumps/toe- walking/skipping/hopping balance on 1 leg) Ball skills Fine Motor activities Eye control exercises + Psycho-Motor Intervention + Self-Concept enhancing	30 mins. x 2/week 8 weeks	7-9	31% (*) improvement in MABC scores * seems unusually high
Morton ²⁰	Dublin	2015	Balance (superman) Ball skills, throw-catch Gross Motor (line- walk/hopping)Ball Ball rolling up the wall Strengthening (Wheelbarrows/crabwalk)	1 hour x 1/week 10 weeks	7-10	5 to 7% improvement in MABC

⁵ **Note:** Only studies investigating participants of appropriate age group (age 8 to 9 and 11 months) and using free, active exercises with the use of simple, minimal equipment, were reviewed.

In **Round 1** of the Delphi process, n=15 “experts” who met the inclusion criteria were identified. An email was sent to each; outlining the nature of the study and their level of involvement required. Each expert was invited to participate and a consent form was attached. The initial prototype of the exercise programme (Table 2) together with an information package was emailed to the experts who had consented to participation. The experts were requested to rate a series of 15 statements/indicators pertaining to content and structure of the exercise programme, on a 9-point Likert scale with three descriptives.

All data was pooled and analysed with consensus determined by a $\geq 70\%$ *a-priori* threshold. Results of Round 1 were collated, appropriate changes were effected and these results assisted in the refinement of the exercise programme and questionnaire for Round 2.

In **Round 2**, a document was generated providing the name of the exercise, description of each exercise, equipment needed, number of repetitions of each exercise and effects of each exercise with an appropriate literary reference. The document consisted of twelve exercise items and an additional five items pertaining to structure of the exercise programme. One or two polar questions were asked on each item and “yes”, “no” and “comments” columns were provided.

Recruitment and Sampling of Experts for Round 2

Experts were recruited from special needs schools in and around the suburb of Durban, in South Africa. Arrangements were made to deliver the second prototype of the exercise programme to all special needs schools that provided occupational and physiotherapy. Inclusion criteria for selection of these experts included (i) a minimum of three years of experience working in the field of paediatrics, (ii) clinical experience in the treatment of ADHD or DCD or both, (iii) willingness and time to participate and (iv) effective communication skills. The responses were collected after a week, and the results of this round were collated and analysed. Consensus was determined by a $\geq 70\%$ *a-priori* threshold. Cronbach’s alpha was utilised as a measure of reliability of the result ($\alpha = 0,802$; close to 1,0 illustrating consistency and reliability of the responses of the “expert” panel).

In **Round 3** items on which consensus was not reached were amended. These were highlighted and forwarded to the experts, who were encouraged to re-evaluate and rate these items. The final draft of the exercise programme was compiled.

Table 2 First draft of Exercise Programme

EXERCISE	EQUIPMENT	DESCRIPTION	REPETITIONS	PROPOSED EFFECTS ¹⁰⁻¹⁴
<i>Abdominal Crunches/ Sit-ups</i>	Floor mat	The child lies supine, with knees bent. The child's arms are placed in the air at 45° shoulder flexion; directly in front of the child. Head and shoulders are raised and held for 10 seconds. For oblique muscle work, the child points the arms to one side. Repeat procedure above.	x 3 straight x3 oblique to right x 3 oblique to left	1. Core strengthening 2. Improvement of posture
<i>Bridges</i>	Floor mat	The child lies supine; with the knees bent. Buttocks are raised, and held for a count of 10 seconds	x 7	1. Core strengthening 2. Improvement of posture 3. Muscle tone normalised
<i>Superman</i>	Floor mat	The child assumes the crawl position. Right arm and left leg are raised and held level with the back for 10 seconds. This is repeated with the left arm and right leg.	x 3 right arm, left leg x 3 left arm, right leg	1. Core strengthening 2. Balance enhancement 3. Bilateral integration 4. Proprioception 5. Muscle tone normalised
<i>Crawling</i>	Carpeted floor	The child assumes the crawl position; with equal weight distributed between arms and legs. The child crawls forwards, backwards, sideways to the right and then to the left.	4m in each direction	1. Core strengthening 2. Bilateral integration 3. Gross motor skill 4. Proprioception 5. Muscle tone normalised 6. Motor planning
<i>Ball skill</i>	Floor mat 23cm plastic ball	Two children; half-kneel 2m apart. The ball is thrown between the children, first in the air, then with a bounce.	x 10 throws in the air x 10 throws with a bounce	1. Eye-hand co-ordination 2. Motor planning 3. Balance enhancement
<i>Half-kneeling balance</i>	Floor mat	The child assumes the two-point kneeling positions. Each lower limb is raised to 90° hip and knee flexion and the position is held for 10 seconds	x 3 with right leg raised x 3 with left leg raised	1. Balance enhancement 2. Gross motor skill 3. Functional activity
<i>Tandem walking</i>	Tiled floor or balance beam	The child walks heel to toe along a line, leaving no gaps between the heel and the toes. The child must try not to overbalance or place either foot on either side of the line.	4m in one direction then 4m in the opposite direction.	1. Balance enhancement 2. Gross motor skill
<i>Hopping</i>	Smooth floor with no clutter	The child is asked to hop a distance, turn and then hop back. If the child cannot manage, he must be first be supported and jumping on one leg is facilitated. Progress to hopping on the spot with support then hopping over a distance, also with support. Finally, independent hopping over a distance.	X1 minute of activity	1. Gross motor skill 2; Eye-foot co-ordination 3. Balance enhancement 4. Motor planning 5. Sensory integration
<i>DDK (Diadochokinesis)</i>	Desk and chair	The child is seated with good posture. The hands are turned quickly so palm faces upwards then downwards. This is done on the desk/on the thighs or on the opposite forearm.	x 10 2 rotations	1. Eye-hand co-ordination 2. Hand dexterity 3. Endurance 4. Fine motor skill
<i>Opposition</i>	Desk and chair	The child is instructed to oppose the tip of the thumb to the tip of each finger; from index finger (IF) to little finger (LF) then LF to IF, in quick succession.	x 3 right hand x 3 left hand x 3 both hands together	1. Eye-hand co-ordination 2. Hand dexterity 3. Fine motor skill

RESULTS

Participant Demographics

Fifteen experts in and around Durban were recruited in round one, including occupational therapists (n=4), physiotherapists (n=4), educational psychologists (n=4) and neuropaediatricians (n=3). Of these, acceptance and consent was received from seven participants, who responded within a given period of two weeks. Only two special needs schools in and around Durban, with occupational and physiotherapists consented to participation in round 2. A total of 10 experts responded on round two and three of the Delphi process.

In Round one, consensus was **not** reached on the following items:

- *Half-kneeling (57%)*: It was felt that half-kneeling is not a good balance exercise or an effective gross motor activity. Response to these comments was that this activity involves the ‘use of elements of a complex body’ and ‘movement of the centre of gravity away from the centre of the base’ definitions of gross motor activity and balance¹⁶. Hence, this exercise was retained as was in the initial draft.
- *Diadochokinesis (DDK) (43%)*: It was felt that this is not a fine motor activity and the response to this was that this exercise enhances pronation/supination which determines the quality of fine motor activity. This exercise was retained; as it appeared in the initial draft.
- *Tandem Walking and Hopping (43%)*. Comment made was that these exercises could not be included; as they are test items of a standardised test. These two exercises were removed and replaced with toe walking and jumping and/or hopping over an object; placed on the floor. These exercises have similar effects on balance, gross motor and eye-foot co-ordination.
- *Effects of all exercises (57%)* Comments made were that all exercises were gross motor in nature and that cutting and writing should have been included. Response to these comments was that DDK and opposition are fine motor activities and that all activities involving weight bearing on the shoulder girdle (for example, wheelbarrow); enhances fine motor control. Cutting and writing should form part of the home programme.
- *Frequency of administration of the exercise programme (29%)*: It was felt that an intervention of this nature should be administered more frequently. A further response was that frequency was sufficient for research purposes but should be more frequent for treatment purposes. Response to this comment was that; with a documented eight-week intervention, once per week, an improvement of 6,46% on the MABC was achieved.¹⁴

- A general comment was made that a motor planning activity should be included. This was felt to be a valid comment, hence the inclusion of a '*star jump*' activity.

The second draft of the exercise programme was compiled after the changes from Round 1 were effected.

In Round 2, consensus was **not** reached on the following items:

- *Abdominal Crunches (60%)*: It was felt that fewer repetitions should be administered. Repetitions were thus altered from nine repetitions; to three to five repetitions depending on individual ability.
- *Half-kneeling balance (40%)*: Comments made was that there were too few repetitions of this exercise. Repetitions were increased from three repetitions on each lower limb; to five repetitions on each lower limb.

Other changes included the following:

- The word '*normalises*' muscle tone was replaced by '*influences*' muscle tone.
- *Ball skills in half-kneeling*: '*enhances posture*' was inserted as an additional effect.
- *Star jumps*: '*sequencing and timing*' and '*enhances bilateral integration*' were inserted as additional benefits.
- *Opposition*: "*final progression*" was inserted, that being performing the exercise with the eyes closed.
- *Proprioceptive Exercises*: The additional outcome of the '*calming/organising*' effect of these exercises on ADHD was inserted.

Changes to the second draft were highlighted and re-ranked in Round 3.

The **structure** of the programme was determined as follows:

- *Group Therapy*: Maximum of eight children in a group. The benefits are that group therapy offers psychosocial and motivational benefits.²⁰
- *Duration and Frequency*: Programme to be repeated once a week, for eight weeks and each session to last one hour. This is the average duration and frequency of exercise interventions administered, in four studies testing the efficacy of exercises in improving motor skills, in children with motor co-ordination difficulties.¹⁸⁻²¹
- *Repetition*: The same programme is to be repeated each week: The decision to do this is supported by the theory of neuroplasticity, that is, a motor skill may be learnt by repetition.²¹

In Round 3, consensus was reached on all items and the third and final draft of the exercise programme was compiled and is illustrated in Table 3.

Table 3 Summarised version of final draft of exercise programme

EXERCISES	REPETITION	EFFECT
Abdominal crunches with knees bent. Hold 10 secs.	1-2 reps straight 1-2 reps oblique R 1-2 reps oblique L	Core stability Posture
Bridges with knees bent. Hold 10 secs	7 reps	Core stability, posture, influence of muscle tone
Four-point kneeling. Raise opposite UL/LL. Hold 10 secs	x 3 R / L x 3 L / R	Core stability, balance, proprioception, bilateral integration, focus/attention, influence of muscle tone. Calming/organising effect of proprioception.
Crawling forwards, backwards, and sideways	4m in each direction	Core stability, bilateral integration, gross motor, proprioception, influence of muscle tone, motor planning. Calming/organising effect of proprioception.
Ball throwing and catching (23cm ball) whilst in half-kneeling	x 10 in the air x 10 with a bounce	Eye-hand co-ordination, motor planning, balance, posture, focus/attention
Half-kneeling balance	X 5 – R leg raised x 5 – L leg raised	Balance, gross motor, function, focus/attention
Wheelbarrow activity	4m forwards 4m backwards	Weight on shoulder girdle = improvement on core strengthening, fine motor. Influence of muscle tone.
Toe-walking forwards and backwards	4m forwards 4m backwards	Balance, gross motor, posture.
Jumping or hopping over an object (hoop)	6 hoops. Different combo's x 3	Gross motor, eye-foot co-ordination, balance, motor planning, sensory integration.
Star jumps	x 10	Gross motor, eye-hand and eye-foot, sequencing and timing; motor planning, bilateral integration, endurance.
Diadochokinesis: Quick door knob action, palm up and palm down	10 x 2	Eye-hand co-ordination Fine motor
Opposition: Quick opposition of thumb to each finger	x 2 L hand x 2 R hand x 2 both hands together. Final progression: eyes closed	Eye-hand, fine motor, focus/attention

DISCUSSION

Consensus was achieved on eight out of ten exercises in the first round of the Delphi process. It was suggested that two exercises be eliminated, as these were test items in a standardised test hence the removal of these. These were line walking/tandem gait and hopping. These were replaced by toe walking and jumping or hopping over an object. The reason for the choice of these exercises, is that they both enhance balance, gross motor co-ordination and eye-foot co-

ordination^{13,15,16}. Consensus was achieved on abdominal crunches and bridges, these being appropriate exercises to improve core stability and enhance posture, this fact being supported by available literature^{15,17}.

One of the comments made by several respondents was that there were insufficient fine motor activities. The exercises that enhanced weight-bearing on the shoulder girdle were thus included, such as wheelbarrow and four point kneeling activities, weight-bearing having a positive effect on building muscle tone, of the shoulder girdle in particular, which then influences fine motor control^{13,15}.

A large number of published studies were reviewed in developing the initial draft of the exercise programme.^{2,4,6,8,10,11,18-21} Important descriptions of the appropriate studies are summarised and illustrated in Table 1. Few studies administered an exercise intervention for management of symptoms of ADHD and DCD in comorbidity². Studies predominantly tested the efficacy of exercise interventions on DCD, minor brain dysfunction (MBD) or gross motor skill deficits¹⁸⁻²¹. The studies cited in the review by Den Heijer², which tested efficacy of an exercise intervention on comorbid ADHD and DCD, did not provide a full description of exercises administered and were not clear on the number of repetitions of each exercise. These studies were thus difficult to replicate. Exercise programmes were not specifically designed to cater for all of the symptoms of the comorbid conditions. Exercises included were often test items on a motor test, for example, hopping and a one-leg balance.²

This study has a unique contribution in that the exercise programme presented in this paper, provides a detailed description of all exercises and the effects of each exercise, supported by the literature. It also gives details on benefits of group therapy, group size, frequency of sessions, duration of each session and number of repetitions of each exercise. To our knowledge, it is the first programme of its kind, developed in this manner, involving a multi-disciplinary team of experts viz: physiotherapists, occupational therapists, educational psychologists and neuropaediatricians. Moreover, the basis of the design of this programme is from the conception that exercises do not only enhance cardiovascular and general body fitness, but also enhances motor co-ordination, balance and more importantly stabilises levels of endorphins, serotonin, dopamine and norepinephrine; which collectively improve executive functions (language, memory, planning, attention, mood-regulation).^{3,22} This programme also includes balance and motor planning exercises, such as ball skills, star-jumps and jumping over/into/out of, which require focus and attention.^{16,17} Consequently, it can be seen how this exercise programme may be effective in managing the symptoms of comorbid ADHD and DCD.

A strength of this study was that the exercise programme was drafted with careful consideration of the following aspects; (i) clinical presentation/symptoms of both ADHD and DCD, (ii) choice of exercises and structure of the programme was based on and supported by the literature and theoretical knowledge, (iii) previous programmes developed were considered in the design of this programme, (iv) the programme was designed with the theoretical knowledge and background of the general effects of exercises as well as more specific effects on neurotransmitters which enhance the symptoms of both ADHD and DCD. Moreover, the exercise programme was also exposed to a consensus process, by a multi-disciplinary team of experts, the result of which has produced an exercise programme that may be suitable in the management of comorbid ADHD and DCD. A limitation of this study was that insufficient experts responded to the invitation to participate in the initial and subsequent rounds.

CONCLUSION

This paper highlights the development and consensus of an exercise programme targeted at addressing the symptoms of comorbid ADHD and DCD. This exercise intervention was designed with rigour; using theory, literature and clinical experience. The consensus on content and structure of the exercise intervention was obtained from a number of experts during three rounds of critical opinion. The next step would be to determine if this exercise intervention is clinically useful in assisting therapists in managing the symptoms of ADHD and DCD, in comorbidity, to ensure a more effective and holistic approach to intervention. Randomised controlled trials and quasi-experimental designs may assist in determining which combinations of interventions may be most effective in the management of comorbid ADHD and DCD.

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CHAPTER 6
MANUSCRIPT 3

A Quasi-Experimental Study testing the Effectiveness of an Exercise Intervention for the Management of Comorbid Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Co-ordination Disorder (DCD)

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Journal: BMC Pediatrics

Status: In Review

A quasi-experimental study was undertaken, with 112 children, aged 8 to 9; clinically diagnosed with ADHD being assigned to one of four intervention groups: neuropharmacological medication, exercises, medication plus exercises, control. The assignment to one of the four intervention groups; was by parental choice. Pre-intervention scores were derived from the following assessment tools: Conner's teacher rating scale; DCDQ and MABC-1. Post-intervention scores were Copeland's symptom checklist, DCDQ and MABC-1. Efficacy of an exercise programme was tested using the above pre- and post-intervention scores.

A QUASI-EXPERIMENTAL STUDY TESTING THE EFFICACY OF AN EXERCISE INTERVENTION FOR THE MANAGEMENT OF COMORBID ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) AND DEVELOPMENTAL CO-ORDINATION DISORDER (DCD)

ABSTRACT

Background: Exercises do not only enhance general health, they also increase levels of neurotransmitter substances such as endorphins, dopamine, norepinephrine and serotonin. This, in turn, produces improvement in co-ordination and executive functions which is affected in comorbid ADHD and DCD. Consequently, exercises should be used as an adjunct to the management of these comorbid conditions. This quasi-experimental research study aimed at testing the efficacy of a specifically designed exercise intervention on improving the symptoms of comorbid ADHD and DCD. **Methods:** Children aged eight to nine years diagnosed with comorbid ADHD and DCD were divided into four groups, namely, group A neuropharmacological medication (n=29), group B prescribed exercises (n=30), group C medication and exercises (n=28) and group D control/no treatment (n=25). The Conners' and Copeland's Teacher rating scale; the DCD Questionnaire and the Movement Assessment Battery for Children (MABC-1) were used to determine the neuromotor status of the participants. Pre- and post-intervention group differences were analysed with use of Wilcoxon Signed Ranked test. Pre-intervention scores were done prior to intervention and post-intervention scores were done six months after the pre-intervention scores. **Results:** Neuropharmacological drugs and exercises is the most effective of the four interventions for improvement of ADHD, DCDQ and MABC-1 scores. Exercise only is more effective than neuropharmacological drugs only for DCDQ and MABC-1 scores. **Conclusion:** ADHD symptoms and motor co-ordination difficulties improved to a large extent in the exercise and medication plus exercise groups; but deteriorated or remained the same; for the medication only as well as control groups. Specific exercises can be used as alternative or additional treatment of comorbid ADHD and DCD; for a more holistic approach. Future research should perhaps involve random controlled trials on the specific designed exercise programme.

