

**The association between motor proficiency,
object control skills and physical fitness during
earlier and later childhood: NW-CHILD study**

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University

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Statement

This dissertation is done in **article format**. The study was planned and executed by three researchers. The contribution of each author is tabulated in coherence with a statement by each co-author on their role in the study. This also serves as permission by the co-authors that the articles in this dissertation can be submitted for degree purposes.

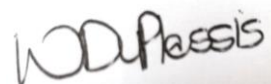
Author's Name and Surname	Role of the Author in this Study
Ms. Carli Gericke (CG) (Hon. Kinderkinetics)	CG, AP and WDP were jointly responsible for the completion of the study. CG, AP and WDP collected the data. CG is the first author, AP the second author and WDP the third author in both articles.
Prof. Anita E. Pienaar (AP) (PhD Human Movement Science)	AP was the supervisor and responsible for the planning, managing and completion of the longitudinal research project. AP has contributed meaningfully to the data collection and writing of the articles.
Ms. Wilmarié du Plessis (WDP) (MA. Kinderkinetics)	WDP was the assistant supervisor. WDP contributed meaningfully to the collection of research data and the writing of the articles.

Solemn statement by supervisor and assistant supervisor

We hereby declare that the above articles are approved and that our roles in the study, such as listed above, is correct and a true reflection of our contributions to the study. We, the study leaders, hereby give further permission that the articles may be submitted as part of the dissertation of Miss. Carli Gericke.



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Preface

"Seek the Kingdom of God above all else, and live righteously, and he will give you everything you need." (Matthew 6:33)

- ❖ This Master's degree could not be completed without the people who assisted and supported me. They are the ones who have experienced the sweat, tears and hours spent to complete this dissertation. I would like to thank each one of the following people, without whom I would have never completed this study:
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Summary

The association between motor proficiency, object control skills and physical fitness during earlier and later childhood: NW-CHILD study

Object control skills mastery during earlier childhood is important for the successful generalization thereof during later childhood. Physical fitness is also considered an important health enhancing aspect in children. The relationship between motor proficiency and physical fitness also increases in nature during later childhood.

The study had two objectives. The first objective was to determine the association between object control skills mastery during earlier childhood (6 and 9 years) and the application of these object control skills during later childhood (12 years) in children living in the North-West Province of South Africa. Secondly, the study aimed to determine if there is an association between motor proficiency and physical fitness in earlier childhood (6 and 9 years) and later childhood (12 years) in children living in the North-West Province of the Republic of South Africa.

This study formed part of the North-West Child Health, Integrated with Learning and Development longitudinal study (2010-2016), which included a baseline and two time point measures (2010, 2013, 2016) and spanned over the seven primary school years (Grades 1, 4 and 7). A stratified random sample of 374 subjects from four different educational districts, twenty schools, representing five different quintiles (1 (low) – 5 (high) socio economic status schools), including both genders (boys=178, 47.59% and girls=196, 52.41%), participated in the study. *Statistica for Windows*, 2017 was used to perform the analyses.

To achieve the first objective results obtained by the Test of Gross Motor Development, Second Edition (TGMD-2) in 2010 and 2013 and the Canadian Assessment of Physical Literacy Obstacle Course (CAPL) in 2016 was used and analysed by means of descriptive statistics, Spearman rank order correlations and stepwise regression analysis. The results revealed that at 6 years, a higher overall and large R^2 (32%) contribution to the variance that were found in the CAPL skills and time score at 12 years were found compared to at age 9 (28.1%). Object control skills made a significant contribution of 4.5% at 6-years-old to application of these skills at the age of 12 years, while it also contributed to the explained variance in the completion time of the CAPL at 9-years-old (0.09%; $p < 0.05$).

To achieve the second objective results obtained by means of The Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF) (2010 and 2013), the TGMD-2 (2010

and 2013), and the Progressive Aerobic Cardiovascular Endurance Run test (PACER) in 2016 were used and analysed by means of the Spearman Rank Order Correlation and Stepwise Regression Analysis. A significant association between motor proficiency during earlier childhood and physical fitness during later childhood emerged. Gender showed a significant contribution to the association with physical fitness between 6 and 12 years, while socio-economic status had a small, but insignificant impact on the independent variables, and only in boys. This warranted separate stepwise analysis for boys and girls. Motor proficiency of both boys and girls at 6-years-old, contributed significantly (6.8%) to physical fitness at 12 years while object control skills made an additional contribution of 2.4% to the physical fitness of girls.

It was concluded that earlier object control skills mastery can provide a baseline from where opportunities for progression or transfer of skills can result in more advanced skilful executions. Motor proficiency at a young age was also found to be relevant to physical fitness during later childhood. Both these positive relationships can contribute to higher physical activity levels and subsequently improve health in general of children during the later stages of their lives.

Key words: object control skills, motor proficiency, physical fitness, earlier childhood, later childhood

Opsomming

Die verband tussen motoriese behendigheid, objektkontrole-vaardighede en fisieke fiksheid tydens die vroeë en latere kinderjare: NW-CHILD studie

Die bemeestering van objektkontrole-vaardighede tydens die vroeë kinderjare is belangrik vir die suksesvolle veralgemening daarvan tydens die later kinderjare. Fisieke fiksheid word ook as belangrik beskou as gesondheidsbevorderende aspek van kinders. Dit blyk ook dat die verwantskap tussen motoriese behendigheid en fisieke fiksheid groter word tydens latere kinderjare.

Die studie het twee doelstellings gehad. Die eerste doelstelling was om die verband tussen objektkontrole vaardigheds bemeestering tydens vroeër kinderjare (6 en 9 jaar oud) en die toepassing van hierdie objektkontrole-vaardighede tydens latere kinderjare (12 jaar oud) te bepaal by kinders wat in die Noordwes Provinsie van Suid-Afrika woon. Tweedens was die studie daarop gemik om te bepaal of daar 'n verband bestaan tussen motoriese behendigheid en fisieke fiksheid in die vroeë- (6 en 9 jaar oud) en latere kinderjare (12 jaar oud) by kinders in die Noordwes Provinsie van Suid-Afrika.

Hierdie studie het deel gevorm van die North-West Child Health, Integrated with Learning and Development longitudinal study (2010-2016) wat 'n basislyn en twee tydpunt-metings (2010, 2013, 2016) wat oor die sewe laerskool jare gestrek het (Graad 1, 4 en 7) insluit. 'n Gestratifiseerde ewekansige steekproef van 374 leerders uit vier verskillende geselekteerde onderwysdistrikte, en twintig skole wat vyf verskillende skool kwintiele verteenwoordig (1 (lae) - 5 (hoë) sosio-ekonomiese statusskole), insluitend beide geslagte (seuns = 178, 47.59% en meisies = 196, 52.41%) het deelgeneem aan die studie. Statistica vir Windows 2017 is gebruik om die statistiese ontledings te doen.

Om die eerste doelstelling te bereik is resultate soos bepaal deur die Test of Gross Motor Development, Second Edition (TGMD-2) in 2010 en 2013 en die Canadian Assessment of Physical Literacy Obstacle Course (CAPL) in 2016 gebruik en is ontleed deur beskrywende statistiek, Spearman rangorde korrelasies en stapsgewyse regressie analyses. Die bevinding was dat op die ouderdom van 6 jaar 'n hoër algehele en 'n groot R^2 (32%) bydra tot die verklaring van die motoriese behendigheid en tyd van die uitvoering van die CAPL in 12 jaar in vergelyking met op die ouderdom van 9 jaar (28,1%). Objektkontrole-vaardighede het ook bygedra tot die variasies in die tyd waarin die CAPL op 9-jarige ouderdom voltooi is (0.09%; $p < 0.05$).

Om die tweede doelstelling te bereik, is die The Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF) (2010 en 2013), die TGMD-2 (2010 en 2013) met as opvolg CAPL in 2016, en die Progressive Aerobic Cardiovascular Endurance Run test (PACER) in 2016 waarna die assosiasies ontleed is deur beskrywende statistiek, Spearman rangorde korrelasies en stapsgewyse regressie analise. 'n Beduidende verband tussen motoriese behendigheid gedurende vroeë kinderjare en fisieke fiksheid in later kinderjare het na vore gekom. Geslag het 'n beduidende bydra tot die assosiasie met fisieke fiksheid tussen 6 en 12 jaar getoon, terwyl sosio-ekonomiese status 'n klein impak gehad het op die onafhanklike veranderlikes, maar slegs in seuns. Die resultaat het dus aparte stapsgewys analyses vir seuns en dogters geregtig. Motoriese behendigheid in seuns en dogters, op 6 jaar, het 'n beduidende bydra (6.8%) tot fisieke fiksheid op 12 jaar getoon, terwyl objektkontrole 'n addisionele impak van 2.4% tot fisieke fiksheid in dogters getoon het.

Die gevolgtrekking word gemaak dat vroeë bemeestering van objektkontrole-vaardighede 'n basis verskaf vanwaar verdere geleenthede vir progressie of oordrag van hierdie vaardighede kan geskied wat weer tot meer gevorderde en vaardiger uitvoering kan bydra. Motoriese behendigheid op 'n vroeë ouderdom het ook 'n verband met hoër fisieke fiksheid tydens later kinderjare getoon. Beide hierdie verbande kan bydra tot verhoogde fisieke aktiwiteit en gevolglik die gesondheid van kinders in die algemeen tydens die later stadia van hulle lewens.

Sleutel terme: objektkontrole-vaardighede, motoriese behendigheid, fisieke fiksheid, vroeë kinderjare, later kinderjare

Contents

Statement	ii
Preface	iii
Summary	iv
Opsomming	vi
List of Tables	xi
List of Figures	xii
List of Abbreviations	xiii
CHAPTER 1	1
INTRODUCTION	2
1.1 Introduction	2
1.2 Problem statement	5
1.3 Objectives	7
1.4 Hypotheses	7
1.5 Structure of dissertation	8
CHAPTER 2	15
LITERATURE REVIEW: THE ASSOCIATION BETWEEN MOTOR PROFICIENCY, OBJECT CONTROL SKILLS AND PHYSICAL FITNESS DURING EARLIER AND LATER CHILDHOOD	16
2.1 Introduction	16
2.2 Terminology	18
2.3 Sport participation and physical activity levels of children in the RSA	23
2.4 Phases of motor development	25
2.5 Object control skills (OCS)	27
2.6 Motor proficiency (MP)	31
2.7 Physical fitness (PF) and physical activity (PA)	33
2.8 Factors that influence the relationship between motor proficiency (MP), physical fitness (PF) and physical activity (PA)	35
2.8.1 <i>Motor proficiency (MP)</i>	35
2.8.2 <i>Physical Fitness (PF)</i>	37
2.8.3 <i>Socio-economic status</i>	38
2.8.4 <i>Gender</i>	40
2.8.5 <i>Culture</i>	41
2.8.6 <i>Race</i>	42