KEYWORDS: Attention Deficit and Hyperactivity Disorder (ADHD), Developmental Co-ordination Disorder (DCD); Comorbidity, intervention, exercises, neuropharmacological drugs

CLINICAL TRIAL REGISTRATION

Clinical Trials.Gov <https://clinicaltrials.gov/>

Registration Number: NCT03595826

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BACKGROUND

Children with Attention Deficit Hyperactivity Disorder (ADHD) often experience motor co-ordination deficits [1]. ADHD and Developmental Co-ordination Disorder (DCD) exist in comorbidity in 33% to 35% of cases [2-3]. There is a general under-treatment of motor co-ordination impairments associated with ADHD [2]. Exercises do not only enhance cardiovascular and general body fitness, muscle tone and muscle strength; they also have the effect of improving motor co-ordination, balance, endurance and core stability [4-5]. Furthermore, exercises stabilise blood and cerebrospinal fluid (CSF) levels of endorphins, serotonin, dopamine and norepinephrine [4, 5], which then improves executive functions (memory, language, planning, focus/attention, mood-regulation) [4, 5]. Considering the above, specific exercises should form an integral part of management of ADHD, with associated motor co-ordination problems. ADHD is described as one of the most common childhood neurobehavioural disorders, which persists into adulthood [1]. The child presents with core symptoms of inattention, impulsivity and hyperactivity [4, 6]. Executive functions (language, memory, organisation and planning, regulating emotions) are also affected [1, 4, 6]. This condition impacts negatively on academic performance, activities of daily living (ADL) and social interaction [1, 4, 6]. DCD can be defined as a neurodevelopmental disorder which develops during early childhood and can continue into adulthood [1]. It is characterised by developmental delays, clumsiness, motor planning problems and motor co-ordination impairments. DCD affects ADL, academic performance, leisure, sport and play [1, 7, 8]. The prevalence of ADHD among school-going children is estimated to be 3% to 7% [1, 6] and international prevalence figures of DCD range from 5% to 15% [1, 7, 9, 10]. Symptoms of ADHD are displayed in a host of comorbid conditions such as Autism Spectrum Disorders (ASD), Tourette's Syndrome, dyslexia and reading disorder, the same is true for DCD [2, 6, 7]. The most commonly occurring co-morbidity in ADHD, is motor co-ordination impairments or DCD, which occurs in 50 to 60% of cases [2, 6, 7]. Despite the common occurrence of motor co-ordination impairments in children with ADHD, little attention seems to be paid to this comorbidity in clinical practice [2, 11]. Main areas of the brain involved in both conditions are the prefrontal and motor cortex, the cerebellum and the basal ganglia. This explains the overlap of ADHD and motor co-ordination impairments [2, 6, 7, 12, 14]. Further evidence of shared aetiology is provided by the reduced levels of dopamine, norepinephrine, endorphins, and serotonin, in the blood and CSF of children with ADHD and with DCD (existing separately). These substances control movement, co-ordination, memory, language, planning, emotional regulation and focus/attention [2, 6, 7, 13]. ADHD is most commonly treated with neuropharmacological drugs, namely, methylphenidate (Ritalin/MPH), Concerta, Adderall (all three neuropharmacologicals) and atomoxetine (Strattera) which is a non-stimulant [15]. These drugs reduce the symptoms of ADHD but do not completely eliminate the symptoms [4, 15].

Effects are only noticeable whilst the child is under the influence of the neuropharmacological medication and they have little or no effect on the commonly experienced motor co-ordination impairments [4, 15]. Significant side-effects resulting from these neuropharmacological drugs include short-term side effects such as nausea, gastrointestinal symptoms, headache, loss of appetite and change of sleeping patterns. Long-term side effects include liver damage, cardiac complications, substance abuse, suicidal ideations, and psychological mood disorders (e.g. anxiety, depression and bipolar disorder) have been reported [4, 6, 15]. This clearly indicates the need for an additional or alternative form of management of ADHD [5]. DCD is most commonly treated with motor interventions which are multi-level, task-oriented and functional [16]. These exercise interventions enhance balance, manual dexterity, gross motor and fine motor skills, muscle strength, visual motor and sensory-motor integration [17-19]. Some studies [17-19] have tested the efficacy of a motor intervention on the symptoms of DCD but very few studies [11, 19] exist that have tested the effects of a motor intervention on the symptoms of comorbid ADHD and DCD. This demonstrates the novelty of this study. Exercises used in the management of DCD enhance cardiovascular and general body fitness, build muscle strength and muscle tone, improve motor co-ordination and reduce bony demineralisation [3, 5, 11, 20]. Of significance is that exercises stabilise the blood and CSF levels of endorphins, dopamine, norepinephrine and serotonin [4, 5, 13]. This, in turn, produces an improvement in movement, co-ordination, memory, language, planning, focus/attention and mood-regulation [4, 5, 13]. A recent systematic review revealed that moderate to intense aerobic exercises, did not only have general health benefits but also produced positive effects on neurocognitive function and inhibitory control in children with ADHD [21]. The aim of this study was to examine the efficacy of a designed exercise intervention in addressing the symptoms of comorbid ADHD and DCD.

METHODS

This study followed a quasi-experimental design. The hypotheses tested were as follows:

- A specific exercise intervention is effective in addressing the symptoms of comorbid ADHD and DCD, in children aged eight to nine years, in KwaZulu Natal (KZN), South Africa (SA)
- A specific exercise intervention with children on neuropharmacological drug therapy is effective in addressing the symptoms of comorbid ADHD and DCD in children aged eight to nine years, in KZN, SA.

Population Recruitment and Sampling Procedure

The participants included primary school children, aged eight to nine years and eleven months, from any population group; who attended a remedial class, in a mainstream school, in and around

the suburb of Durban, in KZN, SA. A list of all mainstream schools; with remedial units was obtained (n=23). The principal of each school was contacted. The school became a study site; once the principal had signed consent. Children included in the study were recently diagnosed with ADHD: within a maximum of three months of being included in the study. Children having started neuropharmacological medication were included, as it is unethical to discontinue this treatment. Children having any other neurological, psychiatric, orthopaedic, intellectual or genetic disorder were excluded from the study. Any child having started any form of therapy, was also excluded from the study. Once the parent and child had signed consent and assent, the child was included as a participant.

Baseline Testing, Allocation and Blinding

Completion of the teacher rating scale and DCDQ was explained to the teachers and parents respectively. The MABC-1 was administered by the first author or research assistant who had followed standardised instruction as per the testing requirements. None of the children allocated to the study was on neuropharmacological drug therapy at the time of testing. Once the child had been tested using Conners' teacher rating scale, DCDQ and MABC-1 and found to have comorbid ADHD and DCD; these test scores were used as pre-intervention scores and the participant was assigned to one of four intervention groups Groups A, B, C or D, by the research assistant, as described in Figure 1, based on CONSORT guidelines [22]. To eliminate bias the first author was blinded to the children that participated in the exercise programme that were on medication.

Sample Size and power calculation

Stratified purposive sampling was used to allocate these children into four groups as indicated in Figure 1.

Based on a publication by Flapper et al [23], in which the median manual dexterity score for participants not on neuropharmacological medication, was 9,8 (range 5.0 to 15.0) compared to participants/children on medication with a score of 8.3 (range 0.0 to 12.0). Our hypothesis of significant change in this measurement of 1.0 point is based on this above-published article [23] With a power ($1-\beta$) of 0.80 and testing α of 0.05, the sample size required to detect a significant difference (9.8 versus 7.3) in this intervention study; was 35 children in each of 4 intervention groups. Thus a sample size of 140 was the aim. A total of n=151 children were available for testing however of these n=112 participants met the inclusion criteria.

Data Collection Tools

The Modified Conners' Teacher Rating Scale [24] was used to confirm the diagnosis of ADHD that had already been confirmed by a medical practitioner. Teachers were requested to rate

children when not on any neuropharmacological medication. *The Developmental Co-ordination Disorder Questionnaire (DCDQ)* [25] is a self-report parental questionnaire that was used to identify DCD in the children. *The Movement Assessment Battery for Children version 1 (MABC-1)* [26] was used to derive a quantitative assessment of DCD. The DCDQ and MABC-1 have concurrent validity and thus have the ability to be used to diagnose DCD [25, 26].

The Modified Copeland's Symptom Checklist [27] was used to derive information on certain behavioural, social and academic issues in children and to confirm a diagnosis of ADHD. As per its definition, this checklist measures the same areas as the Conners' Teacher Rating Scale measures; these tests thus being used interchangeably. This checklist provided percentages on inattention/impulsivity and hyperactivity and is used on ages three to seventeen [27]. The teachers were asked to rate the children whilst not on neuropharmacological drug therapy. The *Modified Conners' Teacher Rating Scale* was used as a pre-intervention score and *The Modified Copeland's Symptom Checklist* was used as a post-intervention score so as to prevent teachers from replicating the information from the pre-intervention scale, onto the post-intervention scale. Both tests (i) derive information on behavioural, social and academic issues; (ii) utilise a 4-point Likert Scale; (iii) provide percentages on inattention, impulsivity and hyperactivity and (iv) are used to test children between the ages six to seventeen years. Due to the similarities; these tests could be used for both pre- and post-intervention scores [24, 27].

Procedure

Intervention and Control Groups

Group B (Exercises only) and Group C (Medication and Exercises) received the exercise intervention for eight weeks, once per week (Table 1). Group A continued with neuropharmacological drugs (monitored by a medical practitioner) and Group D did not receive any intervention until after the study was completed. Exercises were administered to small groups of between five to seven children.

Post-Intervention Testing

All participants were re-tested six months after pre-intervention scores were derived, in accordance with the stipulations by the various tests; that these tests should not be repeated before six months [24-27].

Data Analysis

Data were analysed using the Statistical Package of Social Science (SPSS) version 25. Shapiro Wilk test for normality performed on the data indicated that the data was largely not normally

distributed. Hence, within group comparison for pre-and post-intervention changes in ADHD, DCDQ and MABC-1 scores for each group (A, B, C, D) was done using Wilcoxon Signed Ranked test. Kruskal Wallis test was used for between group comparison of the four groups' scores. Pre- and post-intervention, Mann Whitney U Test Multiple pairwise post hoc analysis (for Kruskal Wallis test) were computed to identify groups that significantly differ. Level of significance was set at $p < 0.05$.

Table 1 Summarised Version of the Exercise Intervention

Exercises	Repetition	Effect
<i>Abdominal crunches with knees bent. Hold 10 secs.</i>	<i>5 reps – straight oblique</i>	<i>Core stability, posture.</i>
<i>Bridges with knees bent. Hold 10 secs</i>	<i>7 reps</i>	<i>Core stability, posture, influence of muscle tone.</i>
<i>Four-point kneeling. Raise opposite UL/LL. Hold 10 secs</i>	<i>x 3 R / L x 3 L / R</i>	<i>Core stability, balance, proprioception, bilateral integration, focus/attention, influence of muscle tone.</i>
<i>Crawling forwards, backwards, and sideways</i>	<i>4m in each direction</i>	<i>Core stability, bilateral integration, gross motor, proprioception, influence of muscle tone, motor planning.</i>
<i>Ball throwing and catching (23cm ball) whilst in half-kneeling</i>	<i>x 10 in the air x 10 with a bounce</i>	<i>Eye-hand co-ordination, motor planning, balance, posture, focus/attention.</i>
<i>Half-kneeling balance</i>	<i>x 3 – R leg raised x 3 – L leg raised</i>	<i>Balance, gross motor, function, focus/attention.</i>
<i>Wheelbarrow activity</i>	<i>4m forwards 4m backwards</i>	<i>Weight on shoulder girdle to enhance fine motor, core strengthening. Influence of muscle tone.</i>
<i>Toe-walking forwards and backwards</i>	<i>4m forwards 4m backwards</i>	<i>Balance, gross motor, posture.</i>
<i>Jumping or hopping over an object (hoop)</i>	<i>6 hoops. Different combos x 3</i>	<i>Gross motor, eye-foot co-ordination, balance, motor planning, and sensory integration</i>
<i>Star jumps</i>	<i>x 10</i>	<i>Gross motor, eye-hand and eye-foot, motor planning, integration, endurance.</i>
<i>Diadochokinesis: Quick door knob action, palm up and palm down</i>	<i>10 x 2</i>	<i>Eye-hand co-ordination, Fine motor.</i>
<i>Opposition: Quick opposition of thumb to each finger</i>	<i>x 2 each hand x 1 both hands together</i>	<i>Eye-hand, fine motor, focus/attention.</i>

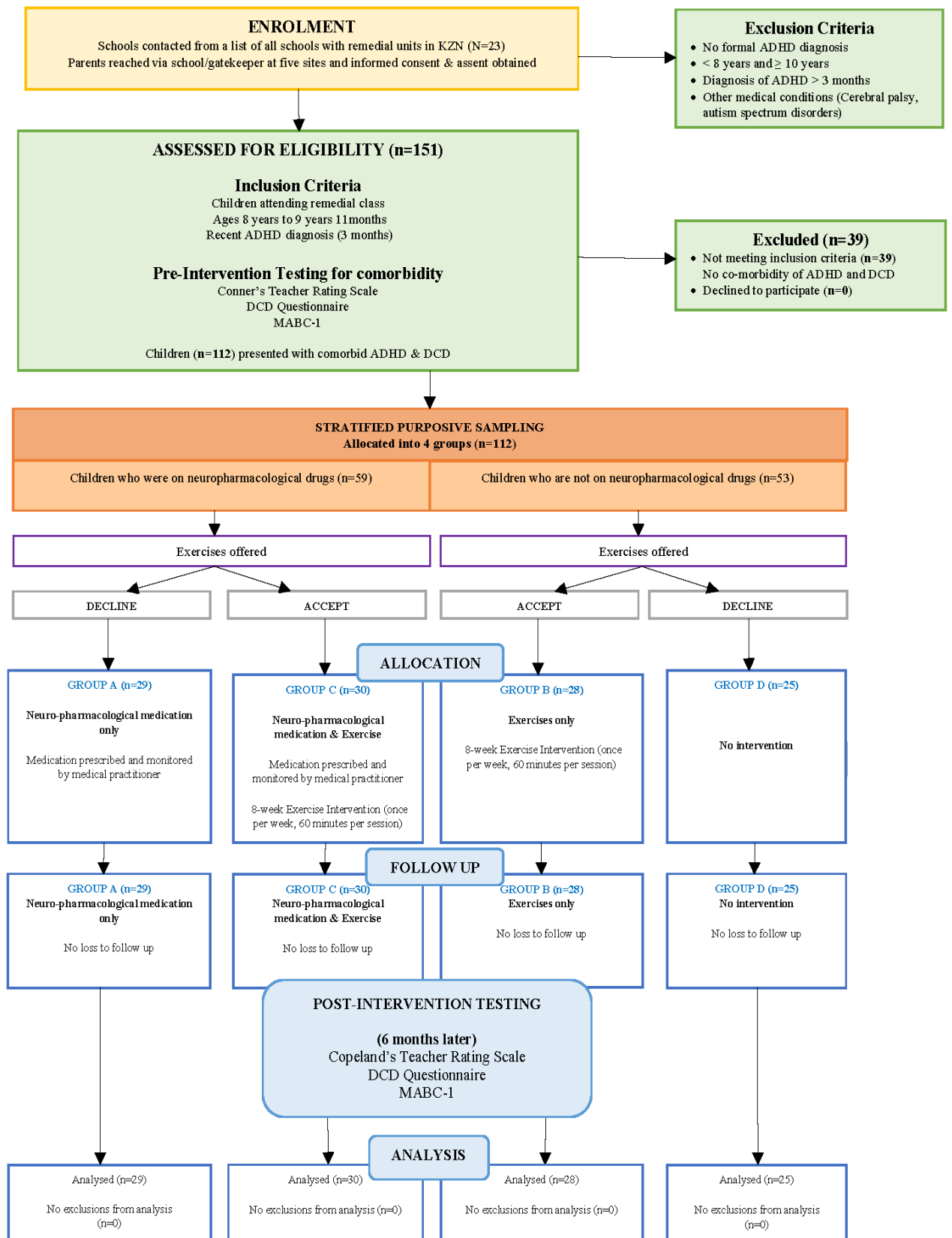


Fig. 1 Procedure and Allocation of Participants (n=112) according to CONSORT Guidelines [22]

Within Group Comparison of ADHD, DCDQ and MABC Scores of Participants

Table 2 shows the comparison of ADHD, DCDQ and MABC-1 scores of participants in all groups pre and post intervention. In Group A, participants' ADHD scores significantly increased ($p=0.018$) while DCDQ scores significantly decreased ($p = 0.007$) from pre-intervention to post intervention. However, there was no significant difference in participants' MABC-1 scores ($p = 0.669$) from pre to post intervention. In Group B, participants' ADHD ($p = 0.046$) and DCDQ ($p < 0.001$) scores significantly increased while there was a significant reduction in MABC-1 scores ($p < 0.001$) from pre-intervention to post intervention. In Group C, significant reductions in participants' ADHD and MABC-1 scores ($p < 0.001$ each) were indicated while DCDQ scores ($p < 0.001$) significantly increased from pre-intervention to post intervention. In Group D, a significant decrease in participants' DCDQ scores ($p = 0.001$) were indicated. There was no significant difference in the changes observed in participants' ADHD and MABC-1 scores ($p = 0.787$ and 0.407 respectively) from pre-intervention to post intervention.