2.9	The association between object control skills (OCS), motor proficiency (MP) and physical fitness (PF) and later physical activity (PA)	42
2.9.1	<i>Cross-sectional studies</i>	42
2.9.2	<i>Longitudinal studies</i>	45
2.10	Conclusion: Chapter summary	47
CHAPTER 3		64
THE ASSOCIATION BETWEEN OBJECT CONTROL SKILLS MASTERY DURING EARLIER AND LATER CHILDHOOD: LONGITUDINAL DATA FROM THE NW-CHILD STUDY		65
3.1	Introduction	67
3.2	Method	70
3.2.1	<i>Study design</i>	70
3.2.2	<i>Participants</i>	71
3.2.3	<i>Measuring instruments</i>	71
3.2.4	<i>Procedures</i>	72
3.3	Results	73
3.4	Discussion	78
3.5	Conclusion	82
CHAPTER 4		88
THE ASSOCIATION BETWEEN MOTOR PROFICIENCY AND PHYSICAL FITNESS DURING EARLIER AND LATE CHILDHOOD		89
4.1	Introduction	91
4.2	Method	93
4.2.1	<i>Study design</i>	93
4.2.2	<i>Participants</i>	94
4.2.3	<i>Measuring instruments</i>	95
4.2.4	<i>Procedures</i>	96
4.3	Results	97
4.4	Discussion	102
4.5	Conclusion	106
CHAPTER 5		112
SUMMARY, CONCLUSION AND RECOMMENDATIONS		113
5.1	Summary	113
5.2	Conclusion	117
5.3	Recommendations	119

Annexure A: CAPL	123
Annexure B: TGMD-2	127
Annexure C: BOT-2 SF	129
Annexure D: Ethics	131
Annexure E: Journal of Perceptual and motor skills submission guidelines	152
Annexure F: Journal of Perceptual and motor skills submission confirmation	155
Annexure G: Journal of Sports Medicine and Physical Fitness submission guidelines	157
Annexure H: Proof of language editing	167

List of Tables

Table 3.1:	Characteristics of the participants per gender and socio-economic school status ($N = 374$)	74
Table 3.2:	Descriptive results of OCS SS (Grade 1, 4 and 7) and CAPL (skills and time score in Grade 7) by group and for boys and girls separately	75
Table 3.3:	Correlation between OCS SS, and the CAPL skills and time scores (Grade 1, 4 and 7)	76
Table 3.4:	The results of a stepwise regression analysis of Grade 1 and Grade 4 OCS SS on Grade 7 participants CAPL skills score as adjusted for SES and gender	77
Table 3.5:	A stepwise regression analysis of the variance explained by Grade 1 and Grade 4 OCS SS on Grade 7 participants' CAPL time score, SES and gender	78
Table 4.1:	Characteristics of the participants per gender and per SES school	97
Table 4.2:	Descriptive results of the BOT-2 SF standard score (Grade 1 and 4), the TGMD-2 (Grade 1 and 4) and the PACER (Grade 4 and 7) per gender (boys and girls) and per group	98
Table 4.3:	Correlations between MP (BOT-2 SF standard scores) and PF (PACER) between Grade 4 (2013) and Grade 7 (2016) as per gender and per group	99
Table 4.4:	A stepwise regression analysis of the variance explained in the PACER in Grade 7 by MP, object control skills, gender and SES of the participants in Grade 1 and Grade 4	100
Table 4.5:	Results of stepwise regression analysis of the variance explained by MP at ages 6, 9 and 12 of PF in girls	101
Table 4.6:	Results of stepwise regression analysis of the variance explained by MP at ages 6, 9 and 12 of PF in boys	102

List of Figures

Figure 2.1:	The association between object control skills, motor proficiency and physical fitness and the relationship of these factors with physical literacy and physical activity	17
Figure 2.2:	Four phases of motor development (Gallahue & Ozmun, 2006:50)	26
Figure 2.3:	Developmental mechanisms influencing physical activity trajectories of children (Stodden & Goodway, 2007:34). EC-Early Childhood (2-6 years), MC-Middle Childhood (6-12 years), LC-Late Childhood (11-13 years)	36
Figure 2.4:	Bronfenbrenner's socio-ecological system theory of development	38

List of Abbreviations

BOT-2 SF	Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form
CAPL	Canadian Assessment of Physical Literacy Obstacle Course
MP	Motor proficiency
NW-CHILD	North-West Child Health, Integrated with Learning and Development
OCS	Object control skills
PA	Physical activity
PACER	Progressive Aerobic Cardiovascular Endurance Run
PF	Physical fitness
TGMD-2	Test for Gross Motor Development, Second Edition
RSA	Republic of South Africa
SES	Socio-economic status

CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 Introduction

Human movement is an extremely complex, integrated, synchronized, interconnected and multi-joined activity, inclusive of neuromotor and biomechanical mechanisms working together (Runhaar, 2010:323). This complexity is endorsed by research studies that highlight the reciprocal and interrelated nature of various enablers in the human movement echelon, together with various biological and environmental factors (Barnett *et al.*, 2013:332), that can influence the development and execution of human movement activities. According to Starosta (2001:3), the paradox of our time lies in the fact that many movement activities demand advanced levels of motor proficiency while lowering levels thereof is observed amongst various nations. Research indicated that a lack of certain skills or capabilities may hamper children's participation in movement activities or sports. According to research, object control skills (OCS), motor proficiency (MP) and physical fitness (PF) can serve as movement and sport participation enablers with a reciprocal advancing effect from earlier to later childhood (De Milander, 2011:12; Cattuzzo, 2016:125).

Fundamental motor skills, which develop during childhood, are considered to be the building blocks upon which sport-specific and specialised skills are built (Burton & Miller, 1998:355; Goodway *et al.*, 2003:299; Barnett *et al.*, 2014:167;), and also lay the foundation for future movement and physical activity (PA) (Clark & Metcalfe, 2002:3; Wrotniak *et al.*, 2006:1758). Barnett *et al.* (2009:252) agreed that for successful participation in sport, and to become physically active children, the mastering of fundamental motor skills during earlier childhood may contribute to the learning and mastering of specialized skills during adolescence or later childhood. Fundamental motor skills are composed of locomotor skills (e.g. smooth coordinated movement of the body through space including running, galloping, skipping, hopping, sliding, and leaping), stability skills (balancing and twisting skills) and object control skills (OCS) which refers to the manipulation and projection of objects and includes throwing, catching, bouncing, kicking, striking, and rolling skills (Gallahue & Cleland-Donnelly, 2007:15). Fundamental motor skill patterns are established between the ages of 4 and 6 years and most of these skills should reach the mature stage of development by 7 years, while the child should be fully proficient in these skills at the ages 8 and 9 (Gallahue & Cleland-Donnelly, 2007:62).

OCS, a subcategory of fundamental motor skills, is predominantly linked to sport-related skills (Barnett *et al.*, 2008; Butterfield *et al.*, 2012:261; Department of Education Western Australia, 2013; Pienaar *et al.*, 2015:309; Barnett *et al.*, 2016:219). Several studies (Barnett *et al.*, 2008:257; Butterfield *et al.*, 2012:261) regard OCS as the key to provide children with the tools to be physically active. These skills which are described as handling and controlling of objects with the hand, foot or an implement (bats, racquets or hoops) with speed and control (Department of Education Western Australia, 2013), provide children with the best possible chance to successfully and continually engage in a range of physical activities and more specifically health enhancing activities (Barnett *et al.*, 2008:257; Butterfield *et al.*, 2012:261; Barnett *et al.*, 2016:219). Poor object control skills on the other hand, can encourage non-participation in sport activities, because children may struggle to master advanced skills (Van Beurden *et al.*, 2002:245). Barnett *et al.* (2008) found in a longitudinal assessment that high levels of perceived sport competence, which was reached through OCS proficiency development during childhood, determine both boys' and girls' PA participation and PF, and they subsequently recommended that perceived proficiency of OCS should be targeted and improved. In alignment, Visagie (2017:199) also recommended from her findings, involving 408 girls in the North-West Province of South Africa (SA), the appropriate development of OCS in girls in order to prevent non-participation in sport. Pienaar *et al.* (2015:309) highlighted that, adequate proficiency of OCS, which are influenced by biological and environmental constraints, underlies the development of more complex sport-specific skills.

Stodden *et al.* (2008:290) reported that an important aspect of general motor competence is proficiency in fundamental movement skills. Children's movement capabilities, however, do not only incorporate fundamental motor skill execution. General motor proficiency (MP) is influenced by running speed and agility, balance, bilateral co-ordination, strength, upper limb co-ordination, reaction speed, visual-motor control, upper limb speed and agility (Sherrill, 2004:56). Children's demonstration of MP is considered a cornerstone leading to their physical and motor skill development according to Chen *et al.* (2016:102). Evidence of the child's ability to combine simple movements and demonstrate complex movement, is indicative of motor proficiency (Schmidt & Wrisberg, 2013:191). A child's motor proficiency can be affected by strength, motivation, equipment and prior experiences (Goodway & Branta, 2003:36) and children also need skills to select, organise, and execute an action appropriate to a given situation in an effective, consistent and efficient manner (Williams *et al.*, 2003:198). All these aspects were taken into consideration in the definition of MP as the degree of skills performance in a wide range of motor tasks that is based on movement control and coordination underlying a motor outcome (D'Hondt *et al.*, 2013:62). This proficiency enables a child to repeatedly apply

practiced fundamental motor skills to execute specific OCS and locomotor actions with competency (Rudd *et al.*, 2015:2; Sherrill, 2004:5).

Health-related fitness is described by Howley (2001:364) to include cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility which is usually related to disease prevention and health promotion. Health-related physical fitness is influenced by a variety of factors including body weight status, cardiorespiratory fitness, musculoskeletal fitness (muscular strength and endurance) and flexibility and are related to health outcomes and/or health markers in youth (Institute of Medicine, (IOM):2012). Physical fitness is also described as a general state of health and well-being which can enhance the enjoyment of participation in physical activities (Stodden *et al.*, 2008:299, Welk, 1999:5) and, more specifically, it supports the ability to perform certain aspects of sport or occupations (De Milander, 2011:20), while also allowing individuals to perform physical activities with vigor and promote resistance to fatigue (Cattuzzo *et al.*, 2016:124). Physical fitness is therefore based on cardio-respiratory endurance, muscle strength endurance, flexibility and body composition and refers to a physiological state of well-being that reduces the risk of hypokinetic disease and set a basis for participation in sports and good health which enables one to be physically active.

It has been suggested that PF, power, muscle strength and endurance are positively associated with MP (Cattuzzo *et al.*, 2016:123; Rivilis *et al.*, 2011:895). The reciprocal and interlinking nature of MP and PF are also evident from various research studies which highlighted that they serve as enabling factors for each other. According to Stodden *et al.* (2008:298) the relationship between MP and PF becomes more reciprocal in nature during later childhood and adolescence. These researchers stated that if children lack the ability to proficiently run, jump, catch and throw, they will have limited opportunities to engage in physical or sport-related activities later in their lives because they will not have the prerequisite skills to be active (Stodden *et al.*, 2008:291). This again, impact negatively on their PF because of the reciprocal influence between physical activities and PF.

Factors that can influence PA and sport-related competencies and engagement, are biological and environmental constraints (Pienaar *et al.*, 2015:309). Barnett *et al.* (2016:219) stated that motor development in young children, specifically during the earlier childhood years, is mainly influenced by biological maturation, and only then the influence of practice and opportunity becomes important. Gender differences are noted from various research findings pertaining to OCS, MP and PF and even sport participation activities. Boys tend to demonstrate stronger

OCS (e.g. kicking, catching and throwing) than girls (Cantell *et al.*, 2008; Haga, 2009; Pienaar *et al.*, 2015) and different patterns of MP have been reported (Field & Temple, 2017).

Environmental influences also play a role in PA and motor proficiency, according to various researchers (Lejarraga *et al.*, 2002; Pienaar *et al.*, 2015:309; Stodden *et al.*, 2008; Van Biljon & Longhurst, 2011; Visagie *et al.*, 2017:200). The findings by Maphatane (1994:24), Kahlenberg (2001:54), Martina *et al.* (2009:236) and Taylor and Yu (2009:1) also confirmed the influence of socio-economic status on the overall development of children.

Associations between earlier and later childhood are investigated in this study and for the sake of brevity earlier childhood in this study is defined as the time period between 6 (earlier childhood) to 9 years of age, also known as the middle childhood years, and later childhood is regarded as the age of 12 years.

1.2 Problem statement

During later childhood, good OCS, MP and PF are important when children should be able to generalize different capabilities in sport-specific and specialized skill environments where time, accuracy and fast decision-making, endurance and accuracy of performance are required (Goodway & Branta, 2003:38). Typically, these basic proficiencies are assessed as discrete skills in closed skill environments which are predictable and give the participant the time to plan the outcome, skill, accuracy and timing needed to complete the skill (Goodway & Branta, 2003:38). This static environment of applying learned isolated skills thus does not assess combined and complex movement capabilities or reflect the open, dynamic and complex nature of environments typical of childhood play or sport, especially during later childhood (Cotterill & Discombe, 2016:54).

In this regard, Cliff *et al.* (2009:439) recommended longitudinal studies to examine subcategories of fundamental motor skills for a better understanding of their associations with physical activity (PA) and PF. Such studies will aid in the development of a stronger rationale for the development of fundamental motor skills during earlier childhood in order to promote PA, physical health, psychological health and social health in later childhood. Children who have obtained the basic skills are better prepared to perform these skills in the context of future activities that involve such movements, according to Schmidt and Wrisberg (2013:191). An example is catching skills which are a prerequisite for playing netball, cricket and rugby. Practising one activity also affects the speed and quality of practising and the subsequent learning of another activity (Schmidt & Wrisberg, 2013:193). In such contexts, there can be a general plan, but specific actions are required based on the demands set by the environment

(Pienaar *et al.*, 2015:309). Cotterill and Discombe (2016:54) showed that adaptability and variation in combination with motor patterns enable individuals to display mastery of previously learned movements and the ability to gain new movement knowledge from executing motor skills in a variety of novel combinations. Stodden *et al.* (2008:296) also reported that older children with lower MP tend to opt out of PA because they have a limited repertoire of skills to participate with, and as they know they are less competent than their peers, they do not want to reveal their lower proficiency in public. Children should therefore be encouraged to develop a variety of fundamental movement skills such as throwing, jumping and running to enable them to execute a wide variety of actions in the future.

Pertaining to OCS, most studies have studied the association between early OCS and PA (Cairney *et al.*, 2011:1198; Cliff *et al.*, 2009:439; Visagie *et al.*, 2017:199). Lloyd *et al.* (2014:68) reported in this regard evidence that early OCS proficiency at the age of 6 was related to long-term PA as measured at 26 years of age, but identified the need for more research with larger sample sizes to investigate the full spectrum of motor skill proficiency. The possible association between early mastery of OCS and the application of these skills in more complex sporting environments during later childhood (thus the stability of these skills during childhood) are less studied and needs better understanding. Lubans *et al.* (2010:1019) and Barnett *et al.* (2016:219) identified various research questions in this regard and stated that future research should continue to examine what needs to be done to promote the development of more physical competent children. The need to establish whether fundamental motor skills provide the foundation for lifelong skills and health-enhancing forms of PA was specifically highlighted. In this regard, it is important to determine the stability or consistency of basic fundamental motor skills not only in adolescence, but also during childhood. A child should be proficient in FMS by the age of 9, which is also the age period that is considered for full mastery of OCS.

As mentioned, children's movement capabilities do not only incorporate fundamental motor skill execution. Children also need to be able to combine simple movements and demonstrate more complex movement to be motor proficient (Schmidt & Wrisberg, 2013:191). A gap found in the literature is that the association between MP and PF has been less studied than the association between MP and PA (Haga 2009:1090; Lloyd *et al.* 2014:68) and the association between MP, sport participation and lifelong PA (De Milander, 2011:12). A systematic review conducted by Cattuzzo *et al.* (2016:123) reported strong evidence of a positive association between MP and PF. A strong association was reported between MP and PF (Cattuzzo *et al.*, 2016:128) specifically when using the Progressive Aerobic Cardiovascular Endurance Run (PACER) to measure cardiorespiratory fitness. It is however unknown whether being motor proficient during

earlier childhood, is likely to be a predictor of physical fitness during later childhood. The association between MP and aspects of PF across childhood and adolescence has, however, been highlighted by Cattuzzo *et al.* (2016:124) as a specific gap in the knowledge. This researcher reported in this regard that various studies (82%) employed cross sectional design studies of which Cattuzzo (2016:124) is one and 18% were longitudinal studies.

This study therefore aims to provide more insight into this knowledge gap, namely by answering two research questions. Firstly the question is asked whether early mastery of object control skills will be beneficial toward the application of these skills during later childhood in more complex environments in children living in the North-West Province of South Africa. Secondly this study asks the question whether motor proficiency during earlier childhood in children living in the North-West Province of South Africa will enhance their physical fitness during later childhood. Answering these research questions by using longitudinal data will directly benefit the health and well-being of children and the community. It will also provide support to the assumption that basic skills are essential for mastering of more advanced skills which are considered prerequisites for being physically active. Furthermore, it will generate knowledge to scientists and health practitioners about the importance of adequate MP and the mastering of OCS at a young age. Knowledge in this regard can also contribute to the development of appropriate strategies to improve fundamental skills and general motor proficiency in children.

1.3 Objectives

The objectives of this study are:

- 1.3.1 To determine the association between object control skills mastery during earlier childhood and the application of these skills during later childhood in children living in the North West Province of South Africa;
- 1.3.2 To determine the association between motor proficiency and physical fitness during earlier and later childhood in children living in the North West Province of South Africa.

1.4 Hypotheses

This study is based on the following hypotheses:

- 1.4.1 There will be a significant association between object control skills mastery during earlier childhood and the application of these skills during later childhood in children living in the North West Province of South Africa;

- 1.4.2 There will be a significant association between motor proficiency during earlier childhood and physical fitness in later childhood in children living in the North West Province of South Africa.

1.5 Structure of dissertation

This dissertation is presented in article format. The structure of the dissertation is as follows:

- 1.5.1 Chapter 1 serves as an introduction and includes the problem statement as well as the objectives and hypotheses of the study. At the end of this chapter references will follow, according to the adapted Harvard guidelines as required by the North-West University.
- 1.5.2 Chapter 2 provides a literature review on the association between object control skills, motor proficiency and physical fitness during earlier and later childhood. At the end of this chapter references will follow. The references of chapter 2 follow after the chapter and are according to the adapted Harvard guidelines as required by the North-West University.
- 1.5.3 Chapter 3 is presented in the form of an article and presents the research results of objective one. The title of the article is: *The association between early object control skills mastery and application during later childhood: Longitudinal data from the NW-CHILD study*, and is presented to the *Journal of Perceptual and Motor Skills*. Guidelines for authors who submit an article for consideration for publication to this journal are attached as Annexure E. For technical purposes and uniformity of the dissertation some amendments have been made to the guidelines and requirements of the journal. The article's margins were set in accordance to the rest of the dissertation (0.98 " left and bottom, 0.79 " right and above) and the line spacing of 1.5 was used throughout. A font size of 12pt Times Roman was used, with no space at the beginning of paragraphs. Periods (.) were used instead of commas (,) between decimals, and numerical values (in par with the rest of the dissertation) were used to ensure that uniformity was maintained throughout the dissertation. Headings were numbered to fit the technical style of the dissertation, which is not required by the journal guidelines. The above changes have been made to make the dissertation technically easier to read and uniform in structure. The references of chapter 3 follow immediately after the chapter (article) and were prepared according to the *Journal of Perceptual and Motor Skills'* prescriptions.
- 1.5.4 Chapter 4 is also presented in the form of an article. The title of the article is: *The association between motor proficiency and physical fitness during earlier and later*

childhood and will be presented for consideration for publication to the *Journal of Sports Medicine and Physical fitness*. The guidelines to authors of this journal are attached as Appendix G. For technical purposes and uniformity of the dissertation, some changes were made to the guidelines of the journal. The article's margins were set to be the same as the rest of the dissertation (0.98 " left and bottom, 0.79 " right and top) and the line spacing is set at 1.5. A font size of 12pt Times Roman was used. Periods (.) were used instead of commas (,) and continuous sequential numerical values were used to ensure uniformity throughout the dissertation. Headings were numbered according to the technical style of the dissertation, which is not required according to the journal guidelines. Aforementioned changes have been made with the aim of making the dissertation technically easier to read and uniform in structure. The references of chapter 4 follow immediately after the chapter and were prepared according to the *Journal of Sports Medicine and Physical Fitness prescriptions*.

1.5.5 Chapter 5 includes the summary, conclusions and recommendations of the study.

1.5.6 All measurements used in this study are part of standardized test batteries which are subject to copyright. Consequently, only a summary of the procedures used for The Canadian Assessment of Physical Literacy Obstacle Course (CAPL), Test of Gross Motor Development, Second Edition (TGMD-2), the Progressive Aerobic Cardiovascular Endurance Run test (PACER) and The Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF) are attached as Annexure A, B and C.

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CHAPTER 2

CHAPTER 2

LITERATURE REVIEW: THE ASSOCIATION BETWEEN

MOTOR PROFICIENCY, OBJECT CONTROL SKILLS AND PHYSICAL FITNESS

DURING EARLIER AND LATER CHILDHOOD

2.1 Introduction

Children's demonstration of proficiency in motor skills is considered to be a cornerstone to their later physical and motor skill development (Chen *et al.*, 2016:102). In this regard fundamental motor skills (FMS), which develop during childhood, provide essential building blocks for motor proficiency (MP) upon which sport-specific and specialised skills are built (Barnett *et al.*, 2012:1024; Barnett *et al.*, 2016:220; Burton & Miller, 1998:355). While FMS lay the foundation for advanced and complex future movement (Logan *et al.*, 2018:781) it is also an important enabler of lifelong physical activity (PA) (Clark & Metcalfe, 2002:3; Wrotniak *et al.*, 2006:1758).