Table 2 Wilcoxon Signed Rank Test Comparison of Group A to D, pre- & post-intervention scores

	Variable	Pre-Intervention	Post-Intervention	z- value	p-value
		Median (IQ)	Median (IQ)		
GROUP A	ADHD scores	170.00 (80.00)	198.00 (68.50)	-2.356	0.018*
	DCDQ scores	51.00 (8.00)	45.00 (8.50)	-2.719	0.007*
	MABC-1 scores	15.00 (7.05)	15.00 (7.75)	-0.427	0.669
GROUP B	ADHD scores	140.00 (153.75)	168.50 (104.75)	-1.995	0.046*
	DCDQ scores	47.0 (15.00)	60.00 (13.25)	-4.790	<0.001*
	MABC-1 scores	13.50 (6.50)	8.00 (5.50)	-4.787	<0.001*
GROUP C	ADHD scores	170.00 (121.25)	140.00 (93.00)	-4.055	<0.001*
	DCDQ scores	45.00 (8.00)	54.00 (8.50)	-4.670	<0.001*
	MABC-1 scores	15.50 (6.00)	9.25 (6.25)	-4.632	<0.001*
GROUP D	ADHD scores	215.00 (135.00)	217.00 (113.00)	-0.257	0.787
	DCDQ scores	48.00(16.5)	45.00(21.00)	-3.189	0.001*
	MABC-1 scores	12.00(5.50)	13.00(6.25)	-0.830	0.407

ADHD: Attention Deficit Hyperactivity Disorder; DCDQ: Developmental Co-ordination Disorder Questionnaire; MABC-1: Movement Assessment Battery for Children; ADHD scores = Sum of Inattention, Impulsivity and Hyperactivity scores; IQ: Interquartile Range (75th percentile– 25th percentile); * denotes significance at $p<0.05$

Pre-Intervention Comparison of the Groups' ADHD, DCDQ and MABC-1 Scores

The groups' ADHD, DCDQ and MABC-1 scores before intervention are compared in Table 3. Kruskal Wallis test did not indicate any significant difference ($p > 0.05$) across the groups on any of the three tested outcomes.

Table 3 *Kruskal Wallis Test comparison of pre-intervention scores Groups A, B, C, and D*

Variable	GROUP A Median (IQ)	GROUP B Median (IQ)	GROUP C Median (IQ)	GROUP D Median (IQ)	H	p=
ADHD scores	170.00(80.00)	140.00 (153.75)	170.00 (121.25)	215.00(135.00)	2.955	0.399
DCDQ scores	51.00 (8.00)	47.00 (15.00)	45.00 (8.00)	48.00 (16.5)	4.558	0.207
MABC-1 scores	15.00 (7.05)	13.50 (6.50)	15.50 (6.00)	12.00 (5.50)	2.3845	0.416

ADHD: Attention Deficit Hyperactivity Disorder; DCDQ: Developmental Co-ordination Disorder Questionnaire; MABC-1: Movement Assessment Battery for Children

Post-Intervention Comparison of the Groups' ADHD, DCDQ and MABC Scores

The groups' ADHD, DCDQ and MABC-1 scores after intervention are compared in Table 4. The results of Kruskal Wallis test indicated significant differences across the four groups on ADHD, DCDQ and MABC-1 scores. Mann Whitney U test post-hoc multiple comparisons showed that Group C had significantly lower ADHD scores than Groups A and D; Group B also had significantly lower ADHD scores than Group D. Post-hoc analysis also showed that Group B participants had significantly higher DCDQ scores than Groups A and D while Group C also demonstrated significantly higher score in the outcome than Groups A and D. Post-hoc analysis results for MABC-1 scores indicated that participants in Groups B and C had significantly lower MABC-1 scores than Groups A and D.

Table 4 *Kruskal Wallis Test comparison of post-intervention scores Groups A, B, C, and D*

Variable	GROUP A Median (IQ)	GROUP B Median (IQ)	GROUP C Median (IQ)	GROUP D Median (IQ)	H	p-value
ADHD Scores	198.00 (68.50)	168.50 (104.75)	140.00 (93.00)	217.00 (113.00)	17.067	0.001*
DCDQ Scores	45.00 (8.50)	60.00 (13.25)	54.00 (8.50)	45.00 (21.00)	49.394	< 0.001*
MABC-1 Scores	15.00 (7.75)	8.00 (5.50)	9.25 (6.25)	13.00 (6.25)	41.553	< 0.001*

ADHD: Attention Deficit Hyperactivity Disorder; DCDQ: Developmental Co-ordination Disorder Questionnaire; MABC-1: Movement Assessment Battery for Children

Post-hoc Multiple Comparisons for Post intervention Scores

Group A demonstrated significant deterioration in ADHD ($p=0.018$) and DCDQ scores ($p=0.007$) but no significant change in MABC-1 scores ($p=0.669$). Group B demonstrated significant improvement in DCDQ ($p<0.001$) and MABC-1 scores ($p<0.001$) but deteriorated significantly in ADHD scores ($p=0.046$). Group C showed significant improvement in all three outcomes: ADHD scores ($p<0.001$), DCDQ scores ($p<0.001$) and MABC-1 scores ($p<0.001$). Group D demonstrated significant deterioration in DCDQ scores ($p<0.001$) but no significant changes in ADHD ($p=0.787$) and MABC-1 scores ($p=0.407$). Neuropharmacological drugs plus exercises is

the most effective of the four interventions for improvement of ADHD, DCDQ and MABC-1 scores while exercise only is more effective than neuropharmacological drugs only for improvement of DCDQ and MABC-1 scores.

DISCUSSION

This paper presents a study that aimed to determine the efficacy of an exercise intervention on comorbid ADHD and DCD in children attending mainstream school in KZN, SA. The null hypotheses are rejected in this study. The most significant improvement in symptoms of ADHD occurred in Group C (neuropharmacological drugs and exercises). This improvement in ADHD scores, with an exercise intervention, is supported by the findings of the systematic review completed by Qin et al [21]. Although Group B (exercises only) showed an overall significant deterioration in ADHD scores; however when each child was used as its own control, an improvement was noted. ADHD scores deteriorated significantly for Group A (neuropharmacological medication only) and remained unchanged for Group D (control). These groups remained with the highest ADHD scores post intervention. These findings are similar to those found in Summerford [20] and Pienaar and du Toit [11] studies.

Looking at motor scores (DCDQ and MABC-1) a significant improvement in these was demonstrated in both Groups B and C. Both groups received the exercise intervention. Pienaar et al [11] also found the neuromotor skills group to improve motor skills most significantly in their study. However, motor scores deteriorated for both Groups A (medication only) and Group D (control). This shows that an exercise intervention is effective in producing an improvement in motor co-ordination symptoms experienced with ADHD.

A strength of this study was that ADHD was originally clinically diagnosed; with the diagnosis confirmed by two teacher-rated scales, namely the Conners' and Copeland's scales. The disadvantage of this is that both scales are subjective. The more objective scale of diagnosis of ADHD, namely, Conners' Performance Test 3rd Edition (CPT-3) was not used as the diagnosis was already confirmed by a combination of tests by the relevant professional/s. Other studies have identified children who are suspected of having ADHD; by using scales such as the Disruptive Behaviour Scale [11] which is a scale not as widely used and well-known (to teachers in particular) as the Conners' and Copeland's scales. Moreover, the exercise intervention was specifically outlined in this study. Group size, frequency, duration of each session and duration of the course of treatment; repetitions of each exercise together with execution of each exercise are all clearly described. Similar studies have not provided details on frequency and provided broad generalisations on choice of exercises, for example: ball handling; balance and manual

dexterity [19]. Furthermore, all areas of motor impairment are included in the choice of exercises, including gross motor co-ordination which is frequently omitted from motor co-ordination interventions. For example, Pienaar et al [11] describe their neuromotor programme as including vestibular and kinaesthetic exercises; balance, eye-hand co-ordination, fine motor and visual fixation with the omission of gross motor co-ordination. Finally, the testing processes in this study was an additional strength in that (i) post-intervention testing adhered to the six month waiting period with the MABC-1 whilst similar studies retested MABC-1 straight after an eight or nine week intervention [9, 23] (ii) the use of the Conners' teacher-rating scale pre-intervention and Copeland's scale post-intervention may have assisted in preventing teachers from replicating the pre-intervention scores based on their initial impression of the child and (iii) DCDQ supplied a parental report score with a degree of subjectivity and the MABC-1 supplied an objective, quantitative score.

A limitation of this study was the inclusion of an exercise intervention that was a generic, 'one-size-fits-all' programme; which is not a particularly realistic situation. However, the design of the exercise intervention caters for most symptoms and combinations of symptoms in these conditions. According to Pienaar and du Toit [11], there is no 'gold' standard' treatment for the management of ADHD with motor co-ordination impairments.

CONCLUSIONS

This study determined the efficacy of exercise in improving symptoms of comorbid ADHD and DCD. The objective of the study was thus achieved. It demonstrated that exercises alone and exercises in tandem with neuropharmacological medication produced the most significant improvement in ADHD scores and motor co-ordination scores. It can thus be concluded that the combination of an exercise intervention and neuropharmacological medication should be used in the management of comorbid ADHD and DCD; in order to yield the best results. This study has provided evidence that exercise may be effective as an adjunct in the management of comorbid ADHD and DCD. Future studies should include random controlled trials with exercise interventions for the different subtypes of ADHD and DCD. It should also endeavour to have more children recruited and randomised into each intervention group. For clinicians, this information has the following implications: a child with ADHD should always be screened for motor co-ordination impairment and should receive additional rehabilitative therapy for the motor co-ordination impairments, which would result in more holistic management of the child with the comorbid conditions in order to produce a better prognosis.

Abbreviations

ADHD : Attention Deficit Hyperactivity Disorder; CSF: Cerebrospinal Fluid; DCD: Developmental Co-ordination Disorder; DCDQ: Developmental Co-ordination Disorder Questionnaire; KZN: KwaZulu Natal; MABC-1: Movement Assessment Battery for Children version 1; SA: South Africa

DECLARATIONS

Ethics approval and consent to participate

The study gained approval from Biomedical Research Ethics Committee of the University of KwaZulu-Natal, (BFC 397/16), and The Department of Education in KZN. Written consent was sought from the school principals and parents and written and verbal assent was obtained from the children.

Competing Interests

None

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Authors Contributions

PMTD, TN & PG designed the study. PMTD was the primary investigator and TN & PG supervised the project. PMTD drafted the manuscript and all authors critically reviewed the manuscript. All authors read and approved the manuscript.

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CHAPTER 7

SYNTHESIS

7.1 INTRODUCTION

This chapter provides a discussion (that demonstrates the logical thread that runs across the manuscripts) and a conclusion with recommendations for further studies. A description of the study objectives is also given and how these were achieved; with reference to the manuscripts. The conclusion discusses the novelty and significance of this study.

7.2 ALIGNMENT OF OBJECTIVES TO STUDY OUTCOMES AND MANUSCRIPTS

The study aim of testing the effects of exercise therapy on the comorbidity of ADHD and DCD has been achieved in this study. This study followed a multi-method sequential design including a closed cohort observational study, Delphi technique and a quasi-experimental design. Chapter 3 provided an overview of the methodology in each of the three phases of this study.

Chapter 4 (Phase 1): The objective of this phase was to establish the prevalence and present a demographic profile of children diagnosed with comorbid ADHD and DCD. This followed a closed cohort design with 151 children, aged eight to nine years, attending a remedial unit or a Learners with Special Education Needs (LSEN) class; recently diagnosed with ADHD; being tested for comorbid DCD. A diagnosis of ADHD was confirmed by administering a Conners' teacher-rated scale and DCD was diagnosed by administration of a parent-rated DCD Questionnaire (DCDQ) and a Movement Assessment Battery for Children (MABC-1). Prevalence of comorbidity of ADHD and DCD was calculated and a demographic profile of children diagnosed with comorbidity was presented; with the objective of this phase achieved. A prevalence of 74% was calculated, much higher than the expected 30% to 55% prevalence cited in the available literature (*Fliers et al; 2008; Watenburg et al; 2007; Pearsall-Jones et al; 2010*). A male to female ratio of 2:1 was established and supported by the literature (*Nelson et al; 2015; Barkley; 2015; Pearsall-Jones et al; 2010*). Mean age of children testing positive for comorbid ADHD and DCD was 8,76 years.

The **combined** subtype of ADHD was most commonly affected by comorbidity. This is supported by the literature in some cases (*Meyer et al; 2006*) and in other cases; it was found that the **inattentive** subtype of ADHD was most commonly affected by comorbidity of ADHD and DCD (*Kaiser et al; 2014*).

A few limitations were experienced in that the sample size was significantly smaller than expected (151 versus 225). This was due to a poor response from the schools. Only five study sites were procured due to this poor response, which had an impact on population figures; with fewer Asian and Coloured children included as participants, because of the location of the schools and the demographic profile of the school. This resultantly skewed the results; providing inflated prevalence figures of 100% Asian children and 79% Coloured children being diagnosed with comorbidity in the sample.

The fact that the general prevalence figures were high (74%), gave a clear indication that motor problems in ADHD, should be addressed; which necessitated the following phase of this study:

Chapter 5 (Phase 2): The objective of this phase was to design and develop an exercise intervention that addresses both motor and inattention/cognitive symptoms of comorbid ADHD and DCD. This phase followed a modified Delphi technique towards consensus of the exercise intervention by a panel of experts (physiotherapists, OTs, educational psychologists and neuropaediatricians). A 100% consensus was reached on all exercises in the final third round of the consensus process. The final draft of the exercise intervention was produced and appears in Appendix K (iv). The exercise intervention addressed all motor symptoms of DCD as well as catered for the attention and focus deficits of ADHD. The structure of the intervention was outlined; including frequency, duration of intervention, group size, and equipment required. An eight-week exercise intervention, based on expert opinion, to be used as an intervention for comorbid ADHD and DCD was the result of this rigorous consensus process; rendering the objective of this phase of the study being achieved. Limitations included the sample size with insufficient experts responding, and those who responded, were not timeous in responses and required multiple reminders. Following the design of the exercise intervention it follows that there was a need to test this intervention, to ascertain how effective the intervention would be in addressing symptoms of comorbid ADHD and DCD; which necessitated the final phase of this study.

Chapter 6 (Phase 3): The objective of this phase was to determine the efficacy of the eight-week exercise intervention in addressing both motor and inattention/cognitive symptoms of comorbid ADHD and DCD. This phase followed a quasi-experimental design; with 112 children diagnosed with comorbidity of ADHD and DCD being allocated to four intervention groups, by parental choice. Pre-intervention scores were derived from the scores obtained in phase one. Following the eight-week exercise intervention for groups B and C, re-testing occurred six months later

given the requirement of the MABC-1. Following this period of time; all children were retested. Statistical analysis revealed the following:

- Group A : ADHD scores significantly increased (deterioration)
DCDQ scores significantly decreased (deterioration)
MABC scores showed no significant difference.
- Group B : ADHD scores significantly increased (deterioration)
DCDQ scores significantly increased (improvement)
MABC scores significantly decreased (improvement).
- Group C : ADHD scores significantly decreased (improvement)
DCDQ scores significantly increased (improvement)
MABC scores significantly decreased (improvement).
- Group D : ADHD scores showed no significant difference.
DCDQ scores significantly decreased (deterioration)
MABC scores showed insignificant changes.

The most significant improvement in symptoms of ADHD was achieved in Group C (neuropharmacological medication and exercises). This improvement with an exercise intervention is supported by the findings of the systematic review completed by *Ng et al (2017)*.

Although Group B (exercises only) showed an overall significant deterioration in ADHD scores; when each child was used as its own control; an improvement in ADHD scores was noted. ADHD scores deteriorated significantly for Group A (neuropharmacological medication) and remained unchanged for Group D (Control).

With respect to the two motor scores, namely, of the DCDQ and MABC-1:

Groups B and C (both groups receiving the exercise intervention) demonstrated significant improvement. However, motor scores deteriorated significantly for Group A (neuropharmacological medication) and Group D (Control). This shows that an exercise intervention is effective in producing an improvement in motor co-ordination deficits experienced with ADHD.

7.3 LIMITATIONS OF THE STUDY

Limitations were experienced in that the sample size was smaller than intended; and there was no control over participants in Group B and C. There is the possibility that sport participation may have contributed to the improvement. Despite these limitations, it was felt that results demonstrated that the exercise intervention may make a significant contribution to the management of comorbid ADHD and DCD.

7.4 SIGNIFICANCE OF THIS STUDY

This study established the prevalence of comorbid ADHD/DCD. The clinical significance of this includes the potential sensitisation of clinicians, as the high prevalence of comorbidity cautions them to screen all children with ADHD for DCD. This study has also contributed towards an exercise intervention that may be considered as an adjunct intervention for this comorbidity. Such an intervention with content and structure described in detail has thus far, not existed. The significance of this intervention is two-fold; from a point of view of having medical and educational significance. Medically, clinicians now have an additional intervention for the management of commonly occurring motor problems in children with ADHD. This exercise intervention can be administered by a multi-disciplinary team; to achieve a more holistic approach to the management of ADHD and DCD, in comorbidity, for example by occupational therapists, physiotherapists and potentially biokineticists. From an educational point of view; these exercises could possibly be incorporated into the school physical education programme; as well as performed during the school-day; between lessons; to enhance focus, attention cognitive ability and motor co-ordination (for improvement in writing, for example). This study is one of few that have tested efficacy of various interventions on ADHD with comorbid motor problems; but is the only known study that has fully outlined the intervention; providing explicit description of content and structure. From the above; the novelty and significance of this research is demonstrated.

7.5 RECOMMENDATIONS FOR FURTHER STUDIES

- Repetition of the study with additional intervention groups and a larger sample size; would be useful. The additional intervention groups can include dietary considerations and natural medicinal remedies.
- Further studies could see the separation of neuropharmacological drugs into stimulants and non-stimulants; which could significantly impact on results.
- A study of this nature should be replicated with a more equal population distribution, being screened for DCD; so as to obtain more realistic population group demographics of comorbidity.

7.6 CONCLUSION

In conclusion, this multi-stage study established the prevalence of comorbid ADHD and DCD and provided a demographic profile of children with the comorbid conditions. It also contributed an exercise programme; on which consensus on exercises and structure was obtained from multi-disciplinary experts. It further tested the efficacy of this exercise intervention in addressing the symptoms of comorbid ADHD and DCD. The overall aim of the study was thus achieved.