An overarching aim in this respect is for children to become physically literate. Physical literacy is identified as the underlying or ultimate goal to becoming physically active for life according to Sport for Life (<http://www.sportforlife.ca>). Physical literate children is described as being physically educated, has the ability to use (certain) skills in their everyday lives and has the disposition towards purposeful PA as an integral part of their daily living (Castelli *et al.*, 2014:95). For a child to be physically literate they should be motivated to move, confident to move and competent to move including affective, behavioural, physical and cognitive components. According to the International Physical Literacy Association (2014) individuals who do not develop physical proficiency, thus competency to move (which is based on aspects such as agility, balance, coordination, speed and jumping), before the onset of the adolescent growth spurt, are unlikely to achieve success in sport. One underlying aspect of physical literacy that is highlighted by researchers is well-developed fundamental motor skills. These include object control skills (OCS) and locomotor skills (LS) which will allow a child to respond efficiently to the environment and to others with control over a wide range of physical activities (Higgs, 2010:6; Killingbeck *et al.*, 2007:20). Fundamental motor skills are described by researchers as the foundation of body movements (Barnett *et al.*, 2012:1024), which are not equal to physical literacy but is one of the key basic ingredients to become physically literate (Barnett *et al.*, 2016:223) while it also serves as the foundation for more complex or specialized skills used in play, games and sport specific applications. Fundamental motor skills proficiency is important for children in order to become physically proficient because once they are physically proficient

they show improved motivation and confidence to take part in PA. It is reported that fundamental motor skills competency is imperative to perceived competence. Perceived competence is defined as an individual's awareness and belief of their capability to perform gross and fine motor tasks as well as their ability to control their environment and situation, and a positive self-perception (Bryant *et al.*, 2016). Perceived competence is associated with improving and increasing PA and correlates with physical fitness (PF) levels in adolescence and adulthood (Giblin *et al.*, 2014:1179). Stodden *et al.* (2008:292) is, however, of the opinion that the development of MP is important in its own right by either encouraging or discouraging children's PA levels. According to this researcher, children choose to be active or inactive due to the MP or skilfulness of the child. Factors influencing the development of MP and PA are according to Stodden *et al.*, (2008:292) perceived MP, PF and obesity. It is furthermore stated by Castelli and Valley (2007:358) that PA behaviour and the trait of PF are reciprocally related and that these factors indirectly influence each other. Therefore, proficient motor skills, self-perception of physical competence and health-related physical fitness (PF) all play a key role in predicting not only PA levels but also health enhancing behaviour and sport participation in children (Chagas & Batista, 2017:7). It thus seems that when a child is confident and competent in fundamental motor skills, specifically with a focus on object control skills (OCS) and motor proficiency, it may result in successful sport-specific and complex movement skills, increased participation in sport with a significant increase in PF. The pathway for children to become physically active, starting with proficiency in FMS, is portrayed in Fig. 2.1. The focus of this literature chapter will be on investigating assumptions of associations of this illustrated pathway.

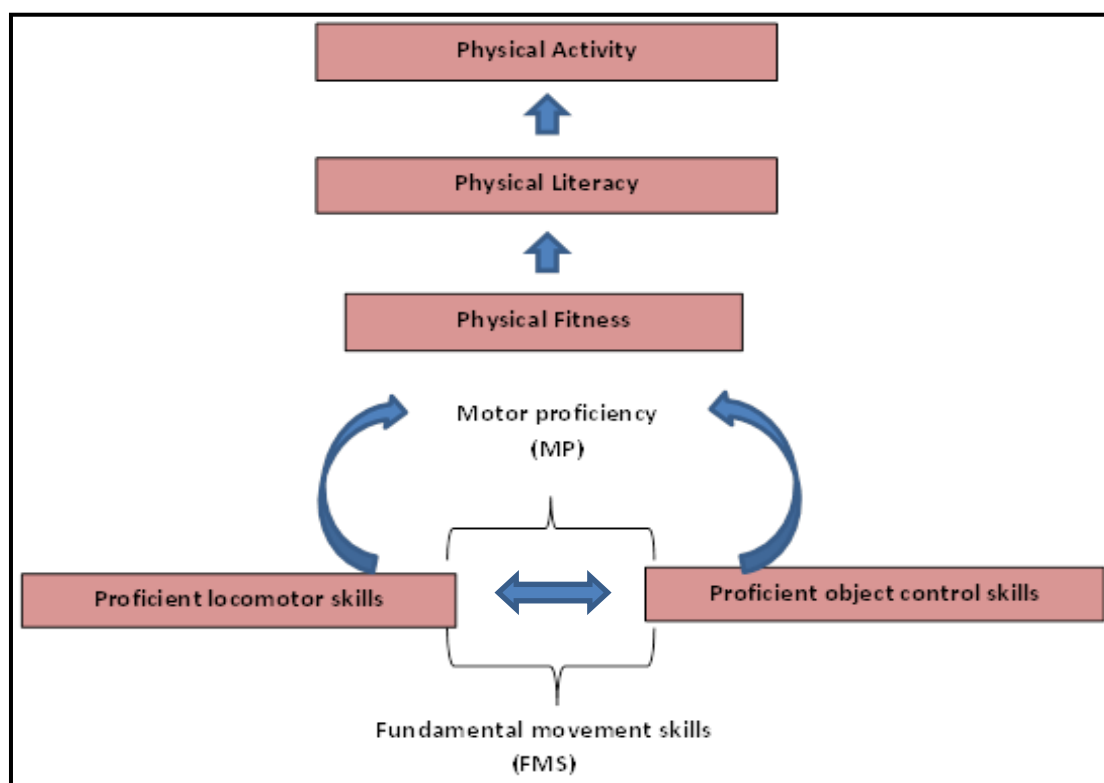


Figure 2.1: The association between object control skills, motor proficiency and physical fitness and the relationship of these factors with physical literacy and physical activity

As this study aims to determine the association between OCS, MP and PF during earlier (children aged 6 and 9) and later childhood (children aged 12), this literature overview mainly focuses on studies and development of children that are applicable to this age period. The reasoning behind fundamental motor skills which includes locomotor and object control skills (OCS) that serve as foundational skills for children to become motor proficient will firstly be investigated. Sport participation statistics regarding children (9 to 13 years) living in the South Africa (SA) and the importance of sport participation for a healthy lifestyle later in life will be provided as a background in this regard. Literature regarding OCS will firstly be described which include a discussion of the importance and status of OCS mastery. Motor proficiency (MP) and physical fitness (PF) will also be discussed in similar matters. A discussion will then follow regarding factors influencing MP and the association between MP and PF. Lastly the findings of cross-sectional and longitudinal studies that are relevant to the aims of this study will be investigated and described. Firstly, terminology that is relevant to this study will be defined.

2.2 Terminology

Motor proficiency, motor mastery, fundamental motor skills that include object control skills, locomotor- and stability skills and physical fitness will firstly be defined as these are the broad outcome variables that were used in this study. Other terms that will also be defined as they have relevance to the study context, include physical literacy and physical activity. It was also deemed necessary to clarify and shortly describe age developmental periods that are applicable in the context of this study.

Motor proficiency (MP). Various definitions for motor proficiency (MP) are provided in the literature. Stodden *et al.* (2008:293) defines MP in terms of proficiency in general fundamental motor skills including OCS and locomotor skills development. More recently Rudd *et al.* (2015:8) highlighted the importance of stability skills as a somehow neglected, but important component of MP. Sherrill (2004:333) describes MP as the ability upon which performance is built, while Henderson and Sugden (1992:59) refer to MP as the ability to execute different motor performances and coordination of both fine and gross motor skills. According to Rudd *et al.* (2015:2), MP describes the ability to perform various fundamental motor skills in a consistent and proficient way. D'Hondt *et al.* (2013:62) defines MP as the degree of skills performance in a

wide range of motor tasks and movement control and coordination underlying a motor outcome. Portela (2007:7) defines MP as multi-dimensional flexion-, extension-, and rotation movements which lead to successful locomotor-, balance- and manipulation skills.

Mastery of motor skills. Motor proficiency and mastery of motor skills are often used interchangeably. However, mastery of motor skills refers to performing motor skills with high levels of proficiency (Figueiredo & Ipiranga, 2015:350). Motor skills should therefore be mastered well by children to become motor proficient. Mastering of FMS therefore reflects MP, and is typically assessed in young children by means of process (performance criteria such as the TGMD-2) or product (outcome) measurements (Burton & Miller, 1998). The tools that measure physical competence in children 8 years and older should however, assess fundamental, combined and complex movement skills in a dynamic and more authentic environment, in an efficient manner. A single assessment that aims to equally assess both the process/technique and the product/outcome aspects of physical competence at older ages is therefore warranted. Currently obstacle courses such as the Canadian Assessment of Physical Literacy Obstacle Course (CAPL) are used in this regard (Canadian Assessment of Physical Literacy, Healthy Active living and Obesity Research Group, 2013). An authentic environment is one that is developmentally appropriate and considers the interaction of the individual and the environment, as well as the specified movement skill. Performance of movement skills in isolation does not incorporate the measurement of an individual's ability to alter and combine movement skills according to the task at hand and the environment, both of which are important traits to advance physical competence (Tyler *et al.*, 2018:2474).

Fundamental motor skills (FMS). In the early childhood years, children acquire a group of motor skills known as fundamental motor skills, which are the equivalent to the ABC's in the world of PA (Stodden *et al.*, 2008:291). Barnett *et al.* (2016:220) describe FMS as basic learnt movement patterns that do not occur naturally and are suggested to be foundational for more complex physical and sporting activities. These skills develop from infancy up to 6/7 years of age (Burton, 2011:2). Clark and Metcalfe (2002:17) suggest that fundamental motor skills represent the base camp from which children will climb on the mountain of motor development to achieve context-specific motor skills. Fundamental skills are generally categorised as locomotor-, object control- and stability skills (Barnett *et al.*, 2016:220; Burton & Miller, 1998:58; Gallahue & Ozmun, 2006:187; Rudd *et al.*, 2015:2) which will all be defined in the following paragraphs. The definitions that will be provided adhere to the outcome of a systematic review of the term; fundamental motor skills by Logan *et al.* (2018:781).

Locomotor skills involve the smooth coordinated movement of the body through space - the basic ways to move - and are distinguished as the building blocks of coordination (Burton & Miller, 1998:58; Gallahue & Ozmun, 2006:187). Locomotor skills consists of skills such as walking, running, galloping, jumping, hopping, side-sliding, leaping and skipping (Haywood & Getchell, 2005:140; Pienaar, 2014:8). Pienaar (2014:9) indicates that locomotor skills can be performed in an upward or forward direction.

Object control skills (OCS) implies the controlling of objects, for example balls, bats, hoops, ribbons, to name but a few with any part of the body including the hand and foot. Throwing, catching, kicking, striking and dribbling are examples (Haywood & Getchell, 2005:144). The Department of Education (2013:15) defines OCS as the ability to control equipment (for example bats, rackets or hoops) or objects (such as balls), with appropriate speed by hand or foot. OCS is one of the core focus areas in this study and therefore it will be discussed in more detail in paragraph 2.5.

Stability skills are movements where the body has to recover from gravitation to be stable and upright or where a person needs to maintain an upright position or have control over the body when walking, sitting and standing (Gabbard, 2008:14). Stability skills are sometimes referred to as non-locomotor skills and are those skills where the body remains in place but moves around its horizontal or vertical axis (Gallahue & Donnelly, 2007:53).

Physical fitness (PF) is described as a set of attributes that are health, skill or performance related and the attributes can be measured with tests (Caspersen *et al.*, 1985:126). Monyeki and Kemper (2007:13) define PF as the maintenance of basic bodily functions that enable people to fulfil their day-to-day activities. PF can be divided into neuro-motor components (e.g. muscle strength, flexibility, speed and movement, and coordination), health-related PF components (muscular strength, muscular endurance, cardiorespiratory endurance, flexibility and body composition), and motor or performance-related fitness skills (balance, co-ordination, agility, speed and power) (Howley, 2001:365). According to Howley (2001:364) health-related fitness refers to cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility and is usually related to disease prevention and health promotion. Neuromotor fitness may however, be just as important as aerobic fitness in maintaining overall health and function (Runhaar *et al.*, 2010:323) and is considered to be the ability of the body's circulatory and respiratory systems to supply fuel and oxygen during sustained PA.