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APPENDIX Ai: REQUEST FOR PERMISSION TO CONDUCT STUDY AT SCHOOLS FROM DOE

(Date)

Dear Sir/Madam,

My name is Pam Dawson; physiotherapist doing my PhD at UKZN; Westville campus.

My contact numbers : 031-7633892; 0825789986

My email address: pdawson@polka.co.za

My research is entitled: *A Study of the Effects of Exercise Therapy on the Co-Morbidity of ADHD and Developmental Co-Ordination Disorder (DCD).*

The aims of this study are:

- 1) *To present a profile of children with both ADHD and DCD.*
- 2) *To design an exercise programme as a form of intervention; which addresses **both** inattention/cognitive symptoms and motor difficulties.*
- 3) *To determine how effective the above exercise programme is; in addressing the symptoms of both conditions in co-occurrence.*

The study is expected to enrol 300 participants; age 8 to 9 from 15 schools in and around Durban, who have a remedial unit.

For the experimental phase (or phase 3) the children will be assigned to four groups; according to parental choice or medical advice.

Procedure:

- 1) *All necessary permission and consent will be sought.*
- 2) *Children suspected to have ADHD will be tested by an educational psychologist; as per normal procedures; using Conners' rating Scale and the Conners' Performance Test-3 (Conners 2004-2016)*
- 3) *When the diagnosis of ADHD has been confirmed the parent will be asked to fill out a motor skill questionnaire. The primary investigator (PI) and/or research assistant; will then perform a short motor test on the child; the MABC (Henderson et al; 2007).*
- 4) *When the diagnosis of both conditions has been made; namely ADHD and DCD; the parent will be "interviewed" to determine which form of treatment they wish their child to receive:*

- a) *Pharmacotherapy*
 - b) *Exercise therapy*
 - c) *Both (a) and (b)*
 - d) *No treatment*
- 5) *Pharmacotherapy will be administered by a medical practitioner and exercises by a trained physiotherapist.*
- 6) *The duration of exercise therapy will be for a term of 8 to 10 weeks and pharmacotherapy as determined by the medical practitioner; usually administered during school term-time only and so the same duration as the exercise therapy.*
- 7) *After a term of therapy; either pharmacotherapy; exercise therapy; both or neither (control group); the tests in (1) and (2) above will be re-administered straight after the intervention and approximately four weeks after the intervention.*

The study may involve the following risks:

Those participants who form part of the exercise programme group(s) may suffer minor injuries; although **every** precaution will be taken to prevent these. The pharmacotherapy may carry the usual risks/side effects; whether administered for research purposes or for normal treatment. Other than pharmacotherapy and exercise therapy, there is no other known form of treatment of the co-morbid ADHD and DCD; other than dietary control and perhaps psychosocial therapy and/or behaviour therapy. The participants will be covered for any research-related injuries by third party cover; from the Registrar of UKZN.

The study has been ethically reviewed and approved by the UKZN Biomedical Research Ethics Committee (BREC); approval number BFC397/16.

In the event of any problems or concerns/questions; you may contact the researcher (see details provided in 1st paragraph); or the UKZN BREC. Contacts as follows:

Biomedical Research Ethics Committee

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X54001, Durban, 4000

KZN, South Africa

Tel :+27 31 2604769 Fax:+27 31 260 4609

Email: brec@ukzn.ac.za

Participation in this research is voluntary and participants may withdraw participation at anytime. In the event of withdrawal/refusal of participation; participants will not incur any penalty or loss of benefit to which they are normally entitled.

Consequences of withdrawal from the study – none. In order to withdraw from the study; the participant's parent should notify the PI via her email address above.

Costs incurred by the participants will only be the cost of the neurostimulant drug therapy, which is at present, most commonly used for treatment of these conditions. These costs are borne by the parent, and is not research related. There will be no incentives to parent or participant given for the participation in this research study.

Confidentiality of personal/clinical information will be strictly protected by using a number to identify the participant, as opposed to the participant's name. The raw data will be kept on the PI's personal laptop and hard copies at the PI's home and this will then be shredded on completion of the study.

I would like to please request your permission to conduct the above-described study at various schools identified in and around Durban.

Yours sincerely

Pam Dawson

APPENDIX Aii: PERMISSION TO CONDUCT RESEARCH IN THE KZN DOE SCHOOLS

Appendix Aii) Permission granted



education

**Department:
Education
PROVINCE OF KWAZULU-NATAL**

Enquiries: Phindile Duma

Tel: 033 392 1041

Ref: 2/4/8/1195

Ms P Dawson
PO Box 1571
Link Hills
3652

Dear Ms Dawson

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"A STUDY OF EXERCISE THERAPY ON THE CO-MORBIDITY OF ADHD AND DCD (DEVELOPMENTAL CO-ORDINATION DISORDER)"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 03 April 2017 to 07 June 2019.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

UMlazi District

Pinetown District



Education

Championing Quality Education - Creating and Securing a Brighter Future

KWAZULU-NATAL DEPARTMENT OF EDUCATION
Postal Address: Private Bag X9137 • Pietermaritzburg • 3200 • Republic of South Africa
Physical Address: 247 Burger Street • Anton Lembede Building • Pietermaritzburg • 3201
Tel.: +27 33 392 1004/41 • Fax: +27 033 392 1203 • Email: Kehologile.Connie@kzndoe.gov.za/Phindile.Duma@kzndoe.gov.za • Web:www.kzneducation.gov.za
Facebook: KZNDOE ... Twitter: @OBE_KZN ... Instagram: kzn_education ... Youtube: kzndoe

APPENDIX B: REQUEST FOR PERMISSION FROM PRINCIPALS FOR PARENTAL CONSENT TO PARTICIPATION IN THE STUDY

(Date)

Dear Sir/Madam,

My name is Pam Dawson; physiotherapist doing my PhD at UKZN; Westville campus.

My contact numbers : 031-7633892; 0825789986

My email address: pdawson@polka.co.za

My research is entitled: *A Study of the Effects of Exercise Therapy on the Co-Morbidity of ADHD and Developmental Co-Ordination Disorder (DCD).*

The aims of this study are:

- 1) *To present a profile of children with both ADHD and DCD.*
- 2) *To design an exercise programme as a form of intervention; which addresses **both** inattention/cognitive symptoms and motor difficulties.*
- 3) *To determine how effective the above exercise programme is; in addressing the symptoms of both conditions in co-occurrence.*

The study is expected to enrol 300 participants; age 8 to 9 from 15 schools in and around Durban, who have a remedial unit.

For the experimental phase (or phase 3) the children will be assigned to four groups; according to parental choice or medical advice.

Procedure:

- 1) *All necessary permission and consent will be sought.*
- 2) *Children suspected to have ADHD will be tested by an educational psychologist; as per normal procedures; using Conners' rating Scale and the Conners' Performance Test-3 (Conners 2004-2016)*
- 3) *When the diagnosis of ADHD has been confirmed the parent will be asked to fill out a motor skill questionnaire. The primary investigator (PI) and/or research assistant; will then perform a short motor test on the child; the MABC (Henderson et al; 2007).*
- 4) *When the diagnosis of both conditions has been made; namely ADHD and DCD; the parent will be "interviewed" to determine which form of treatment they wish their child to receive:*

- a) *Pharmacotherapy*
 - b) *Exercise therapy*
 - c) *Both (a) and (b)*
 - d) *No treatment*
- 5) *Pharmacotherapy will be administered by a medical practitioner and exercises by a trained physiotherapist.*
- 6) *The duration of exercise therapy will be for a term of 8 to 10 weeks and pharmacotherapy as determined by the medical practitioner; usually administered during school term-time only and so the same duration as the exercise therapy.*
- 7) *After a term of therapy; either pharmacotherapy; exercise therapy; both or neither (control group); the tests in (1) and (2) above will be re-administered straight after the intervention and approximately four weeks after the intervention.*

The study may involve the following risks:

Those participants who form part of the exercise programme group(s) may suffer minor injuries; although **every** precaution will be taken to prevent these. The pharmacotherapy may carry the usual risks/side effects; whether administered for research purposes or for normal treatment. Other than pharmacotherapy and exercise therapy, there is no other known form of treatment of the comorbid ADHD and DCD; other than dietary control and perhaps psychosocial therapy and/or behaviour therapy. The participants will be covered for any research-related injuries by third party cover; from the Registrar of UKZN.

The study has been ethically reviewed and approved by the UKZN Biomedical Research Ethics Committee (BREC); approval number BFC397/16.

In the event of any problems or concerns/questions; you may contact the researcher (see details provided in 1st paragraph); or the UKZN BREC. Contacts as follows:

Biomedical Research Ethics Committee

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X54001, Durban, 4000

KZN, South Africa

Tel :+27 31 2604769 Fax:+27 31 260 4609

Email: brec@ukzn.ac.za

DECLARATION OF CONSENT

I give my permission for the PI to contact the head of the remedial unit, to give this person invitations to hand to parents of all children in the remedial unit; aged 8 to 9.

Signature of Principal

Date

Signature of Witness

Date

APPENDIX C: CONSENT FROM PARENTS OF CHILDREN IN THE REMEDIAL UNITS TO PARTICIPATION

DECLARATION OF CONSENT

I/We _____ parent(s) of _____
_____ (Child's name) from _____
_____ (School) have been informed about the study entitled "The effects of Exercise Therapy on the Co-Morbidity of ADHD and DCD" by Pam Dawson; the PI.

- I understand the purpose and procedures of the study.
- I have been given an opportunity to ask questions about the study and have received answers to be satisfaction.
- I declare that participation in this study will be entirely voluntary and that participants may withdraw at any time; without affecting any treatment or care that they would normally be entitled to.
- I have been informed about any available compensation or medical treatment if injury occurs to them as a result of study-related procedures.

If I have any further questions/concerns related to the study; I understand that I may contact the PI at: pdawson@polka.co.za. Alternatively I may contact:

Biomedical Research Ethics Committee
Research Office, Westville Campus, Govan Mbeki Building
Private Bag X54001, Durban, 4000, KZN, South Africa
Tel :27 31 2604769 Fax: 27 31 260 4609 Email: brec@ukzn.ac.za

Dear Parent, please obtain medical advice from a GP, paediatrician or educational psychologist before filling in the portion below: Please mark with an “X”

- I accept the invitation for my child to participate in this research study and give permission for my child’s details and scores to be provided and for my child to be tested; provided my child is happy to participate and freely and willingly signs the assent.

- I understand that if my child is found to have symptoms of both ADHD and motor co-ordination problems, he/she will be assigned to one of four intervention groups, according to my choice below (the PI will try as much as possible to accommodate your choice).

If you feel that your child does not need any treatment we will simply test and monitor your child.

Signature of Parent

Date

Signature of Witness

Date

Signature of Translator

Date

APPENDIX D: ASSENT FROM MINOR CHILD PARTICIPANT

(Date)

Dear Prospective Participant,

I am Ms Dawson; a physiotherapist doing research at your school. My contact numbers are:

My contact numbers : 031-7633892 or 0825789986; My email address: pdawson@polka.co.za

I am testing a whole group of children at your school to see if they battle a little with movement. Once that is done, I will do some exercises with some of the children. I will make sure the children doing the exercises do not get hurt. I have been given permission from the people in charge to do these tests plus exercises.

I would like to invite you to take part in this “project”. You may accept if you would like to take part but you may say “No” if you do not want to take part.

Nothing wrong will happen to you if you say “No”.

Once you are in the “project”, you may leave if and when you want to. This will not cost your parents anything extra to what they normally pay.

If you have any questions, please ask your parents or myself (you have my contact details).

ASSENT (FROM MINOR CHILD PARTICIPANT)

I _____ (child) from _____ (school)

Have been told all about the study Ms Dawson is conducting. I am taking part in it freely and understand that I may say “No” and/or stop taking part at any time. If I have any questions, I can ask my parents and/or Ms Dawson. I accept to be part of this “project” and sign below:

Date: _____

Witness: _____

Signature of Witness: _____

Translator: _____

Signature of Translator _____

APPENDIX E(i): MODIFIED CONNER'S ABBREVIATED TEACHER RATED SYMPTOM QUESTIONNAIRE

Appendix E

MODIFIED CONNER'S ABBREVIATED TEACHER RATED SYMPTOM QUESTIONNAIRE

NAME OF CHILD: _____

DATE OF OBSERVATION: _____

		Not at all 0	Just a little 1	Pretty much 2	Very much 3
1.	Often fails to give close attention to details				
2.	Often has difficulty sustaining attention in tasks				
3.	Often does not seem to listen				
4.	Often does not follow through on instructions and fails to finish tasks				
5.	Often has difficulty organising tasks				
6.	Often avoids tasks that require sustained mental effort				
7.	Often loses things necessary for tasks or activities				
8.	Is often easily distracted by extraneous stimuli				
9.	Is often forgetful in daily activities				
10.	Is easily distracted				
11.	Often blurts out answers				
12.	Often has difficulty awaiting turn				
13.	Often interrupts or intrudes on others				
14.	Often acts without thinking				
15.	Has difficulty awaiting turn in games, etc				
16.	Often fidgets with hands or squirms in seat				
17.	Often leaves seat in classroom				
18.	Often runs about or climbs excessively				
19.	Often acts as if 'driven by a motor'				
20.	Often talks excessively				
TOTAL					

Use this space for any other information or comments that you consider helpful and informative.

NAME OF TEACHER: _____

APPENDIX E (ii): MODIFIED COPELAND SYMPTOM CHECKLIST FOR ADHD

Name of Child: _____

School : _____ Teacher: _____

Date: _____ Medication: _____

- 0: Not at all
- 1: Just a little
- 2: Pretty Much
- 3: Very Much

INATTENTION

1	Short attention span	0	1	2	3
2	Difficulty completing tasks	0	1	2	3
3	Day-dreaming	0	1	2	3
4	Easily distracted	0	1	2	3
5	Nicknames such as “dreamer”	0	1	2	3
6	Accomplishes little with excessive activity	0	1	2	3
7	Enthusiastic beginnings; poor endings	0	1	2	3
8	Failure to complete tasks	0	1	2	3
9	Poor leadership	0	1	2	3
10	Lethargy	0	1	2	3
11	Difficulty in learning and performing	0	1	2	3
		_____/33			_____%

IMPULSIVITY

1	Excitability	0	1	2	3
2	Low tolerance of frustration	0	1	2	3
3	Acts before thinking	0	1	2	3
4	Disorganisation	0	1	2	3
5	Poor planning	0	1	2	3
6	Shifts from one activity to another	0	1	2	3
7	Difficulty working in a group	0	1	2	3
8	Requires much supervision	0	1	2	3
9	Constantly in trouble	0	1	2	3
10	Talks out of turn	0	1	2	3
		_____/30			_____%

HYPERACTIVITY

1	Restlessness	0	1	2	3
2	Reduced need for sleep	0	1	2	3
3	Excessive talking	0	1	2	3
4	Excessive running/jumping/climbing	0	1	2	3
5	Restlessness during sleep	0	1	2	3
6	Difficulty remaining seated	0	1	2	3
		_____/18			_____%

APPENDIX F: DCD QUESTIONNAIRE FOR PARENTS

Date: _____

The Parent

RE : QUESTIONNAIRE ABOUT YOUR CHILD'S MOTOR SKILLS

Dear Sir/Madam

Refer to previous correspondence, (Informed Consent Letter) and (Assent from your Child).

Kindly fill out the 2-page questionnaire attached, and return it to me, Pam Dawson, the researcher, via e-mail or leave it at the front office of the school.

Yours sincerely,

The Researcher : Pam Dawson

Tel : 031-7633892

Cell : 0825789986

Email: pdawson@polka.co.za

The Supervisors: T. Nadasan & P Govender

Tel : 031-2607817/2608258

Cell: 0844944880

Email: nadasant@ukzn.ac.za OR naidoopg@ukzn.ac.za

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Govan Mbeki Building

University of KwaZulu-Natal

Private Bag X 54001, Durban, 4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2602486 - Fax: 27 31 2604609

Email: BREC@ukzn.ac.za

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

**We gratefully acknowledge the financial support of the
Alberta Children's Hospital Foundation and the Alberta
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 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 (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.

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 03	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.

APPENDIX G: MABC – 1 (2007)

AGE BAND 2: 7 AND 8 YEARS

INSTRUCTIONS:

All equipment used is standardised equipment, provided in MABC test kit

The child must wear comfortable/appropriate clothing and trainers

All tests are preceded with a demonstration and practice round

1. PEG BOARD

- The child is comfortably seated at a desk. Place the peg-board on the desk.
- Lay 12 plastic pegs on the side of the board, corresponding to the preferred hand.
- The pegs should be placed on the peg-board in four, horizontal rows of 3 pegs.
- The child holds the board steady with the hand not being used.
- The above is repeated with the non-preferred hand; the position of the pegs is then on the side of the board corresponding to the non-preferred hand.
- Time is recorded with each hand.
- Two trials per hand are completed.
- A failure is recorded if the child:
 - Picks up more than 1 peg at a time.
 - Changes hand.
 - Uses two hands.

2. THREADING LACE

- The child is comfortably seated at a desk.
- Place the lace and lacing board on the desk in front of the child.
- The child chooses the preferred hand.
- The lace is threaded back and forth through the holes in the lacing board.
- Time taken to thread the lace and take up the slack is recorded.
- Two trials are recorded.
- A failure is recorded if the child:
 - (i) Laces around the edge of the board.
 - (ii) Misses a hole in the board.

3. FLOWER TRAIL

- The child is comfortably seated at a desk.
- The flower trail is placed on the desk in front of the child.
- The child draws one continuous line; following the trail.
- The child is not penalised for lifting the pen, provided he or she starts again at the point where he or she left off.
- Only the dominant hand is tested.
- Number of errors are recorded. Errors are recorded if the child:
 - (i) Crosses the boundary of the trail.

- A failure is recorded if the child:
 - (i) Picks up the pen and starts drawing away from where he or she left off.
 - (ii) Reverses direction of drawing trail (see diagram of flower trail)
- 4. ONE HAND BOUNCE AND CATCH**
- The child stands in a clear space.
 - The child bounces a tennis ball on the floor and catches it with the same hand.
 - Both hands are tested.
 - The child completes ten attempts with each hand.
 - Number of correctly executed catches out of 10 are recorded for each hand.
 - A failure is recorded if the child:
 - (i) Catches the ball with two hands
 - (ii) Catches the ball by “trapping” it against the body.
- 5. THROWING BEAN BAG INTO BOX**
- The child stands on a line; 2m away from the rectangular target box.
 - The short side of the box faces the child.
 - The child throws the bean-bag into the box, using the dominant hand.
 - Ten throws are attempted.
 - Number of correctly executed throws are recorded.
 - A failure of a trial is recorded is the child:
 - (i) Steps over the line during a throw.
- 6. BALANCE ON ONE LEG**
- The child stands in a clear space, with trainers off.
 - With the hands on the hips, the child lifts one foot up by bending the knee to 90 degrees.
 - The child remains on one leg for a maximum of twenty seconds.
 - Two trials are performed on each leg.
 - A failure is recorded if the child:
 - (i) Moves the weight-bearing foot from its original place.
 - (ii) Moves the non-standing foot away from the knee of the standing foot.
 - (iii) Takes the hands off the hip.
- 7. JUMPING IN SQUARES**
- Six adjacent squares 0,45m² are taped down on the floor.
 - The child starts with both feet in the first square.
 - The child jumps five times, continuously from square to square.
 - Each jump must be balanced and controlled.
 - Three trials are attempted and number of correct jumps out of 5 are counted.
 - Procedural faults are recorded; if the child:
 - (i) Lands on or outside the line.
 - (ii) Jumps more than once in any square.
 - (iii) Lands with feet wide apart.

8. HEEL TO TOE WALKING

- A 4,5m line is taped on the floor.
- The child walks on the line, placing the heel of one foot against the toes of the other with each step.
- Fifteen steps are taken on average.
- Three trials are attempted.
- Number of correct steps are counted; that is: steps without leaving a space between heel and toes and without stepping off the line.

MABC: AGE 7 TO 8 – SCORE SHEET

NAME: _____ GENDER: _____

POPULATION GROUP: _____ DATE: _____

1. PEG BOARD (2 trials each hand)				2. THREADING LACE (2 trials)		
Dominant		Non-Dominant		0 to 20	0	0
0 → 21	0	0 → 25	0	21 to 22	1	1
22 → 23	1	26 → 28	1	23 to 24	2	2
24	2	29 → 30	2	25 to 28	3	3
25 → 27	3	31 → 32	3	29 to 39	4	4
28 → 29	4	33 → 34	4	40+	5	5
30+	5	35+	5	(Trial 1 + Trial 2 ÷ 2)		
Average		Average				

(Dominant and non-dominant) ÷ 2 =

3. FLOWER TRAILS (2 trials)			4. ONE HAND BOUNCE & CATCH (1 trial each hand)			
Errors	Score	Hand Used: _____	Dominant	Score	Non-dominant	Score
0	0		10	0	9 to 10	0
1	1		9	1	8	1
2	2		8	2	7	2
3 to 6	3		7	3	6	3
7 to 9	4		5 to 6	4	5	4
10+	5		0 to 4	5	0 to 4	5
(Trial 2 and Trial 2) ÷ 2 =			(Dominant and non-dominant ÷ 2)			

5. THROWING BEAN-BAG (1 Trial)			6. BALANCE ON ONE LEG (2 Trials each leg)			
No. Correct	Score	Hand Used: _____	Dominant		Non-Dominant	
6 → 10	0		20	0	19-20	0
5	1		13-19	1	11-18	1
4	2		9-12	2	9-10	2
3	3		6-8	3	6-8	3
2	4		4-5	4	4-5	4
0-1	5		0-3	5	0-3	5
		Average		Average		
			(Dominant + Non-Dominant) ÷ 2 =			

7. JUMPING IN SQUARES (3 Trials)				8. HEEL TO TOE WALK (3 Trials)			
No Correct	①	②	③	No Correct			
5	0	0	0	15	0	0	0
--	1	1	1	14	1	1	1
4	2	2	2	13	2	2	2
3	3	3	3	10-12	3	3	3
2	4	4	4	7-9	4	4	4
0-1	5	5	5	0-6	5	5	5
Average				Average			

Total Score = _____ (Total Motor Impairment Score)

Under 10,5 (Child Fine)

10,5 → 14 (Borderline)

14,5 and more (Definite)

AGE BAND 3 : 9 AND 10 YEARS

INSTRUCTIONS:

- *All equipment used is standardised equipment, provided in MABC test kit*
- *The child must wear comfortable/appropriate clothing and trainers*
- *All tests are preceded with a demonstration and practice round*

1. SHIFTING PEGS BY ROWS

- The child is comfortably seated at a desk. Place the peg-board on the desk.
- Lay 12 plastic pegs on the side of the board, corresponding to the preferred hand.
- Place twelve pegs in the 2nd, 3rd and 4th rows from the top, leaving top row empty.
- The child holds the board steady with one hand and uses the other hand to transfer the pegs from the second row into the first row, the third row into the second row and the fourth row into the third row.
- Both hands are tested.
- Two trials are completed per hand.
- Time is recorded for each trial on each hand.
- A failed trial is recorded if the child:
 - (i) Moves more than one peg at one time.
 - (ii) Changes hands or uses two hands.

2. THREADING NUTS ON A BOLT

- The child is comfortably seated at a desk.
- The bolt and nuts are placed at 90° to each other on the desk.
- The child chooses which hand he/she would like to use.
- The child screws down each bolt until the first touches the fixed nut, the second touches the first and the third touches the second.
- Two trials are recorded.
- Amount of time taken to complete task is recorded.
- A failed trial is recorded if the child:
 - (i) Screws on more than 1 bolt at a time.
 - (ii) Fails to screw the bolts all the way to the fixed nut.

3. FLOWER TRAIL

- The child is comfortably seated at a desk. The flower trail is placed on the desk in front of the child.
- The child draws one continuous line; following the trail.
- The child is not penalised for lifting the pen, provided he or she starts again at the point where he or she left off.
- Only the dominant hand is tested.
- Number of errors are recorded.
- Errors are recorded if the child:
 - (i) Crosses the boundary of the trail.
- A failure is recorded if the child:
 - (i) Picks up the pen and starts drawing away from where he or she left off.
 - (ii) Reverses direction of drawing trail (see diagram of flower trail)

4. TWO-HAND CATCH

- A distance of 2m is measured from a wall and marked with tape.
- The child throws a tennis ball at the wall from behind the tape and catches it (on return) with both hands.
- The child completes ten attempts.
- Number of correctly executed attempts are recorded.
- A trial is failed if the child:
 - (i) Steps over the tape on the floor.
 - (ii) Catches the ball by trapping it against his/her body.

5. THROWING BEAN BAG INTO THE BOX

- The child stands on a line; 2,5m away from the rectangular target box (beer-box). The short side of the box faces the child.
- The child throws the bean-bag into the box, using the dominant hand.
- Ten throws are attempted.
- Number of correctly executed throws are recorded.
- A failure of a trial is recorded is the child:
 - (i) Steps over the line during a throw.

6. ONE BOARD BALANCE

- The child stands in a clear space, with trainers off.
- The balance board is placed on a non-slip surface, positioned so that the examiner has good view of child and balance board.
- The child balances on one foot, placed on balance board for up to 20 seconds.
- Both legs are tested.
- Two trials per lower limb are attempted.
- Number of seconds up to 20 seconds, are recorded.
- A procedural fault is recorded if the child:
 - (i) Tilts the board enough to allow the side to touch the floor.
 - (ii) Touches the floor with the free foot.

7. HOPPING IN SQUARES

- Six adjacent squares; 0,45m², are taped down on the floor giving an overall distance of 2,7m.
- The child begins with one leg in the first square.
- The child hops continuously 5 times from square to square. The last hop should be well-controlled.
- Both legs are tested.
- Three trials on each leg are completed.
- Number of correct hops are recorded.
- A procedural fault is recorded if the child:
 - (i) Hops on or outside the lines.
 - (ii) Hops more than once in a square.
 - (iii) Puts the free foot down.

8. BALL BALANCE

- The jump-stands are placed with a distance of 2,7m between them
- The peg-board and tennis ball are placed on a table.
- The child picks up the peg-board and ball; places the ball on the peg-board, (upside down) and the board on the palm of one hand.
- The child stands at mid-point between the two jump-stands.
- The child steadies the ball while walking around the jump-stand and then returns to starting position.
- The ball is **not** to be held by either hand.
- If the ball falls, the examiner returns it to the child.
- Only one hand is tested.
- Two trials are completed.
- The number of times, up to ten, that the ball falls, is recorded.
- A failure of a trial is recorded if the child:
 - (i) Holds the board improperly.
 - (ii) Does not resume walking from the point of the drop, after dropping the ball.
 - (iii) Uses the free hand to hold/steady the ball.

MABC: AGE 9 TO 10 – SCORE SHEET

NAME: _____

GENDER: _____

POPULATION GROUP: _____

DATE: _____

1. PEG BOARD (2 trials each hand)				2. NUTS AND BOLTS (2 Trials)		
Dominant		Non-Dominant		Time	Trial 1	Trial 2
0 → 12	0	0 → 14	0	0 → 20	0	0
13	1	15	1	21 → 23	1	1
14	2	16	2	24	2	2
15	3	17	4	25 → 28	3	3
16 to 17	4	18 to 19	4	29 → 33	4	4
18+	5	20+	5	34+	5	5
Average		Average				

(Dominant and non-dominant) ÷ 2 =

(Trial 1 and Trial 2) ÷ 2 =

3. FLOWER TRAILS (2 trials)				4. TWO HAND CATCH (1 Trial)			
Errors	Trial 1	Trial 2	Hand Used: _____	No. Correct	Score		
0	0	0			6 → 10	0	
1	1	1			5	1	
-	2	2			4	2	
2	3	3			3	3	
3	4	4			1-2	4	
4+	5	5			0	5	

(Trial 1 and Trial 2) ÷ 2 =

5. THROWING BEAN-BAG (1 Trial)				6. ONE BOARD BALANCE (2 trials each leg)			
No. Correct	Score	Hand Used: _____		Dominant		Non-Dominant	
5 → 10	0			6 → 20	0	6 → 20	0
4	1			5	1	5	1
3	2			4	2	4	2
2	3			3	3	3	3
-	4			2	4	2	4
0 → 1	5			0 → 1	5	2	4
			Average		Average		

(Dominant + Non-Dominant) ÷ 2 =

7. HOPPING IN SQUARES (3 Trials)								8. BALL BALANCE (2 trials)			
Dominant				Non-Dominant				No. Falls	1	2	Hand Used: _____
5	0	0	0	5	0	0	0	0	0		
-	-	-	-	-	-	-	-	-	-		
-	-	-	-	4	2	2	2	1	2		
4	3	3	3	3	4	4	4	2	3		
1-3	4	4	4	1-2	4	4		3-4	4		
0	5	5	5	0	5	5	5	5+	5		
Average											

(Trial 1 and Trial 2) ÷ 2 =

(Dominant + Non-Dominant) ÷ 2

Total Score =

=

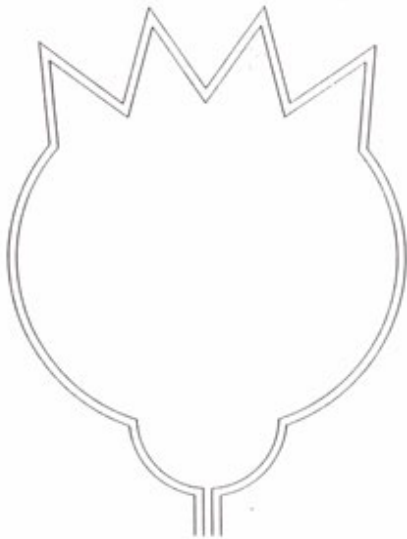
(Total Motor Impairment Score)

Under 10,5 (Child Fine)

10,5 → 14 (Borderline)

14,5 and more (Definite)

FLOWER TRAIL



START HERE

Name

FLOWER TRAIL



START HERE

Name

FLOWER TRAIL



START HERE

Name

APPENDIX H: PERMISSION FROM PEARSON FOR USE OF DCD-Q (2007) AND MABC-1/2 (2007)

Pam Dawson

From: Robert Craig [info@pearsonclinical.co.uk]
Sent: 11 June 2018 05:21 PM
To: pdawson@polka.co.za
Subject: [#CYY-948-44790]: Re: Request for URGENT permission from Pearson Clinical to utilise the DCD-Q and MABC-2(2007)/URGENT

Flag Status: Flagged

Dear Pam,

Thank you for your enquiry.

For DCD-Q please contact Brenda Wilson at info@dcdq.ca and/or visit <http://www.dcdq.ca/cross-cultural-adaptations/permission-for-new-translations-and-cross-cultural-adaptations.html>

If you are seeking permission to reproduce copyright material from Movement Assessment Battery for Children - Second Edition (Movement ABC-2), we receive a high volume of these requests and for this reason require them to be submitted via the permissions form found on the page below which submits them to us in a standard format with all of the info we require to consider the request. I also note that you've attached your own permission document, this is something we aren't able to sign. If permission is granted, Pearson will send an agreement to be signed.

<https://www.pearsonclinical.co.uk/Psychology/ChildCognitionNeuropsychologyandLanguage/ChildPerceptionandVisuomotorAbilities/MABC-2/ForThisProduct/Permissions.aspx>

Kind regards,

Robert Craig
Head of Clinical
0845 630 88 88 (Mon to Fri, 8.30am to 5pm)
(Calls cost 3p per minute plus your phone company's access charge)

Learn more at pearsonclinical.co.uk

Ticket Details

Ticket ID: CYY-948-44790
Department: Pearson Clinical - UK
Type: Email
Status: Closed

Helpdesk:

Pam Dawson

From: bill.schryver@pearson.com on behalf of Licensing, - [pas.licensing@pearson.com]
Sent: 12 June 2018 04:17 PM
To: pdawson@polka.co.za
Subject: Fwd: Request for URGENT permission from Pearson Clinical to utilise the DCD-Q and MABC-2(2007)/URGENT
Attachments: Request for Permission from Pearson Clinical.pdf
Flag Status: Flagged

Dear Ms Dawson,

Your request has been forwarded to me for response and I have the following comments.

The MABC (Movement Assessment Battery for Children, Second Edition (Movement ABC2) is owned by Pearson Clinical in the United Kingdom, and you must request your permission at this link: <https://www.pearsonclinical.co.uk/Psychology/ChildCognitionNeuropsychologyandLanguage/ChildPerceptionandVisuomotorAbilities/MABC-2/ForThisProduct/Permissions.aspx>

Pearson in the US has no licensing or permission rights to the test. However, permission to use any Pearson test is inherent in the qualified purchase of the test materials in sufficient quantity to meet your research goals.

For the Developmental Coordination Disorder Questionnaire (DCDQ) the copyright is owned by Brenda N. Wilson, and it is not a Pearson assessment.

However, on the DCDQ internet site it seems that the questionnaire and the Administration Manual are available for download free-of-charge, and no permission is needed.

The link to the DCDQ site is: <http://www.dcdq.ca/>

Regards,

William H. Schryver
Senior Legal Licensing Specialist

Please respond only to pas.licensing@pearson.com

----- Forwarded message -----

From: Pam Dawson <pdawson@polka.co.za>
Date: Tue, May 22, 2018 at 6:58 AM
Subject: Re: Request for URGENT permission from Pearson Clinical to utilise the DCD-Q and MABC-2(2007)/URGENT
To: licensingcanada@pearson.com

Dear Sir/Madam

Hope you are well.

Please see attached Request for Permission from Pearson Clinical to utilise the DCD-Q(2001) and MABC-2(2007).

Please , if you are unable to authorise , are you able to provide the correct e mail address for a person/place to whom I could

address this request to .

Thanking you (in advance) for all your help in this matter. It is much appreciated.

Keep Well and Kind Regards.

Pam Dawson(Master of Physiotherapy)

Cell: 27 82 578 9986

APPENDIX I: CONSENT FROM EXPERTS IN DELPHI TECHNIQUE

<p>DECLARATION OF CONSENT</p>

I _____ a physiotherapist/Occupational Therapist/Educational Psychologist consent to being on the panel of experts, to validate the exercise programme to be used as an intervention in this research study.

I understand the purpose and procedure of this study.

I give consent to the PI to send me the “package”.

Signature of Professional/Expert

Date

Signature of Witness

Date

Signature of Translator

Date

APPENDIX J: DELPHI TECHNIQUE FOR FIRST CONSENSUS PHASE

Dear Respondent,

Please refer to the attached Exercise Programme (Appendix H) to rate the statements below on the Likert Scale. When completed, please scan and email to pdawson@polka.co.za

Round 1

Indicator 1: Exercise 1 – Crawling is a good exercise to build muscle tone, to enhance gross motor co-ordination, improve balance and build core muscles.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 2: Exercise 2 – Balance in crawl position is a good exercise to improve balance; build muscle tone and enhance core stability

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 3: Exercise 3 – Abdominal crunches is a good exercise to build core stability and thus enhance good posture.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 4: Exercise 4 - Bridging in supine lying is a good exercise to build core stability and thus enhance good posture.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 5: Exercise 5 – Half-kneeling balance is a good exercise to improve balance, enhance gross motor co-ordination and improve posture.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 6: Exercise 6 – Hopping is a good exercise to enhance balance and improve gross motor co-ordination.

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 7: Exercise 7 – Tandem/heel-to-toe walking is a good exercise to improve balance and enhance gross motor co-ordination and visual motor integration. (eye foot co-ordination)

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 8: Exercise 8 – This ball skill is a good exercise to improve visual motor integration/eye foot co-ordination and enhance gross motor co-ordination.

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 9: Exercise 9 – DDK is a good exercise to improve and enhance fine motor activities.

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 10: Exercise 10 – Thursday’s or opposition exercise is a good exercise to improve fine motor activities and enhance visual motor integration/eye hand co-ordination.

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 11: Exercises in this programme collectively address the MAIN problem areas in DCD: Core stability, posture, gross motor; balance; fine motor and visual motor.