Physical literacy, as a core objective in the movement enabling echelon, is defined by Longmuir *et al.* (2015:767) as the motivation, confidence, physical competence, knowledge and understanding to value and engage in a physical active lifestyle. Giblin *et al.* (2014:1177) defines physical literacy as a multifaceted conceptualization of the skills required to fully realize potential (physical education, PA and sport skills) through embodied experience.

The ultimate, namely to endorse PA, is defined as any bodily movement that is initiated when skeletal muscles and energy usage are required (WHO, 2013a: xx). Increased PA provides opportunities to promote neuro-motor development, which in turn promotes fundamental motor skills development (Fisher *et al.*, 2005:684). PA during early childhood may drive development of MP (Stodden *et al.*, 2008:294).

Early childhood generally refers to the developmental period between 2 to 6 years which is the period when fundamental motor skills develop forming the foundation for more specialized movement skills (Branta, 1982:39; Burton, 2011:2; Gabbard, 2008:12; Krüger, 2002:33). During early childhood children should learn to perform the following fundamental motor skills: jump with two legs, jump with one leg, running, sliding, long jump, skipping, standing on one leg, walking on a line forward and backwards, heel-toe standing and walking (Pienaar, 2012:81-85). Most of these skills should reach the mature stage by 7 years and the child should be fully proficient in these skills by the age of 8 and 9 years (Gallahue & Donnelly, 2007:62). During early childhood it is subsequently important for children to experiment with different motor tasks that will help them to develop and learn progressively (Malina *et al.*, 2004:202). Stimulation, learning and exposure to fundamental motor skills during this period are therefore important for optimal development to take place (Hands, 2002:3). Researchers (Lee *et al.*, 1995:384; Rose *et al.*, 1994:18) state that if a child masters fundamental motor skills well, it will enable him/her to move on to the sport-specific phase having more self-confidence, being more active in specialised movement skills and it may lead to lifelong sport participation. Stodden *et al.* (2008:296) reported that perceived MP, which is an individual's awareness and belief of their capability to perform gross and fine motor tasks is not correlated to levels of motor skill proficiency nor PA during early childhood, although the transition from early to later childhood marks an important transitional developmental time when the role that perceived MP plays in the relationship between MP and PA will change (Davison *et al.*, 2006:30). It is also important to note that during early childhood, skills is mostly performed in closed environments where the environment is predictable and the child is giving time to plan the outcome, skill, accuracy and timing needed to complete the skill (Goodway & Branta, 2003:38). During this period, skills are mostly performed and assessed in isolation or in closed environments, which does not take into

consideration nor assess combined and complex movement capabilities or reflect the open, dynamic and complex nature of environments typical of later childhood play or sport (Cotterill & Discombe, 2016:54).

Middle and late childhood developmental periods refers to the period between 6 to 12 years when children are typically in the primary school. During this period the stability and consistency of basic fundamental motor skills at which a child should be proficient at the age of 9 needs to be further refined. Fundamental motor skills develop as a result of an increase in strength, coordination and muscular control in late childhood as well as balance and poised execution of physical movement (Louw & Louw, 2014:215). Considerable physical development of the body takes place during the late childhood years (6 to 12 years) such as rapid growth of the arms and legs in relation to the torso, while considerable adjustments are seen in eye, hand and foot co-ordination (Branta, 1982:40; Gabbard, 2008:12; Krüger, 2002:33; Louw & Louw, 2014:216). During the transition from childhood to adolescence biological maturation influences all developmental variables (Luz *et al.*, 2017:9). Thomas (2001:4) stated that changes in children during childhood and adolescence are mostly driven by an interaction between biological factors, genetics, puberty, maturation and growth, and environmental factors such as practice, experience, opportunity and encouragement. During the late childhood years, children should be able to generalise different capabilities in sport-specific and specialised skill environments where time, accuracy and fast decision-making and accuracy of performance is required from older aged children (Goodway & Branta, 2003:38). Pertaining to this study, an obstacle course protocol (Canadian Manual for Test Administration, 2013) that assesses motor competence based on the execution of fundamental motor skills in the 12-year-old group was used. The obstacle course protocol presents an open environment setting. This allowed associations to be drawn between OCS, MP and PF during earlier and later childhood. In an open environment setting more complex movements (similar to what is needed during organized play and sport participation activities) are needed and combined (Lloyd *et al.*, 2014:68) and may provide insights into the sport-related applications during later childhood.

For the purpose of this literature study where the time period of investigation is children between the ages of 6 and 12, the terminology earlier and later childhood will be used broadly, where the earlier childhood period will be considered the time period from 6 to 9 years while the term later childhood will be applicable to 12-year-old children. The age period from 9 years is also referred to as a time period relevant to the middle childhood years.

Against this background it was considered to be relevant to provide a short background on PA and sport participation patterns of children in South Africa (SA).

2.3 Sport participation and physical activity levels of children in the SA

In SA a high premium is placed on sport participation to enhance nation-building, character development and to serve as a cohesive factor for binding the SA 'rainbow-nation' (Department of Sport and Recreation, 2012:15-19). Nelson Mandela stated at the Inaugural Laureus Lifetime Achievement Award, Monaco in 2000: "Sport has the power to change the world. It has the power to inspire. It has the power to unite people in a way that little else can." (<http://www.db.nelsonmandela.org>). He also continued to say that sport can awaken hope where there is despair, can break down racial barriers and discrimination and promote peace. Aligned with these benefits, Holt *et al.* (2011:491) reported that sport provides the best setting for developing a wide range of positive social results. These researchers highlight the positive contribution that sport has on nation-building, national identity, globalisation, economic development and character development.

Uys *et al.* (2016:265) state that according to the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the World Health Organization (WHO) the opportunity for children to participate in sport, PA and to obtain the 'highest attainable standard of health' are considered fundamental human rights. The World Health Organization (2012:5) highlights the importance of Physical Education and school sport; the reason being that it contributes to the immediate advantage of PF and fundamentally serves as preparation for a physically active and healthier lifestyle.

A study done by The Human Science Research Council (HSRC) confirmed that an average of only 25% of South African children participate in sport. It is indicated that there are three factors that motivate people to participate in sport or any recreational activities, namely: exposure to sport at school (33%), an active and healthy lifestyle (19%) and friends (18%) (Department: Sport and Recreation, 2009:35). In 2007 the estimated total population of 13 to 18-year-olds was 5843 out of the total estimated population of 47488 (Department: Sport and Recreation, 2009:36). This report furthermore reveals that the ten most popular sports among children in this age group are soccer, netball, athletics, cricket, basketball, tennis, swimming, rugby, volleyball and aerobics (2009:36). The Department: Sport and Recreation (2009:39) furthermore found that soccer, athletics, rugby, tennis, volleyball and hockey in that order have the highest number of participants within a school context. An estimated 63% of 13 to 18-year-olds participated in one sport while some participated in two sports (Department: Sport and

Recreation, 2009:37). Looking at the sports participation trends as reported by the Department: Sport and Recreation (2009:39) an increase of 5% was seen since 1993 with 57% of 13 to 18-year-old children participating in sport during 2006 and 2007. In 2007, 58% of all boys participated in sports compared to 42% of girls. Soccer, cricket, athletics, rugby, basketball, swimming and tennis are the most popular sports among boys aged 13 to 18 while netball, athletics and tennis are the most popular sports among girls in the same age group (Department: Sport and Recreation, 2009:43). The Healthy Active Kids South Africa (HAKSA) report card (2014:S100) reported the results of a worldwide survey done by Katzmarzyk *et al.* (2013:371) that also involves 500 primary school children in the Western Cape Province that shows that 54% participated in at least one school team sport; boys (72%) were more likely to participate than girls (43%). In agreement Cozett (2014:68) reported that just over a third (34.4%) of children aged 11 to 13 belongs to a sports team; again boys are more likely to participate than girls. These statistics clearly indicate the significance of basic sport skills that children need to participate in ball skill related sports among South African children.

A survey done by the South African Youth Risk Behaviour Survey in 2008 reports that 43% of adolescents that participate in sport has sufficient levels of health-enhancing, vigorous PA, but it shows a decrease in prevalence of 2% from 2002 (Reddy *et al.*, 2002:205). With regard to PA patterns of South African children, McVeigh and Meiring (2014:374) completed a study in the Gauteng Province of SA and found that 78% of learners meet the recommended guidelines of 60 minutes per day of moderate-to-vigorous PA. The HAKSA Report Card of 2014 furthermore reported that 50% of the children did not reach the recommended daily PA, 30% to 60% do not participate in weekly physical education and children are spending an average of 3 hours per day on screen time. During the same year a regional study done in the Western Cape reported that 74.8% of boys and only 54.8% of girls aged 11 to 13 were engaged in self-reported moderate-to-vigorous PA at least 3 times per week (Cozett, 2014:79).

When comparing the results of the HAKSA report cards of 2010; 2014 and 2016, an overall decrease in PA in children and an increase in obesity and health risk diseases are notable. HAKSA (2014:S98) reported a particular concern that overweight and obesity in adolescent boys have doubled while physical inactivity has risen over a six-year period (2002-2008). Approximately 16% of boys reported low levels of moderate-to-vigorous PA while 39% of girls were inactive (Micklesfield *et al.*, 2014:20). When comparing the PA indicators in the HAKSA report cards of 2010 and 2014, it is evident that there has been no decrease or increase in their overall fitness, organized sport participation, physical education and sedentary behaviour, although a Survey of Time (2010) shows that children 10 to 17 years watches 3 hours of

television per day. Lennox and Pienaar (2013:154) also reported an increase of television viewing to 3.5 hours per day in grade eight children (13 to 14-years-old). When comparing the gradings from the HAKSA 2014 and more recent 2016 report cards, studies on South African children show that although overall PA levels have improved and contributed to an improved grading, organized sport participation have decreased. It is also found that overall PA of girls and older children fared poorer, therefore strategies to improve participation in PA in girls and adolescents are recommended (HAKSA, 2016:S267).

Socio-economic settings seem to play a significant role in sport participation and should be taken into consideration in this regard. In the HAKSA (2010:5) report card mention was made of the National Youth Fitness Survey, involving 10 000 children aged 7 to 13 years and revealed that fitness levels were lower in children from disadvantaged backgrounds. In agreement Elgar *et al.* (2015:2088) and Muthuri *et al.* (2014:3327) also highlighted, among other things, the influences of socio-economic inequalities on PA levels of children.

2.4 Phases of motor development

Pertaining to motor development, four phases of motor development as described by Gallahue and Ozmun (2006:50) are relevant to this study. The phases will only be described superficially to provide a background on early motor development. These include the *reflexive movement phase* (prenatal to birth), *first movement phase* (birth to 2 years), *fundamental movement phase* (2 to 7 years) and the *sport related movement phase* (seven and older) as illustrated in Figure 2.2. A specific focus of this discussion will be on motor development during the earlier childhood years, or the fundamental movement stage and the development in the later childhood years known as the sport related movement phase.