Scale	1	2	3	4	5	6	7	8	9
Definitely			Uncertain				Definitely		
Not							So		

Indicator 12: It is sufficient to administer the exercise programme once a week, for research purposes.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 13: There are sufficient repetitions of each exercise in the programme.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 14: 8 weeks of intervention will be adequate to test whether exercises produce a positive change in the symptoms of co-morbid ADHD and DCD.

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Indicator 15: A 30-minute exercise programme as described in Appendix H; is long enough in duration. (considering children with DCD tire easily)

Scale	1	2	3	4	5	6	7	8	9
	Definitely				Uncertain				Definitely
	Not								So

Any other comments:

APPENDIX K (i): FIRST PROTOTYPE OF EXERCISE INTERVENTION FOR CHILDREN WITH ADHD AND DCD

This exercise programme will be administered to those children; whose parents/GP/Paediatrician chose the exercise route and the combination of exercises plus neurostimulant drugs. The exercises will be administered once per week; to a group of about 6 to 8 children; for 30 minutes per session.

Exercises will be administered for 8 weeks. Children will be barefoot and comfortably clad. The exercises will be administered in a suitable area, for example a gymnasium or a school hall, free from any clutter or potential danger.

	Exercise	Equipment	Instructions	Repetitions	Effect
1	Crawling	Exercise mat	The child must assume a hands and knees position, with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle. The instruction to the child is to form a “coffee-table”. The child must then crawl forwards and backwards maintaining the same distance between the hands and knees at all times. The child must also look up while doing the exercise. With sideways crawling; align the child’s feet to one line and the knees to another line in order to maintain the same distance between the hands and knees. The child must crawl sideways towards the right and then towards the left.	4m forwards, 4m backwards x2 4m sideways to the right then 4m sideways to the left x2	Building muscle tone by joint compression through weight bearing Enhancing Gross Motor coordination Improving Balance Building core stability
2	Balance in crawl position (superman)	Exercise mat	The child must assume the hands and knees position with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle. The instruction to the child is once again to form a “coffee-table”. The child is then asked to lift the right arm and the left leg and hold the limbs level with the back and in full extension (elbow and knee straight) for about 10 seconds. The child then changes sides. If the child is unable to hold for any length of time: the therapist can start by getting the child to lift just one limb at a time or by giving minimal assistance to the child.	x3 of right leg, left arm and x3 of left leg, right arm	Improving Balance Building muscle tone Building core stability

3	Abdominal crunches	Exercise mat	<p>The child lies supine (on his/her back) on a comfortable floor-mat with both the knees bent. The child is instructed to place the arms in the air, tuck the chin in and lift the head and shoulders up. This position is held for the count of ten seconds. A few repetitions are performed to strengthen the straight abdominal muscles followed by diagonal crunches to strengthen the oblique abdominals.</p> <p>The child may initially need assistance.</p> <p>He/she may complain of neck pain as the neck muscles will tend to overwork until the abdominal muscles gain sufficient strength. If neck pain occurs, the child's neck should be offered some support.</p>	<p>x 3 central x 3 diagonal to right x 3 diagonal to left</p>	<p>Building Core stability</p> <p>Improving Posture by building core muscles</p>
4	Bridging	Exercise mat	<p>The starting position is the same as for abdominal crunches but the child keeps the arms down for this exercise. The buttocks are then raised and the position is held for the count of ten seconds. Check that the child does not raise the heels or arch the back.</p>	x7 of each	<p>Building Core muscles</p> <p>Improving posture by building core muscles</p>
5	Half kneeling Balance	Exercise mat	<p>From the kneeling down position, the child must raise one knee and place it in front of him/her with the hip and knee at ninety degrees and the foot on the floor. This position is maintained for ten seconds or more.</p> <p>When one knee has been raised, this knee is lowered and the child resumes the kneeling position. The exercise is then repeated with the other knee. If needed, the child may use some support initially.</p>	x3 on each side	<p>Improving Balance</p> <p>Enhancing Gross Motor Coordination</p> <p>Improving Posture by encouraging good body position during this exercise.</p>
6	Hopping	Smooth floor	<p>If the child is unable to hop; start with providing support and facilitate jumping on one leg. Next, progress to hopping on the spot, both with support and then without support. The progression from this is hopping over a distance with support and then without support.</p>	x 1 minute each leg of whatever type of hopping the child can manage	<p>Enhancing Gross Motor coordination</p> <p>Improving Balance</p>

			Finally the child is asked to hop a distance, turn and hop back. All hopping is repeated on both legs. The therapist must check that the child is getting sufficient lift-off and that there is a certain amount of “spring” as opposed to a heavy landing during all the hopping activities.		
7	Tandem walking (heel to toe)	Line on a tiled floor or a balance beam	The child is asked to walk along a line, on the floor, heel to toe. The child must place the heel close to the toes, leaving no gaps between the heel and the toes. The child might at first require assistance/support. The child must try not to overbalance or place either foot on either side of the line.	Distance of 4m then turn and go back Repeat twice.	Improving Balance Enhancing Gross Motor Co ordination Improving Visual Motor/eye-foot co-ordination.

8	Ball skill	23cm plastic ball Exercise mat	This exercise is to be done between two children; whilst both children are half-kneeling. The children are 2m apart. Firstly, the ball is thrown in the air, then it is thrown with a bounce.	X10 throws in the air X10 throws with a bounce.	Improving Visual Motor/eye-hand co-ordination. Enhancing Gross Motor co-ordination.
9	DDK (Diadochokinesis)	Desk and chair	The child must sit at a desk (suitable height) and bend his/her elbows to 90 degrees with the palms of the hands flat on the table. The hands are then turned over rapidly so that the back of the hand then rests on the table then the palm of the hand repetitively. This primarily exercises the two joints between the forearm bones (radio-ulna joints) which are important in determining end product of fine motor movements.	x 1 min of activity	Enhancing Fine Motor activities.
10	Thursday's or opposition exercise		The child is instructed to oppose the tip of the thumb to the tip of each finger starting with the index finger through to the little finger then back to the index finger. This must be done as accurately and as quickly as possible. A few repetitions are done on the one hand then the other hand and then both hands together.	3 repetitions on right hand, 3 repetitions on left hand then 3 reps with both hands together.	Enhancing Fine Motor activities. Improving Visual Motor/eye-hand co-ordination.

APPENDIX K(ii) : ROUND TWO OF DELPHI PROCESS

Dear Colleague

I am Pam Dawson, a physiotherapist doing my PHD on “The Effects of Exercise Therapy on the Co-Morbidity of ADHD and DCD”

For this purpose I have drafted the exercise programme which follows in the table.

Please could I request that you kindly provide your expert opinion on the various aspects of this draft exercise programme, by ticking under the Y (Yes) column on N (No) column? Please feel free to give your comments as well.

Please note that certain exercises were omitted, since they form part of the items tested in the MABC, which will be utilised to derive pre- and post-intervention scores.

Thanking you so much for filling this in.

I will liaise with you for collection of the completed questionnaire.

Kind Regards

PAM DAWSON

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(082 578 9986)

1.	EXERCISES: NAME AND DESCRIPTION		FOCUS and EFFECTS/LITERATURE	QUESTION	Y	N	COMMENTS
1.1	<p>Sit-ups/Abdominal Crunches This child lies in supine (on his/her back) on a comfortable floor-mat with both the knees bent. The child is instructed to place the arms in the air (45 to 50 degrees shoulder flexion), tuck in the chin and to lift the head and shoulders up, off the floor. This position is held for the count of ten seconds. A few repetitions (see below) are performed to strengthen the straight abdominal muscles followed by diagonal crunches to strengthen the oblique abdominals. The child may initially need assistance. Progression: Independently executed exercise, described above. He/she may complain of neck pain as the neck muscles will tend to overwork until the abdominal muscles gain sufficient strength. If neck pain occurs, the child's neck should be offered some support.(from the therapist or by the therapist teaching the child how to support his or her own neck) x 3 straight crunches. x 3 oblique crunches towards the right x 3 oblique crunches towards the left</p>	1. 2.	<p>Core (abdominal or flexor muscle) strengthening Improvement of anti-gravity postures eg: sitting/standing. (Lin et al; 2015)</p>	<p>Do you feel that abdominal crunches serve the purpose of strengthening the flexor core muscles and thus improving the anti-gravity postures?</p> <p>Do you feel that the number of repetitions are adequate?</p>			
1.2	<p>Bridges This starting position is the same as for abdominal crunches, in 1.1 above (that is: crook lying) but the child keeps the arms on the floor, for this exercise. The buttocks are then raised and the position is held for the count of ten seconds. Check that the child does not raise the heels or arch the back. The child may initially need assistance. Progression: The child performs a full bridge with no assistance. Repeat x 7</p>	1. 2. 3.	<p>Core (extensor muscle) strengthening Improvement of anti-gravity postures eg: sitting/standing. (Lin et al; 2015) Weight-bearing through the pelvic girdle normalizes muscle tone (Shepherd and Carr; 2018)</p>	<p>Do you feel that bridges are effective in strengthening the core muscles (Extensor), improving anti-gravity postures and normalizing lower limb muscle tone?</p> <p>Do you feel that the number of repetitions are adequate?</p>			
1.3	<p>Superman The child must assume the hands and knees/crawl position, with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle, hips, knees and shoulders at 90 degrees. The instruction to the child is to form a "coffee-table". The child is then asked to lift the right arm and the left leg and hold the limbs level with the back and in full extension</p>	1. 2. 3. 4.	<p>Core(extensor muscle) strengthening Improvement of Static and Dynamic Balance Enhancement of bilateral integration by involving integrated movement of opposite upper limb, lower limb and the trunk. Proprioceptive input to the weight bearing joints, (hands and knees),</p>	<p>Do you feel that the "Superman" exercise is effective in achieving the 5 areas of focus outlined?</p>			

	<p>(elbow and knee straight) for 10 seconds.</p> <p>The child then changes sides.</p> <p>If the child is unable to hold for any length of time: the therapist can start by getting the child to lift just one limb at a time or by giving minimal support to the child.</p> <p>Progression: The child then progresses to executing the full exercise as described above, without assistance.</p> <p>X 3 right arm; left leg lifted. X 3 left arm; right leg lifted.</p>	5.	<p>thus enhancement of sensory integration.</p> <p>Weight-bearing, on the joints of the supporting limbs, thus normalization of muscle tone. (Shepherd and Carr; 2018)</p>	Do you feel that the number of repetitions are adequate?		
1.4	<p>Crawling</p> <p>The child must assume a hands and knees/crawl position, with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle. Hips, knees and shoulders at 90 degrees.</p> <p>The instruction to the child is to form a “coffee-table”. The child must then crawl forwards and backwards maintaining the same distance between the hands and knees at all times. The child must also look up while executing this exercise.</p> <p>With sideways crawling; align the child’s hands to one line and the knees to another line in order to maintain the same distance between the hands and knees.</p> <p>The child must crawl sideways towards the right and then sideways towards the left.</p> <p>4m forwards 4m backwards 4m sideways to the right and then 4m sideways to the left</p>	1. 2. 3. 4. 5. 6.	<p>Core (extensor muscle) strengthening</p> <p>Enhancement of bilateral integration by contralateral movement of the upper limbs, lower limbs and the trunk</p> <p>Gross motor skills are improved in co-ordinating contralateral movement of the upper limbs, lower limbs and the trunk.</p> <p>Proprioceptive input is provided to the weight-bearing joints, (the hands and knees) thus enhancement of sensory integration occurs.</p> <p>Weight-bearing on the joints of the supporting limbs, thus normalisation of muscle tone</p> <p>Motor planning is enhanced in co-ordinating the contralateral movement of all the limbs. (A.Pienaar et al; 2011)</p>	Do you feel that crawling is effective in achieving the 6 areas of focus outlined?		
1.5	<p>Ball</p> <p>This exercise is to be executed between two children; whilst both children are in the half-kneeling position, (two point kneeling with one lower limb raised, with the knee of the raised lower limb in 90 degrees flexion and the foot in neutral position.)</p> <p>The children are 2m apart.</p> <p>Firstly, the ball is thrown between the two children, in the air, ten times, with the right lower limb lifted/placed anteriorly.</p> <p>The ball is then thrown between the two children, with a bounce, ten times, with the left lower limb lifted/placed anteriorly.</p> <p>If the child cannot cope with this, he/she can start with 2 point kneeling.</p> <p>Progression: The child can then adopt the half kneeling position, as described above.</p> <p>A 23cm plastic ball is used. x10 throws in the air x 10 throws with a bounce</p>	1. 2. 3.	<p>Eye-hand co-ordination is enhanced by the visual/sensory input of watching the ball and then by the motor output of throwing/catching the ball.</p> <p>Motor Planning is enhanced by throwing and catching with the correct speed and accuracy and in the correct direction.</p> <p>Improvement of Static and Dynamic Balance is enhanced, due to maintenance of the half kneeling position. (A. Pienaar et al; 2011)</p>	Do you feel that ball throwing and catching; as described; whilst half-kneeling is effective in achieving the 3 areas of focus outlined?		

1.6	<p>Half-Kneeling Balance</p> <p>From the two point kneeling position, the child must raise the right knee and place it in front of him/her with the hip and knee of the raised lower limb, at ninety degrees and the foot in neutral position on the floor. This position is maintained for 10 seconds.</p> <p>When the right knee has been raised, this knee is then lowered and the child resumes the two point kneeling position. The exercise is then repeated with the left knee.</p> <p>If needed, the child may initially use some support.</p> <p>Progression: Performance of the exercise without support. X 3 with right leg raised. X 3 with left leg raised.</p>	1. 2. 3.	<p>Improvement of Static and Dynamic Balance (by reducing the size of the base and by shifting the centre of gravity (COG) away from centre of the base. (COB)</p> <p>Gross motor skills are improved in co-ordinating use of the large muscles and balance, to perform the activity.</p> <p>This is a Functional activity, which enhances getting up into standing position, from sitting on the floor. (T. Gasser et al; 2010)</p>	<p>Do you feel that this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the number of repetitions are adequate?</p>			
1.7	<p>Wheelbarrow</p> <p>The children work in pairs. Child A assumes the four point kneeling/crawl position, as described in 1.3 and 1.4 above. Child B grasps Child A at the ankles. Child A must walk a distance of 4m forwards, on his/her hands and then 4m backwards in the same manner. The therapist must watch that Child A does not arch his/her back.</p> <p>The children then swap over. If either child battles with being the wheelbarrow, Child B can support Child A at the thighs.</p> <p>Progression: The grasp is then altered to hold the ankles. This is repeated X2.</p>	1. 2. 3.	<p>Core (extensor muscle) strengthening</p> <p>Normalisation of muscle tone of the upper limbs, through weight-bearing on the shoulder girdle</p> <p>Tone normalisation of the shoulder girdle has a spin-off on improving fine motor activities (Shepherd and Carr; 2018)</p>	<p>Do you feel that this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the distances covered are adequate?</p>			
1.8	<p>Toe Walking Forwards (FW) and Backwards (BW)</p> <p>Each child must assume the close standing position, on tip-toes, with the knees extended and with good posture. (Back extended and chin up) They must then walk a distance of 4m FW then 4m BW. Progression: The distance can initially be less than 4m, then progress to the 4m. Repeat X2</p>	1. 2.	<p>Static and Dynamic Balance is enhanced (by raising the COG away from the base of support and by reducing the size of the base)</p> <p>Gross motor skills are improved by co-ordinating use of the large muscles and balance to perform the activity. (A.Pienaar et al; 2011)</p>	<p>Do you feel that this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the distances covered are adequate?</p>			
1.9	<p>Jumping or Hopping Over an Object</p> <p>6 Hula Hoops are placed adjacent to each other, on the ground. (in a long row)</p> <p>The child/children are told to hop over the hoop and into the middle of the hoop. They must then jump into hoop 2; hop into hoop 3; jump into hoop 4; etc.</p>	1. 2.	<p>Gross motor skills are improved by co-ordinating use of the large muscles and balance, to perform the activity.</p> <p>Eye-foot co-ordination is enhanced by the visual/sensory input of watching where the hoop and foot/feet are and motor output of performing the jump or hop into the middle of the hoop.</p>	<p>Do you feel that this exercise is effective in achieving the areas of focus outlined?</p>			

	<p>Progression: The child can initially start with jumping only followed by introducing both jumping and hopping. Repeat x 2</p>	<p>3. 4. 5.</p>	<p>Improvement of Static and Dynamic Balance (hopping) Motor planning is enhanced, by ensuring accuracy in planning which hoop to jump into and which hoop to hop into. Also, in planning how high to hop/jump so as to avoid touching the hoops. Sensory integration is enhanced by integrating the visual (where the hoops are) and proprioceptive (weight bearing on the lower limbs during hopping and jumping) stimuli, with the appropriate motor output. (jumping or hopping) (T. Gasser et al; 2010) (A. Pienaar et al; 2011)</p>	<p>Do you feel that the number of repetitions are adequate?</p>		
1.10	<p>Star-Jumps The child starts in close standing, with good posture (back extended and chin up) arms at the side. The child then jumps to land with the legs apart and arms up in a “V” shape. The child then jumps to resume the starting position. Progression: This exercise can be started slowly and with slightly less repetitions than the required 10. It can then be progressed by increasing speed and building up to ten repetitions. Repeat X10.</p>	<p>1. 2. 3. 4. 5.</p>	<p>Gross motor skills are improved by co-ordinated use of the large muscles, to perform the activity accurately and rhythmically. Eye-hand co-ordination and eye-foot co-ordination is enhanced by the visual/sensory input of watching where the limbs are placed, to determine the motor output of performing the actual starjump. Motor planning is enhanced by ensuring correct placing of the lower and upper limbs, with correct timing/speed. Sensory integration is enhanced by integrating the visual and proprioceptive information, from the present position of the limbs, to produce the motor action of the next movement/position of the limbs. Endurance is increased, in that this is a strenuous exercise, done with quite a few repetitions (X10), with a bit of speed. (A.Pienaar; 2011)</p>	<p>Do you think this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the number of repetitions are adequate?</p>		
1.11	<p>DDK/DIADOCHOKINESIS The child must sit at a desk (suitable height) and bend his/her elbows to 90 degrees with the palms of the hands flat on the table. The hands are then turned over rapidly so that the entire back of the hand then rests on the table then the palm of the hand repetitively. This primarily exercises the two joints between the forearm bones (radio-ulna joints) which are important in determining the hand position and thus quality of fine motor movements. Progression: This exercise can be started slowly then progressed, by speeding the activity up.</p>	<p>1. 2. 3.</p>	<p>Eye-hand co-ordination is improved by the visual/sensory input of watching the position of the hands, to determine accuracy of the motor output/next movement. Improves hand dexterity, thereby facilitating fine motor activity. Improves endurance for hand activities, by encouraging quick repetitive movements. (T. Gasser et al; 2010.)</p>	<p>Do you think this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the number of repetitions are adequate?</p>		

	This is done 10 times. 2 rotations.					
1.12	<p>Opposition The child is instructed to oppose the tip of the thumb to the tip of each finger starting with the index finger through to the little finger then back to the index finger. This must be done as accurately and as quickly as possible.</p> <p>Progression: The exercise can initially be executed with the dominant hand alone, then progressed by doing the non-dominant hand. Further progression can be the execution of the activity with both hands together. Progression can also be achieved by increasing speed of the activity.</p> <p>3 repetitions on right hand. 3 repetitions on left hand. 3 repetitions with both hands together.</p>	<p>1.</p> <p>2.</p>	<p>Eye-hand co-ordination is enhanced by the Visual/sensory input of watching the position of the fingers, to ensure accuracy thereof. Improves hand dexterity thereby facilitating fine motor skills. (T. Gasser et al; 2010)</p>	<p>Do you think this exercise is effective in achieving the areas of focus outlined?</p> <p>Do you feel that the number of repetitions are adequate?</p>		
2.1	<p>2. STRUCTURE OF PROGRAMME Repetition of Programme The same programme of 12 exercises will be repeated for 8 weeks.</p>		<p>This works on the basis of neuroplasticity: A specific skill is taught repetitively; the child can improve that motor skill, which can then become a permanent change/an improved motor skill. (Nahum et al; 2013)</p>	<p>Do you agree that the programme must be repeated (for motor learning purposes)?</p>		
2.2	<p>Duration of Course of Intervention The sessions will be run once a week, over 8 weeks</p>		<p>Kolesky (2017) completed a systematic review, from which the following was established, on frequency of repeating an exercise intervention: Bardid et al (2015): twice per week x 10 weeks Peens et al (2007): twice per week x 8 weeks Satre et al (2009): three times per week; x 10 weeks Maharaj et al (2016): Once per week, for 8 weeks. All of these interventions sited above, irrespective of duration, produced a substantial improvement in motor skill scores.</p>	<p>“The intervention once a week; for 8 weeks is adequate for this particular study.” Do you agree, with this statement?</p>		
2.3	<p>Group Therapy The intervention will take place in a group of maximum 8 children.</p>		<p>The literature sites the following advantages of group exercise intervention, for children with co-ordination difficulties: Significant improvement in motor skills, occurred, administering interventions, having same sort of exercises, in a similar sized, group set-up. There are both psychosocial and motivational benefits of group exercise therapy. Healthy competition motivates participants. (Morton, 2015)</p>	<p>Do you agree with the administration of the intervention, in a group set-up?</p>		

2.4	Effect of Exercise on ADHD/ADD The exercise intervention will alleviate symptoms of inattention, impulsivity and hyperactivity		Evidence in the literature suggests that exercises may be a beneficial, additional or alternative treatment option for patients with ADHD. (Den Heijer et al; 2016)	Do you agree with the statement made under the description?		
2.5	Symptoms This exercise intervention was designed to assist with all the symptoms of DCD.		Main symptoms of DCD according to Nelson; (2015). Reduced muscle tone 1. Reduced muscle power 2. Gross motor co-ordination 3. Fine motor co-ordination 4. Poor balance 5. Poor visual motor (eye-hand /eye-foot) 6. Postural problems 7. Poor core stability 8. Bilateral and Sensory integration 9. Motor planning 10.	Do you agree to the following statement: The exercises in this programme assist with all the symptoms of DCD, as listed. Please tick "Yes" or "No", next to each symptom:		1 2 3 4 5 6 7 8 9 10

APPENDIX Kiii: FINAL EXERCISE INTERVENTION

Children to be barefoot and comfortably clad. Exercises to be administered to a group of 6 to 8 children in a suitable area; free from any clutter. To be administered once a week, for 8 weeks.

1.	EXERCISES: NAME AND DESCRIPTION	FOCUS and EFFECTS/LITERATURE
1.1	<p>Sit-ups/Abdominal Crunches</p> <p>This child lies in supine (on his/her back) on a comfortable floor-mat with both the knees bent. The child is instructed to place the arms in the air (45 to 50 degrees shoulder flexion), tuck in the chin and to lift the head and shoulders up, off the floor. This position is held for the count of ten seconds. A few repetitions (see below) are performed to strengthen the straight abdominal muscles followed by diagonal crunches to strengthen the oblique abdominals.</p> <p>The child may initially need assistance. Progression: Independently executed exercise, described above.</p> <p>He/she may complain of neck pain as the neck muscles will tend to overwork until the abdominal muscles gain sufficient strength. If neck pain occurs, the child's neck should be offered some support.(from the therapist or by the therapist teaching the child how to support his or her own neck)</p> <p>Total of 3 to 5 repetitions dictated by individual ability.</p>	<ol style="list-style-type: none"> 1. Core (abdominal or flexor muscle) strengthening 2. Improvement of anti-gravity postures eg: sitting/standing. (Lin et al; 2015)
1.2	<p>Bridges</p> <p>This starting position is the same as for abdominal crunches, in 1.1 above (that is: crook lying) but the child keeps the arms on the floor, for this exercise. The buttocks are then raised and the position is held for the count of ten seconds. Check that the child does not raise the heels or arch the back. The child may initially need assistance.</p> <p>Progression: The child performs a full bridge with no assistance.</p> <p>Repeat x 7</p>	<ol style="list-style-type: none"> 1. Core (extensor muscle) strengthening 2. Improvement of anti-gravity postures eg: sitting/standing. (Lin et al; 2015) 3. Weight-bearing through the pelvic girdle influences muscle tone (Shepherd and Carr; 2018)
1.3	<p>Superman</p> <p>The child must assume the hands and knees/crawl position, with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle, hips, knees and shoulders at 90 degrees.</p> <p>The instruction to the child is to form a "coffee-table". The child is then asked to lift the right arm and the left leg and hold the limbs level with the back and in full extension (elbow and knee straight) for 10 seconds.</p> <p>The child then changes sides.</p> <p>If the child is unable to hold for any length of time: the therapist can start by getting the child to lift just one limb at a time or by giving minimal support to the child.</p> <p>Progression: The child then progresses to executing the full exercise as described above, without assistance.</p> <p>X 3 right arm; left leg lifted.</p> <p>X 3 left arm; right leg lifted.</p>	<ol style="list-style-type: none"> 1. Core(extensor muscle) strengthening 2. Improvement of Static and Dynamic Balance 3. Enhancement of bilateral integration by involving integrated movement of opposite upper limb, lower limb and the trunk. 4. Proprioceptive input to the weight bearing joints, (hands and knees), thus enhancement of sensory integration. 5. Weight-bearing, on the joints of the supporting limbs, thus normalization of muscle tone. (Shepherd and Carr; 2018) 6. Focus/Attention.
1.4	<p>Crawling</p> <p>The child must assume a hands and knees/crawl position, with equal weight distribution on the hands/shoulder girdle and the knees/pelvic girdle. Hips, knees and shoulders at 90 degrees.</p> <p>The instruction to the child is to form a "coffee-table". The child must then crawl forwards and backwards maintaining the same distance between the hands and knees at all times.</p> <p>The child must also look up while executing this exercise.</p> <p>With sideways crawling; align the child's hands to one line and the knees to another line in order to maintain the same distance between the hands and knees.</p> <p>The child must crawl sideways towards the right and then sideways towards the left.</p> <p>4m forwards</p> <p>4m backwards</p> <p>4m sideways to the right and then 4m sideways to the left</p>	<ol style="list-style-type: none"> 1. Core (extensor muscle) strengthening 2. Enhancement of bilateral integration by contralateral movement of the upper limbs, lower limbs and the trunk 3. Gross motor skills are improved in co-ordinating contralateral movement of the upper limbs, lower limbs and the trunk. 4. Proprioceptive input is provided to the weight-bearing joints, (the hands and knees) thus enhancement of sensory integration occurs. 5. Weight-bearing on the joints of the supporting limbs, thus normalisation of muscle tone 6. Motor planning is enhanced in co-ordinating the contralateral movement of all the limbs. (A.Pienaar et al; 2011)

1.5	<p>Ball This exercise is to be executed between two children; whilst both children are in the half-kneeling position, (two point kneeling with one lower limb raised, with the knee of the raised lower limb in 90 degrees flexion and the foot in neutral position.) The children are 2m apart. Firstly, the ball is thrown between the two children, in the air, ten times, with the right lower limb lifted/placed anteriorly. The ball is then thrown between the two children, with a bounce, ten times, with the left lower limb lifted/placed anteriorly. If the child cannot cope with this, he/she can start with 2 point kneeling. Progression: The child can then adopt the half kneeling position, as described above. A 23cm plastic ball is used. x 10 throws in the air x 10 throws with a bounce</p>	1. 2. 3. 4.	<p>Eye-hand co-ordination is enhanced by the visual/sensory input of watching the ball and then by the motor output of throwing/catching the ball. Motor Planning is enhanced by throwing and catching with the correct speed and accuracy and in the correct direction. Improvement of Static and Dynamic Balance is enhanced, due to maintenance of the half kneeling position. (A. Pienaar et al; 2011) Enhances posture</p>
1.6	<p>Half-Kneeling Balance From the two point kneeling position, the child must raise the right knee and place it in front of him/her with the hip and knee of the raised lower limb, at ninety degrees and the foot in neutral position on the floor. This position is maintained for 10 seconds. When the right knee has been raised, this knee is then lowered and the child resumes the two point kneeling position. The exercise is then repeated with the left knee. If needed, the child may initially use some support. Progression: Performance of the exercise without support. x 3 with right leg raised. x 3 with left leg raised. If child can manage, increase to 5 repetitions with each leg.</p>	1. 2. 3.	<p>Improvement of Static and Dynamic Balance (by reducing the size of the base and by shifting the centre of gravity (COG) away from centre of the base. (COB) Gross motor skills are improved in co-ordinating use of the large muscles and balance, to perform the activity. This is a Functional activity, which enhances getting up into standing position, from sitting on the floor. (T. Gasser et al; 2010)</p>
1.7	<p>Wheelbarrow The children work in pairs. Child A assumes the four point kneeling/crawl position, as described in 1.3 and 1.4 above. Child B grasps Child A at the ankles. Child A must walk a distance of 4m forwards, on his/her hands and then 4m backwards in the same manner. The therapist must watch that Child A does not arch his/her back. The children then swap over. If either child battles with being the wheelbarrow, Child B can support Child A at the thighs. Progression: The grasp is then altered to hold the ankles. This is repeated x2.</p>	1. 2. 3.	<p>Core (extensor muscle) strengthening Normalisation of muscle tone of the upper limbs, through weight-bearing on the shoulder girdle Tone normalisation of the shoulder girdle has a spin-off on improving fine motor activities (Shepherd and Carr; 2018)</p>
1.8	<p>Toe Walking Forwards (FW) and Backwards (BW) Each child must assume the close standing position, on tip-toes, with the knees extended and with good posture. (Back extended and chin up) They must then walk a distance of 4m FW then 4m BW. Progression: The distance can initially be less than 4m, then progress to the 4m. Repeat x2</p>	1. 2.	<p>Static and Dynamic Balance is enhanced (by raising the COG away from the base of support and by reducing the size of the base) Gross motor skills are improved by co-ordinating use of the large muscles and balance to perform the activity. (A.Pienaar et al; 2011)</p>
1.9	<p>Jumping or Hopping Over an Object 6 Hula Hoops are placed adjacent to each other, on the ground. (in a long row) The child/children are told to hop over the hoop and into the middle of the hoop. They must then jump into hoop 2; hop into hoop 3; jump into hoop 4; etc. Progression: The child can initially start with jumping only followed by introducing both jumping and hopping. Repeat x 2</p>	1. 2. 3. 4.	<p>Gross motor skills are improved by co-ordinating use of the large muscles and balance, to perform the activity. Eye-foot co-ordination is enhanced by the visual/sensory input of watching where the hoop and foot/feet are and motor output of performing the jump or hop into the middle of the hoop. Improvement of Static and Dynamic Balance (hopping) Motor planning is enhanced, by ensuring accuracy in planning which hoop to jump into and which hoop to hop into. Also, in planning how high to hop/jump so as to avoid touching the hoops. Sensory integration is enhanced by integrating the visual (where the hoops are) and proprioceptive (weight bearing on the lower limbs during hopping and jumping) stimuli, with the appropriate motor output. (jumping or hopping) (T. Gasser et al; 2010) (A. Pienaar et al; 2011)</p>

		5.	
1.10	<p>Star-Jumps</p> <p>The child starts in close standing, with good posture (back extended and chin up) arms at the side.</p> <p>The child then jumps to land with the legs apart and arms up in a “V” shape.</p> <p>The child then jumps to resume the starting position.</p> <p>Progression: This exercise can be started slowly and with slightly less repetitions than the required 10. It can then be progressed by increasing speed and building up to ten repetitions.</p> <p>Repeat x10.</p>	<ol style="list-style-type: none"> 1. 2. 3. 4. 5. 6. 	<p>Gross motor skills are improved by co-ordinated use of the large muscles, to perform the activity accurately and rhythmically.</p> <p>Eye-hand co-ordination and eye-foot co-ordination is enhanced by the visual/sensory input of watching where the limbs are placed, to determine the motor output of performing the actual starjump.</p> <p>Motor planning (sequence and timing) is enhanced by ensuring correct placing of the lower and upper limbs, with correct timing/speed.</p> <p>Sensory integration is enhanced by integrating the visual and proprioceptive information, from the present position of the limbs, to produce the motor action of the next movement/position of the limbs.</p> <p>Endurance is increased, in that this is a strenuous exercise, done with quite a few repetitions (X10), with a bit of speed. (A.Pienaar; 2011)</p> <p>Enhances bilateral integration</p>
1.11	<p>DDK/DIADYCHOKINESIS</p> <p>The child must sit at a desk (suitable height) and bend his/her elbows to 90 degrees with the palms of the hands flat on the table.</p> <p>The hands are then turned over rapidly so that the entire back of the hand then rests on the table then the palm of the hand repetitively.</p> <p>This primarily exercises the two joints between the forearm bones (radio-ulna joints) which are important in determining the hand position and thus quality of fine motor movements.</p> <p>Progression: This exercise can be started slowly then progressed, by speeding the activity up.</p> <p>This is done 10 times. 2 rotations.</p>	<ol style="list-style-type: none"> 1. 2. 3. 	<p>Eye-hand co-ordination is improved by the visual/sensory input of watching the position of the hands, to determine accuracy of the motor output/next movement.</p> <p>Improves hand dexterity, thereby facilitating fine motor activity and co-ordination.</p> <p>Improves endurance for hand activities, by encouraging quick repetitive movements. (T. Gasser et al; 2010.)</p>
1.12	<p>Opposition</p> <p>The child is instructed to oppose the tip of the thumb to the tip of each finger starting with the index finger through to the little finger then back to the index finger. This must be done as accurately and as quickly as possible.</p> <p>Progression: The exercise can initially be executed with the dominant hand alone, then progressed by doing the non-dominant hand. Further progression can be the execution of the activity with both hands together. Progression can also be achieved by increasing speed of the activity.</p> <p>3 repetitions on right hand.</p> <p>3 repetitions on left hand.</p> <p>3 repetitions with both hands together.</p> <p>Final progression: (eyes closed)</p>	<ol style="list-style-type: none"> 1. 2. 	<p>Eye-hand co-ordination is enhanced by the visual/sensory input of watching the position of the fingers, to ensure accuracy thereof.</p> <p>Improves hand dexterity thereby facilitating fine motor skills. (T. Gasser et al; 2010)</p>
2.2.1	<p>STRUCTURE OF PROGRAMME</p> <p>Repetition of Programme</p> <p>The same programme of 12 exercises will be repeated for 8 weeks.</p>		<p>This works on the basis of neuroplasticity: A specific skill is taught repetitively; the child can improve that motor skill, which can then become an improved motor skill. (Nahum et al; 2013)</p>
2.2	<p>Duration of Course of Intervention</p> <p>The sessions will be run once a week, over 8 weeks</p>		<p>Kolesky (2017) completed a systematic review, from which the following was established, on frequency of repeating an exercise intervention:</p> <p>Bardid et al (2015): twice per week x 10 weeks</p> <p>Peens et al (2007): twice per week x 8 weeks</p> <p>Satre et al (2009): three times per week; x 10 weeks</p> <p>Maharaj et al (2016): Once per week, for 8 weeks.</p> <p>All of these interventions sited above, irrespective of duration, produced a substantial improvement in motor skill scores.</p>

2.3	<p>Group Therapy</p> <p>The intervention will take place in a group of maximum 8 children.</p>	<p>The literature sites the following advantages of group exercise intervention, for children with co-ordination difficulties:</p> <p>Significant improvement in motor skills, occurred, administering interventions, having same sort of exercises, in a similar sized, group set-up.</p> <p>There are both psychosocial and motivational benefits of group exercise therapy.</p> <p>Healthy competition motivates participants.</p> <p>(Morton, 2015)</p>
2.4	<p>Effect of Exercise on ADHD/ADD</p> <p>The exercise intervention will alleviate symptoms of inattention, impulsivity and hyperactivity</p>	<p>Evidence in the literature suggests that exercises may be a beneficial, additional or alternative treatment option for patients with ADHD. Proprioceptive input is calming and organising to the body.</p> <p>(Den Heijer et al; 2016)</p>
2.5	<p>Symptoms</p> <p>This exercise intervention was designed to assist with all the symptoms of DCD.</p>	<p>Main symptoms of DCD according to Nelson; (2015).</p> <ol style="list-style-type: none"> 1. Reduced muscle tone 2. Reduced muscle power 3. Gross motor co-ordination 4. Fine motor co-ordination 5. Poor balance 6. Poor visual motor (eye-hand /eye-foot) 7. Postural problems 8. Poor core stability 9. Bilateral and Sensory integration 10. Motor planning

APPENDIX L: MALPRACTICE INSURANCE CERTIFICATE



Trishantha Singh

Marsh Proprietary Limited
10 Torsvale Crescent
Torsvale Park, La Lucia Ridge Office Estate
La Lucia 4051
P.O Box 782 Umhlanga Rocks
4320
+27 31 830 6059
Fax +27 086 623 1533
www.marsh-africa.com

University of KwaZulu Natal
University Road
Chiltern Hills
WESTVILLE CAMPUS

Attention: Charmaine Musto

11th August 2017

CONFIRMATION OF INSURANCE – UNIVERSITY OF KWAZULU NATAL – PROFESSIONAL INDEMNITY – STUDENT/ STAFF RESEARCH IN PHYSIOTHERAPY

We confirm that the activities of this Student will be covered in terms of the Medical Malpractice Extension, provided that their activities are supervised by duly qualified practitioner and subject to all other terms, exclusions and conditions of the policy.