The *reflexive movement phase* (prenatal to birth) refers to a time period of motor development characterised by involuntary and automatic movement (Pienaar, 2012:8). This movement is the result of primitive and postural reflexes.

The *first movement phase* (birth to 2 years) reflects the development of basic voluntary movements like locomotor skills (crawling and walking), manipulation skills (reaching and grasping) and stability skills (body control) which is considered to be important building blocks for fundamental and more specialised motor skills development (Pienaar, 2012:8).

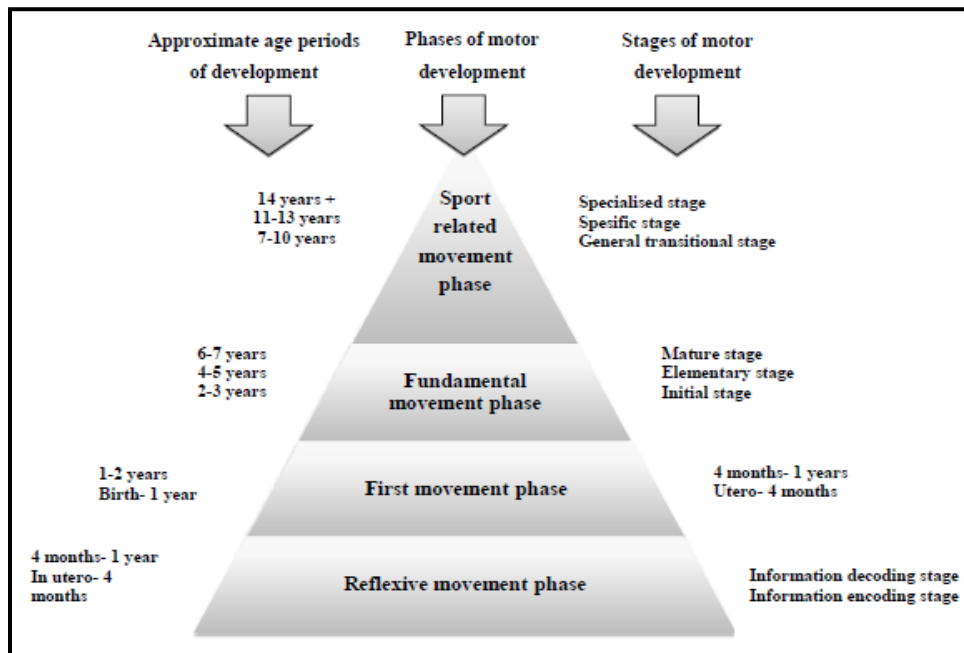


Figure 2.2: Four phases of motor development (Gallahue & Ozmun, 2006:50)

The *fundamental movement phase* describes the age period between 2 and 7 years and are subdivided into three developmental stages, the initial developmental stage (2 to 3 years), elementary stage (4 to 5 years) and the mature stage (6 to 7 years) (Gallahue & Ozmun, 2006:51). Pienaar (2012:9) described the initial stage (2 to 3 years) as characteristic of performance of relative uncoordinated movements. During the elementary stage (4 to 5 years) coordination, rhythm of movement and control of movement is improving, but smoothness of movement is still lacking. During the mature stage (6 to 7 years) skills is executed in a coordinated, mechanically and correct manner. Burton and Miller (1998:58) and Gallahue and Donnelly (2007:62) stated that the developmental period between 6 and 7 years is a sensitive time period for the development of fundamental motor skills. It is also an important phase for the development of motor skills, because this is a time of experimenting with new body movements. In this phase of development children have to build upon previously learned movements and are prepared for the achievement of more advanced skills to be executed as specialised sport-specific skills (Gallahue & Ozmun, 2006:51).

The *sport related movement phase* which involves children 7 years and older, is divided into different developmental stages: transition stage (7 to 10 years), specific stage (11 to 13 years) and specialised stage (14 years), see Figure 2.2. Pienaar (2012:8) reported that the transition stage describes children who are typically in grade 1, 2 and 3 which is known as the middle childhood years. During this transition period expansion and refinement of locomotor skills,

manipulation and stability skills, that was learnt during the fundamental motor skills development stage, takes place. The second stage is called the specific stage of development and refers to the late childhood and early adolescence time periods of this development phase. During this stage children should show mature execution patterns of performance criteria related to different motor skills (Pienaar, 2012:8). Basic fundamental skills are now combined and refined to become more specialised (Gallahue & Ozmun, 2006:53). Children also start to realise their physiological and personal limitations but also their strengths known as perceived proficiency. The important focus in this phase should be to improve performance criteria and the quality of skills through repeated practice (Pienaar, 2012:24). The final stage of the transition phase is referred to as the specialized stage when children are 14 years and older and show more interest in sport and performance (Gallahue & Ozmun, 2006:53). The development of fundamental motor skills into specialized skills should now be of such a nature that it can be applied in sport-specific games. Good MP and PF are important during application at older ages when children should be able to generalize the different capabilities in sport-specific and specialised skill environments as timing, accuracy, fast decision-making and accuracy of performance is now required to be successful.

Literature findings regarding OCS, MP and PF, which are the focus of this study, will now be discussed in more detail.

2.5 Object control skills (OCS)

OCS encompasses either gross motor or fine motor movement, although this study will only focus on gross motor OCS which implies movement giving force to objects or receiving force from objects. This includes skills such as throwing, catching, kicking, trapping and striking (Haywood & Getchell, 2005:140; Pienaar, 2014:8). OCS is refined into sport skills for example when playing tennis and hitting a tennis ball with a backhand swing (Gallahue & Donnelly, 2007:57). OCS do not develop automatically, therefore opportunities for practice and coaching are important for children to be able to master advanced OCS movement patterns which is typically assessed as performance criteria of the skill (Burton and Miller, 1998:58).

Research indicates gender differences in motor skill competence and more specifically in OCS (Butterfield *et al.*, 2012:261). Girls show less proficiency in ball skills compared to boys, according to Seefeldt and Haubenstricker (1982:59). Boys reached a mature one-handed overarm throwing pattern at 63 months, whereas girls reached the mature one-handed throwing pattern only at 102 months. Boys outperformed girls in preschool and elementary school in OCS, while Lubans *et al.* (2010:1033) also found that boys were significantly more proficient

than girls in ball skills during childhood and the adolescence years. Other studies also confirm OCS differences in childhood and adolescence, showing that boys are more proficient than girls (Barnett *et al.*, 2010:162; Butterfield *et al.*, 2012:270).

A few studies also reported on the mastery status of OCS skills in children (Cliff *et al.*, 2009:436; Draper *et al.*, 2012:137; Lubans *et al.*, 2010:1019; Pienaar *et al.*, 2015:309; Van Waelvelde *et al.*, 2004:348; Wong & Cheung, 2006:28). Pienaar *et al.* (2015:309) reported OCS mastery on 826, 9 to 10 year old South African children (M= 9.9 year), of which 433 were boys, 393 girls, 207 white and 619 black. The largest percentage of the group (69.1%) displayed average OCS mastery, 23% displayed poor mastery while only 8% showed above average mastery. The study of Pienaar *et al.* (2015:317) additionally reported a mastery of 96.2% in catching while the lowest proficiency is obtained during underhand rolling (79.5%) in the group. Boys achieved a 96.2% proficiency in catching and girls 96.3%. These researchers concluded from their findings that environmental opportunities are the primary cause of the differences found in OCS skills mastery as well as regarding the rate at which OCS skills are mastered. Wong and Cheung (2006:28) furthermore reported that children in Hong Kong aged between 3 and 10 years have lower OCS mastery in comparison to the performance criteria standards of the Test of Gross Motor Development (TGMD-2). A study using the TGMD-2 was also done on 46 three to 5-year-olds of which fundamental motor skills were analyzed according to video's (Cliff *et al.*, 2009:436). Amongst boys, OCS were associated with objectively measured PA and explained the variance percentage of time in 16.9% moderate-to-vigorous PA and 13.7% total PA, respectively, after controlling for age and SES. OCS was not related to PA outcomes in girls, although locomotor skills were inversely associated with their moderate-to-vigorous PA and explained a 19.2% variance after accounting for background variables (Cliff *et al.*, 2009:443).

Butterfield *et al.* (2012:266-267) completed a study at a rural school, of which 99% were Caucasian children, to determine the mastery characteristics of four different OCS (catching, kicking, throwing, striking) in 186 children (105 boys, 81 girls) with a mean age of 9.6 years. The results showed that at 10 years of age, 80.5% of the children achieved a mature catching pattern while a plateau appears at age 11. Throwing and kicking skills show mature mastery levels of 72.2% for throwing at age 10 and 80% for kicking by 11.45 years. Both boys and girls have a low probability of a mature pattern in these skills at younger ages (4 to 7 years). Researchers also reported gender differences in OCS mastery and Butterfield *et al.* (2012:269) mentioned that boys outperformed girls at all the ages. At 10 years, 78.8% of boys and 47.0% of girls achieved a mature throwing pattern, while 80% of boys demonstrate a mature pattern by

10.26 years. Boys achieved a 62.2% and girls a 44.7% mastery of the striking pattern at the age of 10 years, while boys reached a mature pattern of 80% by 13.38 years.

In the following section different OCS skills that is assessed typically in children will be described separately; i.e. catching, throwing, kicking, underarm rolling, dribbling and hitting. The Test of Gross Motor Development, Second Edition (TGMD-2) is a process based measure that is used to assess gross motor functioning of children 3 to 10-years-old. The test consists of twelve motor skills and is divided into two sub-tests, namely locomotor (run, hop, gallop, leap, horizontal jump and slide) and object control skills (overhand throwing, catching, underhand rolling, dribbling, kicking and striking a stationary ball) (Ulrich, 2000).

Catching

During catching tasks, the hands are used to stop any object that is coming your way (Gallahue & Ozmun, 2006:226). This skill can be performed using an underarm- (when the ball is caught under the waist and the palms of the hands are showing upwards) or overarm catching technique (when the object is caught above the waist line and the palms of the hands are turned away from the body) (Gallahue & Ozmun, 2006:226). The performing of the catching skill is usually divided and described as arm-, hand- and body components that represent the whole catching skill (Payne & Isaac, 2008:341). Catching skills develop slower than rolling-, throwing-, hitting- and dribbling skills. Gabbard (2008:28) and Gallahue and Ozmun (2006:232) noted that the catching of an object with both hands are the most difficult OCS because of the complexity of the hand-eye coordination that is needed for this skill. Children at the age of 6 to 8 years should however be able to catch a ball effortlessly with both hands where no environmental demands are applicable, whilst children at the age of 10 to 12 will be able to catch a ball naturally in more complex environmental demands for example when playing netball (Winnick, 2006:28; Gabbard, 2008:210).