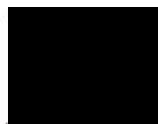
PERIOD OF INSUREANCE: 1 January 2017 to 31 December 2017

INSURER Santam Limited
POLICY NUMBER 4000/24907

All other terms, conditions, deductibles, exclusions as per the policy wording/endorsement.

Please do not hesitate to contact the writer should you have any queries.

Sincerely,



Trishantha Singh
Technical Broker
031 – 830 6059

An authorised financial services provider
FSB/FSP Licence no. 8414
Registration no. 1999/0034507
Directors: IB Skosana (Non-Executive Chairman), JJ Erwee (CEO), BR Baker*, F Abrahams,
R Ebrahim, S Moutsi, M Pienaar, MG Sookie (*BrisA)

SOLUTIONS...DEFINED, DESIGNED, AND DELIVERED.





31 August 2017

To whom it may concern

Proof of Insurance

This letter serves to confirm that the Insured below has the following cover in place.

Briefly, the terms of the policy are as follows:

Policy No: MED30966POL-17
Insurer: Hollard Insurance Company Limited
Insured: Miss PMT Dawson
Registration No: PT0039543
Business Description: Physiotherapists
Period of Insurance: 01 October 2017 to 30 September 2018
Retroactive Cover: 01 October 2017
Cover: Medical Malpractice, Professional Indemnity
Extensions: Council Hearings
Defamation
Breach of Confidentiality
Products Liability in respect of defective workmanship
Criminal Defence Costs
Public Liability

Combined Single Limit of Indemnity: R 5 000 000.00 in the aggregate

Reinstatement: 1 (additional limit of R 5 000 000.00 in the aggregate)

Excess: R 1 000.00 each and every claim

Jurisdiction: South Africa

Standard Exclusions: Fines & Penalties

We hereby confirm that the cover is in full force and effect subject to the terms, exclusions and conditions of the policy and subject to paying premiums when due.

Should you have any queries, please do not hesitate to contact us.

Yours faithfully

Carol-Lee Axford

Aon South Africa

Tel No: 27 11 944 7457

Fax No: 27 86 639 2614

Email : carol-lee.axford@aon.co.za



Aon South Africa (Pty) Ltd | Risk, Reinsurance, Human Resources.

The Place, 1 Sandton Drive, Sandhurst, Sandton, South Africa | P.O. Box 1874, Parklands, 2121

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Registration Number 1978/004501/07 | VAT Number 4320101498 | Authorised Financial Services Provider Licence 20555

Directors: T Williams (CEO), V Mahlangu*, NF Manyonga, Dr NB Molele (née Mabuya)*, NL Morwe, KH Setzin*, E van Rensburg

*Non-Executive

Company Secretary: JA Howell

**GUIDELINES FOR PRESENTATION OF MASTERS AND PHD
DISSERTATIONS/THESES BY RESEARCH**

1. Purpose

The purpose of this document is to provide guidance to students and supervisors on how to prepare a dissertation/thesis for Masters by Research and PhD degrees using the manuscript or publication format..

2. Introduction

These guidelines must be read together with the College of Health Sciences (CHS) Handbook as well as the Jacobs documents on examination policies and procedures for PhD degrees. The rules on thesis format are based on modification of point 1 of the definition of terms section in the Jacobs document. In this section a thesis is defined as *“the supervised research component of all PhD degrees, whether by supervised research only, or coursework and research, or by papers that are either published or in manuscript form (the supervised research component of the PhD degree by paper(s) comprises the introduction, literature review, account of the methodology, selection of manuscripts, and conclusion).”* A dissertation is defined as *“the supervised research component of all Masters degrees, whether by supervised research only, or coursework and research, or by papers that are either published or in manuscript form (the supervised research component of the Masters degree by paper(s) comprises the introduction, literature review, account of the methodology, selection of manuscripts, and conclusion).”*

2.1 PhD thesis

In the CHS Handbook the rules for a PhD thesis are not in one place; they are stated in DR8 a i & ii, DR9 c and CHS 16. DR8 a i & ii and direct that a thesis be presented in the standard format together with one published paper or an unpublished manuscript that has been submitted to an accredited journal, arising from the doctoral research. CHS16 (thesis by publications states that the thesis may comprise of at least three published papers or in press in accredited journals; such papers must have the student as the prime author. The same CHS16 provides for a thesis by manuscripts that may have at least 3 papers with the student as the prime author that have not yet been published but are in the form of manuscripts; at least two of such papers must constitute original research. In both cases (thesis by publications and manuscripts), there must be introductory and concluding integrative material sections.

The standard type thesis is being phased out in many African countries in favour of the other options that originate from the Scandinavian countries. While this format ensures that all details of the work done for the doctoral degree are captured and thoroughly interrogated, they often remain as grey literature which is mainly useful to other students, usually within the same university, although with digitization of theses, such work may become more accessible beyond the source university. Apart from the risk of losing good work because of it not being on the public domain, as students rarely publish such work after graduating, this approach denies the college additional productivity units (PUs) emanating from publications.

The thesis by publication encourages students to publish key aspects of their doctoral research as they will not graduate if the papers are not published or in press. This approach ensures that the work of the student enters the public domain before the thesis is examined, providing the examiner with some assurance of prior peer review. The thesis must constitute a full study of the magnitude expected of a PhD with the papers providing a sound thread or storyline. Furthermore, the college maximizes the students' work as PUs are awarded for the papers as well as for graduating. However, this approach may negatively affect throughput and frustrate students as

they cannot graduate unless all the papers are published or in press, in addition to the synthesis chapter demonstrating the story line of the thesis.

The option of a thesis by manuscripts ensures that students make efforts to start publishing. The risk of not passing because of failure to publish all papers (as in the thesis by publication) does not exist under this option. However, the PUs emanating from publications from the doctoral work are not guaranteed as the submitted papers may eventually be rejected. Thus there is a possibility of the doctoral work remaining on the university library shelves as is the case for the standard thesis format. The standard thesis does have the advantage that more details of the doctoral work are usually included.

In view of the above, the best option for the college is that of a thesis by publication. However, in the interim, the attractive option is that of thesis by manuscripts, as it provides the possibility of publication without putting the student at risk of delayed graduation when some of the manuscripts are not published/accepted, which also disadvantages the college in terms of PU earnings. The standard thesis option should ultimately be phased out for the stated reasons and students are not encouraged to present their theses in that format. Consequently this document does not describe the standard thesis.

2.2 MSc dissertation

The rules on presentation of MSc dissertations are presented in CR13 (course work), CHS 14 (course work) and MR9 (research) in the CHS Handbook. CR13 c and MR9 c direct that a dissertation “may comprise one or more papers of which the student is the prime author, published or in press in peer-reviewed journals approved by the relevant college academic affairs board or in manuscripts written in a paper format, accompanied by introductory and concluding integrative material.” Such a dissertation should include a detailed description of the student’s own distinct contribution to the papers. Both CHS14 and CR13 specify that reviews and other types of papers in addition to original research paper/s may be included, provided they are on the same topic.

3 Length of thesis and dissertation by word count

Table 1 provides a guide of the length of a thesis or dissertation by word count excluding preliminary pages and annexes.

Table 1: Thesis length by word count

Sections				
	Minimum	Maximum	Minimum	Maximum
Introduction	2700	2700	2000	2000
Chapters	10000	25000	6000	11000
synthesis	2000	2000	1700	1700
bridging	300	300	300	300
Total	15000	30000	10000	15000

4. Intention to submit

A written intention to submit a thesis or dissertation should be submitted to the appropriate postgraduate office with endorsement of the supervisor at least three months before the actual date of submission which should be before November if the student intends to graduate in the following year. The actual submission will under normal circumstances require approval of the supervisor.

5. Format for theses/dissertation

There is little variation in the actual format of the PhD thesis and Masters dissertation for the various types described above. The box below summarise the outline of a thesis/dissertation for the thesis by manuscripts and thesis by publications.

Box 1: Outline of thesis

Preliminary pages

- i. Title page
- ii. Preface and Declaration
- iii. Dedication
- iv. Acknowledgements
- v. Table of contents
- vi. List of figures, tables and acronyms (separately presented)
- vii. Abstract

Main Text

1. Chapter 1: Introduction
Introduction including literature review
Research questions and/or objectives
Brief overview of general methodology including study design
2. Chapter 2
First manuscript/publication
3. Chapter 3
Second manuscript/publication
4. Chapter n
Final manuscript/publication
5. Chapter n+1: Synthesis
Synthesis
Conclusions
Recommendations
6. References Appendices

NB. Between the manuscripts or publications there must be a 1 page (maximum) bridging text to demonstrate the link between them

6. Details for thesis/dissertation subheadings

This section summarizes what is expected under each subheading shown in Boxes 1 and indicates where there might be variations between a Masters Dissertation and PhD Thesis.

6.1 Title Page

The officially approved title that is concise (Fewest words that adequately describe the contents of the thesis/dissertation – usually 15 or fewer words) is presented at the top. This should be followed by the candidate's name in a new line. At the bottom the thesis statement should be presented. The thesis statement may be stated as "*Submitted in fulfillment of the requirements for the degree of _____ in the School of _____, University of KwaZulu-Natal*" for a PhD/Masters by Research thesis. In the case of a Masters Dissertation it should be stated as "Submitted as the dissertation component in partial fulfilment (% stated) for the degree of _____ in the School of _____, University of KwaZulu-Natal". For both Masters and PhD the date of submission must be stated.

6.2 Preface (Optional)

The preface merely states the reason (motivating factors) why the study was conducted without getting into details of what was investigated.

6.3 Declaration

This must be structured as follows:

I, Dr/Mr _____, declare as follows:

1. That the work described in this thesis has not been submitted to UKZN or other tertiary institution for purposes of obtaining an academic qualification, whether by myself or any other party.

Where a colleague has indeed prepared a thesis based on related work essentially derived from the same project, this must be stated here, accompanied by the name, the degree for which submitted, the University, the year submitted (or in preparation) and a concise description of the work covered by that thesis such that the examiner can be assured that a single body of work is not being used to justify more than one degree.

2. That my contribution to the project was as follows:

This is followed by a concise description of the candidate's personal involvement in and contribution to the project, in sufficient detail that the examiner is in no doubt as to the extent of their contribution.

3. That the contributions of others to the project were as follows:

This is followed by a list of all others who contributed intellectually to the project, each accompanied by a concise description of their contribution. This does not include people who ordinarily would be "acknowledged" as opposed to considered for authorship.

4. Signed _____ Date _____

6.4 Dedication

This is an optional section. Should it be included it must be very brief merely indicating to whom the work is dedicated. Avoid anything too flowery

6.5 Acknowledgements

This section acknowledges all individuals, groups of people or institutions that the candidate feels indebted to for the support they rendered. The funding source for the work should also be acknowledged.

6.6 Table of contents

Table of contents must be inserted after the preliminary sections and must capture all major sections of the thesis at the various levels (primary, secondary, tertiary subheadings). It should be electronically generated and should be able to take the reader to specific headings in the thesis.

6.7 Lists of figures, tables and acronyms

These lists must be presented separately. All titles of figures presented in the thesis/dissertation must be listed indicating on what page they appear. Similarly for tables the titles must be presented indicating on what page they appear. In the case of acronyms, the acronym is stated and all the words describing the acronym are presented. Only key acronyms should be stated. In some cases they may not be listed as long as full text is presented whenever the acronym is used for the first time.

6.8 Abstract

The abstract should summarize the thesis mainly stating the purpose of the study, highlights of chapters and the new knowledge contributed by the thesis. The abstract must be approved by the supervisor of the thesis and should not be more than 350 words in length.

6.9 Introduction

The introductory chapter for both types of thesis is similar. The section should include literature review and have the following information. Headings are used as appropriate and need not correspond exactly to the following.

- i. Background and the context of the study
- ii. Description of the core research problem and its significance
- iii. A comprehensive, critical, coherent overview of the relevant literature leading to clearly defined knowledge gaps
- iv. A coherent problem statement highlighting the nature and magnitude of the problem, the discrepancy, knowledge gaps therein and possible factors influencing the problem.
- v. Clear and SMART research questions, objectives and hypothesis and/or theoretical framework
- vi. A conceptual framework (optional)
- vii. Description of the study area and general methodology (*in a standard thesis this should be a stand-alone section*)
- viii. Layout of the thesis (thesis structure) indicating what chapters are presented in the thesis and how they address the objectives.

6.10 Literature review

This section is subsumed in the introduction within the stipulated word count for a thesis or dissertation.

6.11 Methodology

A standalone section is not needed as the methods are adequately described in each manuscript/publication.

6.12 Data chapters/manuscripts/publications

The full published paper or manuscript submitted for publication should be presented as published or submitted to the journal. The actual published paper should be scanned and inserted

in the chapter. There should be a separator page between chapters that has text linking the previous chapter to the next and providing details of the next manuscript/publication indicating publication status.

6.13 General discussion/Synthesis chapter

This is a general discussion that demonstrates the logical thread that runs across the various manuscripts/publications (synthesis). There should be no doubt that the manuscripts/publications complement each other and address the original objectives stated in the general introduction of the thesis. The general discussion/synthesis chapter should end with a conclusion and recommendations where necessary.

6.14 References

Only references cited in the introduction and synthesis chapters should be listed as all other references should be within the manuscripts presented under data chapters.

6.15 Annexes

All information (questionnaires, diagrams, ethics certificates, etc) considered important but not essential for inclusion in the actual thesis is put in this section as reference material. In addition papers that emanated from the work but not directly contributing to the thesis may be included.

7. Thesis formatting

For standardisation of thesis the following formatting specifications should be followed.

7.1 Font

Times New Roman 11pt should be used throughout the thesis. However, major headings may be made bigger (12pt) but using the same font type

7.2 Paper size and margins

A4 (297 x 210 mm) should be used and in the final thesis both sides of the paper should be used. However, the loose bound copy submitted for examination should be printed on only one side. The recommended margins are 30mm for all the left, right, top and bottom margins.

7.3 Line spacing

The copy submitted for examination should have 1.5 line spacing but the final copy should have single line spacing. Paragraphs should be separated by a blank line. Published or submitted manuscripts should remain in their original format in all aspects as they are inserted in their published format in appropriate places.

7.4 Headings

A consistent numbering system and captions should be maintained with first level being in CAPS and centred, second level being **normal bold** font and third level being *italics bold*. If there is need for 4th level it should be *normal italics*.

7.7 Pagination

Page numbers should be centred at the bottom of the page. All preliminary pages should be numbered in lower case Roman numerals and subsequent pages should be numbered as indicated in the Box The title page should not be numbered.

The body of the thesis (chapter 1 onwards) should be numbered consecutively with Arabic numerals. The numbers should continue consecutively from the introduction through the through the publications or submitted manuscripts and subsequent sections. The published papers will therefore bear two numbers: a set specific to the manuscript (it is recommended to place these in the upper right hand corner) or published paper, as well as the consecutive numbers belonging to the thesis as a whole. Care must be taken to distinguish these in terms of position and font.

7.8 Referencing

Supervisors have the freedom to decide the type of citation of references but there must be consistency. This is mainly applicable to the standard type of thesis. In the case of thesis by manuscripts or publications, individual papers will maintain the reference system of the journal but the supervisor can decide on the type of referencing for the introductory and synthesis chapters.

8. Final thesis submission

The thesis should be submitted for examination in a loose bound form accompanied by a PDF copy. After the examination process the final version PDF copy of the thesis must be submitted to PG office for onward submission to the library. It is not a requirement to submit a copy fully bound in leather cloth or similar material.

APPENDIX N: ETHICAL FINAL CLEARANCE



20 November 2017

Ms P.M.T. Dawson (8421775)
Discipline of Physiotherapy
School of Health Sciences
pdawson@polka.co.za

Dear Ms Dawson

Protocol: A study on the effects of exercise therapy on the co-morbidity of attention deficit and hyperactivity disorder (A.D.H.D) and development co-ordination disorder. Degree: PhD
BREC reference number: BFC397/16

The Biomedical Research Ethics Committee (BREC) has considered the abovementioned application at a meeting held on 16 August 2016.

The study was provisionally approved by BREC pending appropriate responses to queries raised. Your responses received on 02 November 2017 to queries raised on 23 October 2017 have been noted and approved by the Biomedical Research Committee at a meeting held on 14 November 2017.

This approval is valid for one year from **20 November 2017**. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

Pg. 2/...

Biomedical Research Ethics Committee

Professor J Tsoka-Gwegweni (Chair)

Westville Campus, Govan Mbeki Building

Postal Address: Private Bag X54001, Durban 4000

Telephone: +27 (0) 31 260 2486 Facsimile: +27 (0) 31 260 4809 Email: brec@ukzn.ac.za

Website: <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>

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Faculty of Health Sciences Faculty of Education Faculty of Business Faculty of Science Faculty of Arts Faculty of Law