Throwing

The first signs of throwing skills emerge from the age of 6 months although the throwing skill will only be mastered at the age of 6 (Gabbard, 2008:299; Halverson *et al.*, 1982:199; Krüger, 2002:77). The throwing skill can be divided into overarm- or underarm-throwing. The overarm throwing is the most general and most researched object control skill (Haywood & Getchell, 2005:144; Payne & Isaacs, 2008:329). According to Halverson *et al.* (1982:199) and Gabbard (2008:298) a large percentage of children, especially girls, will struggle to develop the correct throwing pattern; however, with enough practice and the correct technique the throwing action can be improved (Butterfield & Loovis, 1993:462; Lubans *et al.*, 2010:1033; Van Beurden *et al.*, 2002:244). Payne and Isaacs (2008:329) divide and describe the throwing action in three

phases: the preparation, execution and follow-through phases. They further divided the development of the throwing action into four developmental stages namely: stage one (children aged 2 and 3), stage two (children aged 3.5 to 5), stage three (children aged 5 to 6) and lastly, stage four (children aged 6.5 and older) (Payne & Isaacs, 2008:329). A study done on 3 to 10-year-olds in Hong Kong found that the overarm throwing skill is more difficult to master compared to the catching, kicking, rolling and bouncing of a ball (Wong & Cheung, 2006:25). Pienaar *et al.* (2015:317) noted that at 9 years the mature shoulder and hip rotation pattern of striking and throwing was not yet being proficiently used during performing striking (59.5%) and throwing skills (78.5%). In a study conducted by Gromeier *et al.* (2017:212) significant differences also emerged regarding qualitative (or process based) throwing performances between boys and girls, although not necessarily in quantitative or outcome based throwing performances.

Kicking

Payne and Isaacs (2008:329) divided the kicking skill into arm and leg components and classify the kicking skill into four developmental stages (initial, intermediate, advanced and mature). Gallahue and Ozmun (2006:232) and Haywood and Getchell (2005:155) reported that during the execution of the kicking skill the foot is used to give power to an object which will lead to the object changing direction or making the object move. Children need perceptual skills as well as foot-eye coordination to perform kicking skills, and because of this Haywood and Getchell (2005:155) declared the kicking skill to be more complex than catching. In agreement Gabbard (2008:28) and Gallahue and Ozmun (2006:232) also reported that the kicking of a ball is one of the most difficult OCS for most of the children, because of the complexity of the foot-eye coordination that are needed in the performance of this skill. Wong and Cheung (2006:25) assessed the execution of kicking skills in 3 to 15-year-old Chinese children, and found to the contrary, that the kicking skill is the easiest skill compared to catching, hitting, rolling and dribbling a ball for most of the children to master. In this study, 37.06% scored full marks during the kicking skill. Pienaar *et al.* (2015:317) reported that only 85% of 9-year-olds were able to use an elongated step prior to contacting the ball which is the most difficult performance criteria of kicking skills to mastery.

Underarm rolling

During underarm rolling, power is given to the object while it stays on the ground moving forward. Gabbard (2008:28) mentioned that this skill is developing from early on where 1-year-old child will start to push or hit a ball on the floor. Children between 2 to 4 years will have a more specific rolling action. The underarm rolling is the first ball sport skill to be mastered, and

children are supposed to be fully proficient in underarm rolling at 6-years-of-age (Gabbard, 2008:28; Krüger, 2002:8). However, Pienaar *et al.* (2015:317) reported that mastery of rolling skills of 9-year-old boys were 81.9% compared to 76.8% in girls. It was found that bending the knees when performing the underhand rolling is the most difficult sub criteria.

Dribbling

Dribbling describes the skill where a ball is continuously hit downward to the ground with the hand at the age of 5 or 6. A 2-year-old will be able to bounce a ball with both hands (Gabbard, 2008:29). When a 3 to 4-year-old child dribbles the ball it will be done with a slack joint in comparison to a 4 to 5-year-old who will dribble the ball with a follow through movement of the arms, wrist and fingers (Gallahue & Ozmun, 2006:238). According to Gallahue and Ozmun (2006:236) the dribbling skill is a very complex skill that requires accurate timing and following through of the ball.

Hitting

Miller *et al.* (2007:67) and Payne and Isaacs (2008:348) stated that the first signs of hitting skills can be seen when a child hits objects against each other. The hitting skill can be done using different objects such as a racket, a cricket bat or a hockey stick. According to Krüger (2002:79) children aged 3 years are able to perform the hitting skill although the skill will only be fully mastered at the age of 5. An inexperienced hitter will perform the skill in a static position with no hip rotation, while an experienced hitter will show clear hip rotation (Payne & Isaacs, 2008:349). Pienaar *et al.* (2015:317) only found 59.5% mastery of hitting skills at the age of 9 with the most difficult part being the mature shoulder and hip rotation that is not being used frequently. These results of more recent studies on OCS mastery, is indicative that children are not as proficient at OCS at early ages, as is indicated by older studies.

2.6 Motor proficiency (MP)

Another focus in this study is MP. According to D'Hondt *et al.* (2009:22) MP describes the quality of movement coordination during the execution of motor skills that requires gross- and fine motor skills. Researchers (Goodway & Branta, 2003:45) state that there is a misconception that children “naturally” learn fundamental motor skills, since many children do not obtain proficiency in fundamental motor skills development.

Clark and Metcalfe (2002:25) state that the overall goal of the “fundamental patterns period” of development is to build a sufficiently diverse motor repertoire that will allow for later learning of adaptive, skilled actions that can be flexibly tailored to different and specific movement contexts. According to these researchers the preschool period that refers to the age period between 3 to

5 years is an important time to intervene in movement skill development since this is when movement skills starts to develop (Clark & Metcalfe, 2002:8).

Studies demonstrate that there is an association between fundamental motor skills and PA (Cliff *et al.*, 2009:439; Fisher *et al.*, 2005:684) and that movement skill proficiency is an important PA determinant. Wrotniak *et al.* (2006:296) contended that good MP is positively associated with PA and inversely relates to sedentary activity. It is also reported that children with higher MP, have higher PF scores such as higher muscular strength than their peers with lower MP (Santos *et al.*, 2012:748). Similarly, Fransen *et al.* (2014:11) reported that participation in sports as well as muscular strength and endurance are higher in children with higher MP, where children with low MP are more likely to have lower flexibility and explosive strength levels (Chaves *et al.*, 2016:107). Children and adolescents with lower PF are also more likely to have gross motor coordination difficulties (Chaves *et al.*, 2016:107). The degree of MP that is achieved by children is a critically important, yet underestimated, casual mechanism partially responsible for the health-risk behaviour of physical inactivity. Individual and environmental constraints operating during early childhood will also compound over time to result in a stronger relationship between PA and MP (Wrotniak *et al.*, 2006:296). During middle and later childhood, higher levels of motor skill proficiency will offer a greater motor repertoire to engage in various physical activities, sports and games. Differences in MP between boys and girls should also be taken note of. Such differences had been noted not only in cross-sectional but also in longitudinal studies (Graf *et al.*, 2004:24), suggesting that boys are more motor proficient than girls. Gross motor proficiency differences within and between genders might be explained by the differential expression of their PF characteristics (Vandorpe *et al.*, 2011:384), because it has been suggested that cardiorespiratory fitness, power, muscle strength and endurance are positively associated with MP (Cattuzzo *et al.*, 2016:126; Rivilis *et al.*, 2011:894). From this background it can be concluded that children's MP may be an appropriate target for increasing PA in youth.

An assessment tool that is typically used as a measurement to measure MP in children is the Bruininks-Oseretsky Test for Motor-Proficiency; Second edition (BOT-2) (Bruininks & Bruininks, 2005), which also includes a Short Form (SF). This test battery is individually administered to determine the fine and gross motor skills of children. This norm-based instrument is suitable for use in 4 to 21-year-old children (Bruininks & Bruininks, 2005:1). The BOT-2 SF evaluates motor skills in four area components and consists of fine motor skills (divided into fine motor precision and fine motor integration); hand coordination (divided into hand agility and upper limb coordination); body coordination (divided into bilateral coordination and balance); and a strength and agility component (divided into running speed, agility and strength).

2.7 Physical fitness (PF) and physical activity (PA)

Researchers give considerable attention to PA and PF behaviour of children because of the concern for a decrease in well-being of future generations (Finkelstein *et al.*, 2012:563; Olshansky *et al.*, 2005:1138). The interrelatedness of PF and PA are also highlighted in research literature since PA and sports engagement often require significant levels of PF for example flexibility, muscular strength, agility and cardiorespiratory endurance. This link also suggests that there is a direct link between being physically active and being physically fit. In this regard it is reported by Castelli and Valley (2007:358) that PA behaviour and the trait of PF are reciprocally related and indirectly influence each other.

Various health-related benefits of PF are highlighted by various researchers, i.e., to reduce the risk of cardiovascular disease, type II diabetes and obesity (Hillman *et al.*, 2008:58); and an improvement of psychological effects on stress, anxiety and depression (Eveland-Sayers *et al.*, 2009:99). More recently PF is also acclaimed to show significant associations with academic achievement (Du Toit *et al.*, 2011:23). However, a global decline of children's aerobic fitness levels and PA had been reported. International (Katzmarzyk *et al.*, 2008:371) and South African studies (Hurter & Pienaar, 2007:35) showed increases in overweight, poorer fitness levels and sedentary behaviour in children. Tomkinson *et al.* (2007:314) reported a decline in the aerobic fitness of Australian children, as tested by the 20-m shuttle run, where 10 to 11-year-old children declined by 0.5-0.8% per year in the 1600-m walk/run between 1985 and 1997. The shuttle run performance of children in developed countries also declined with an average of 0.4% per year over the period of 1981 to 2000 (Tomkinson *et al.*, 2007:314). An analysis done on Japanese children also reported a decline in children's physical performance over the last two decades as well as a decline seen in Korean children between 1979 and 1986. This decline is likely to be caused by a network of social, behavioural, physical, psychosocial and physiological factors (Tomkinson *et al.*, 2007:314).

When focusing on research pertaining to the impact of PA, Uys *et al.* (2016:265) mentioned that PA during childhood is essential for normal growth and development, where PA and sport participation provide a platform for the development of social capital, social cohesion and inclusiveness as well as gender equity. According to the World Health Organization (2014) the recommended time for children and adolescents to be physically active are 60 min of moderate-to-vigorous PA per day. Andersen *et al.* (2006:304) concurred that PA is important for children's metabolic health; to prevent the clustering of cardiovascular risk factors and to prevent insulin resistance, therefore at least one hour per day of participation in moderate intensity PA is recommended for children. Earlier, Hannaford (1995:239) stated that PA and movement can result in synaptic development which contributes to neural growth during the developmental

period which is a critical period when the brain is more receptive to stimulation and which decrease with an increase in age. Pesce *et al.* (2016:1) reported that physical active games provide a unique form of cognitive enrichment through motor coordination, specifically OCS which is also linked to children's future PA habits.

Overall, most research findings indicate that children and adolescents participate in insufficient amounts of PA to obtain health benefits (Andersen *et al.*, 2006:304), confirming that inactivity is a threat to the health and well-being of children. The results of the Youth Risk Behaviour Survey (YRBS) showed that a higher percentage of girls (46.2%) are less active than boys (36.7%). In this study, children that participated in sufficient moderate PA were living in the Free State (34.1%), Gauteng (33.1%) and Limpopo (33.0%) province while 41.5% were inactive. Provinces with lower PA prevalence's were the Western Cape (23.2%) and the Northern Cape (21.8%). A national average of 29.3% children was reported to be sufficiently moderately physically active. Adolescents in the Western Cape (51.6%) were more inactive (Reddy *et al.*, 2010:44) than the other provinces. Mixed results were reported by a study done in the Johannesburg area in the Gauteng Province of South Africa by McVeigh and Meiring (2014:374) who found that much higher percentages of children (78%) meet the recommended guidelines of 60 minutes per day of moderate-to-vigorous PA. A recent regional study done in the Western Cape of South Africa also found that nearly 75% of boys and 54% of girls (11 to 13 years) engaged in moderate-to-vigorous PA at least three days per week (Uys *et al.*, 2016:266).

The HAKSA (2014) report card reported that only 50% of children met the recommendations for PA; 30% to 60% did not participate in weekly physical education and an average of 3 hours per day was spent on screen time. Health risk behaviours can be significant reasons for the decrease in children's PA levels. A cross-national study by the World Health Organization amongst children and adolescents from 44 countries across Europe and North America found that 25% of 11-year-olds, 20% of 13-year-olds, and 16% of 15-year-olds engage in at least 60 minutes of moderate-to-vigorous PA per day. Belgian statistics showed a small number of children that meet the moderate-to-vigorous PA guidelines, with only 7% of 6 to 9-year-olds and 2% of 10 to 17-year-old adolescents met the moderate-to-vigorous PA guidelines (Wijtzes *et al.*, 2016:S96). Troiano *et al.* (2008:185) reported that 42% of American children aged 6 to 11-years met the moderate-to-vigorous PA guidelines while a study among 10 to 12-year-old children from five European countries revealed that 16.8% boys and 4.6% girls met the benchmark (Verloigne *et al.*, 2012:4). This decline in moderate-to-vigorous PA levels is reported to go along with decreasing participation rates in sports with increasing age (Brettschneider & Naul, 2007:177). The reciprocal effect of PA on PF and vice versa is eminent from the aforementioned discussion.

2.8 Factors that influence the relationship between motor proficiency (MP), physical fitness (PF) and physical activity (PA)

Different factors can influence mastery of OCS, MP, PF and PA. With regard to the focus of this study, only six factors will shortly be discussed: proficiency in motor skills, PF, socio-economic factors, gender, culture and race.

2.8.1. Motor proficiency (MP)

The following dynamic systems approach by Stodden *et al.* (see Fig 2.3) provides a good explanation for the role that MP plays in later PA and PF and the developmentally dynamic relationship between MP and PF. The dynamic systems approach refers to an ecological approach, which assumes that a child's functional performance of movement depends on the interaction between his innate and developing skills, the characteristics of the desired task or activity and the environment in which the activity is performed (Stodden & Goodway, 2007:33-34). Stodden *et al.* (2008:290) is of the opinion that previous research has failed to consider the dynamic and synergistic role that MP plays in initiation, maintenance, or decline of PA and how this may influence development over time. The focus of previous researchers was on the measuring of PA although they do not understand that learning to move is a necessary skill underlying PA and PF, Stodden *et al.* (2008:293) claimed. These researchers therefore developed a conceptual model addressing the potential role that the development of MP may have on promoting positive or negative trajectories of PA and weight status. Considering the aforementioned, a child's motor skill development is thus based on the interaction between the task, the individual and the environment. Movement depends on the requirements of the task as well as the interaction between cognitive, neuro-skeletal, sensory, perceptual, socio-emotional and environmental factors. These factors are adaptable and flexible and work interdependent to help the child to perform a motor task correctly (Case-Smith & O'Brien, 2018:33). According to Stodden *et al.*, (2008:291) children who cannot proficiently run, jump, catch and throw, will have limited opportunities to engage in PA later in their lives because they will not have the qualified skills to be active. Clark and Metcalfe (2002:170) report in this regard that children who do well in OCS and locomotor skills have higher levels of sport aptitude that leads to them being more active as teenagers. To the contrary, it was reported that children with inadequate levels of MP will not continue to be physical active into middle and later childhood and will not develop or maintain aspects of PF (Stodden *et al.*, 2008:295).

According to Stodden and Goodway (2007:34) motor skills, health-related PF and obesity are three important variables that will account for variability found in physical activity research.

Stodden and Goodway (2007:34) believed that the sum effect of these variables promote either a negative or positive spiral of engagement in physical activity and influences the possibility of continuous development of fundamental motor skills. The dynamic systems approach as illustrated in figure 2.3 demonstrates the interrelated effects of these variables and how it contributes to either a positive or negative spiral linkage in physical activity. Motor skills and health-related PF can thus either worsen the negative spiral or it can improve the positive spiral (Stodden & Goodway, 2007:34).

Stodden *et al.* (2014:232) further indicated that MP is the mediating variable that is influenced differently by the relationship between MP and PA. The conceptual model of development shows that there is no strong correlation between perceived MP and actual MP or PA during the early childhood years. This correlation is in contrast to what is found during the middle childhood years when children transfer to higher levels of cognitive development and are able to compare themselves more accurately to their peers.

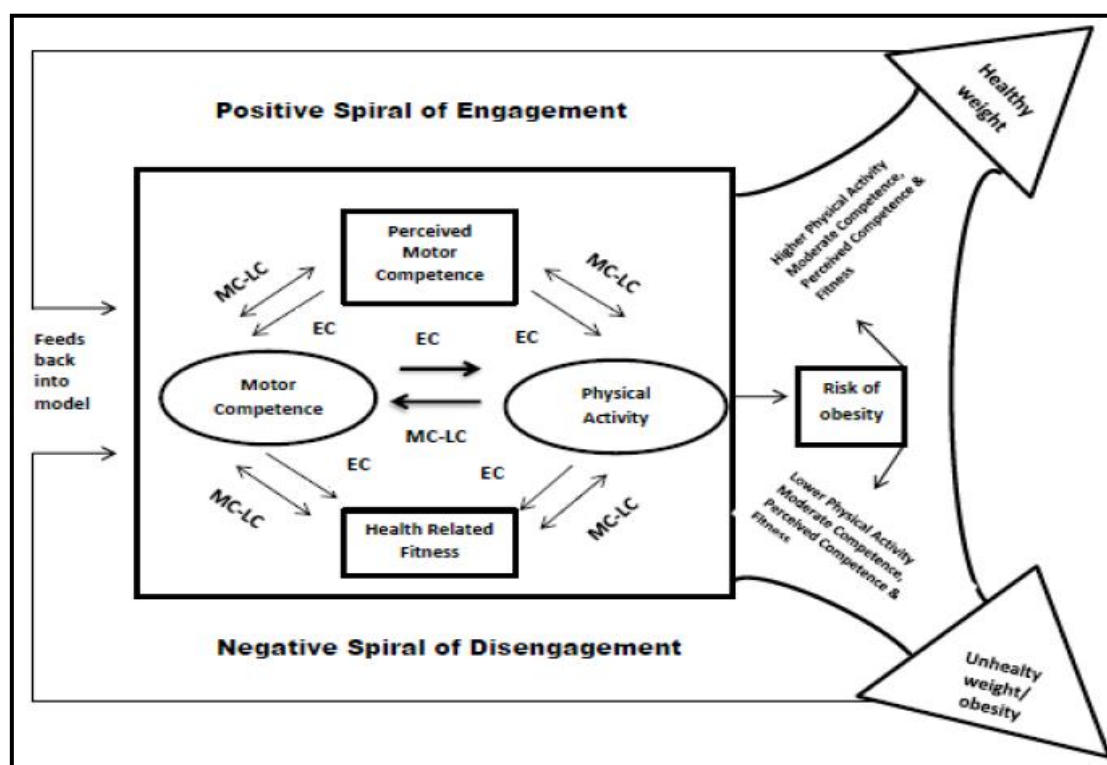


Figure 2.3: Developmental mechanisms influencing physical activity trajectories of children (Stodden & Goodway, 2007:34). EC-Early Childhood (2-6 years), MC-Middle Childhood (6-12 years), LC-Late Childhood (11-13 years).

This means that during middle childhood, children with lower actual MP will demonstrate lower perceived MP and hence will become less physically active. Stodden *et al.* (2008:295) hypothesized that young children will demonstrate variable levels of PA and MP that are weakly related at this point in developmental time. Children with higher perceived MP and actual MP will however persist in more PA (Stodden *et al.*, 2014:232). Recent studies reported a decline in

MP where high percentages of children did not reach proficiency levels (Stodden *et al.*, 2014:232). The lack of an adequate foundation of MP may also be linked to a hypothetical proficiency barrier (Seefeldt & Haubenstricker, 1982:315) where low MP individuals may not demonstrate health-enhancing levels of PA and health-related fitness later in life (Stodden *et al.*, 2009:224). According to Seefeldt and Haubenstricker (1982:315) a 'critical threshold' may occur in MP, above which children will be active and apply fundamental motor skills to lifetime PA, but below they will be less successful and drop out of physical activity at a higher rate. The reciprocal link between PA and PF (Castelli & Valley, 2007:358) suggests that there is a direct link to being physically active that leads to being PF; that PA and sports engagement often require significant levels of PF for example flexibility, muscular strength, agility and cardiorespiratory endurance. If children avoid getting involved in PA it will lead to them being less physically fit and their PA and sport will subsequently move even more down the negative spiral. The importance of PF to enhance PA and physical development, another focus component in this study, will now be discussed.

2.8.2. Physical Fitness (PF)

Limited research pertaining to PF could be found. Children who are physically fit during later childhood will be more likely to maintain physical activity for longer periods of time and will continue to improve their MP, according to Stodden *et al.* (2008:295). The relationship between MP and PF also becomes more reciprocal in nature during later childhood and adolescence (Stodden *et al.*, 2008:298). The relationship of MP with physical activity is mediated by PF and MP where MP is the underlying determinant of PA. According to Welk (1999:5) physical skills and fitness act as "enabling factors" that are promoted by PA where increased fitness and skilfulness contribute to increased persistence in PA, perceived proficiency that refers to the awareness and belief of the capability to perform gross and fine motor tasks, and self-efficacy (one's belief in the ability to succeed in specific situations or to accomplish a task).

A study done by Stodden *et al.* (2014:239) found that the correlation between OCS and health-related fitness increase over time, suggesting that OCS may play a role in the association between MP skills and PF. Luz *et al.* (2017:7) furthermore reported that locomotor skills proficiency has a significant relationship to PF in boys and girls. Luz *et al.* (2017:8) tested the association between MP and PF in a sample of 546 children (278 males, mean = 10.77 years). They found that MP composites and MP components can predict a reasonable 74% of PF variance which is higher than a 65% prediction of variance that was reported by Stodden *et al.* (2014:239) in a similar study. Luz *et al.* (2017:8) also reports an influential role of MP in the development of PF during childhood and that boys and girls do not share the same motor

activities in this relationship. Girls need locomotor motor proficiency to trigger their involvement in PA while boys need both locomotor, OCS and MP for involvement in motor activities. Since childhood is a critical period for the development of MP and PF, Luz *et al.* (2017:8) concluded that it should be fundamental to promote MP and PF to benefit the healthy development of children.

2.8.3. Socio-economic status

Bronfenbrenner's socio-ecological systems theory of development will be discussed in more detail, as it highlights that a child develops within a specific context, where each system has its own role, norms and values which may influence the development of the child. It is indicated in this regard that an individual develops within different levels of social relationships (see Figure 2.4), comprising of different systems. The model consists of four systems, namely a microsystem, mesosystem, exosystem and macrosystem. Bronfenbrenner added a fifth aspect, the chronosystem that envelops the change and interaction between these systems (Bronfenbrenner, 1979:331; Johnson, 2008:2; Van Staden, 2009:26).

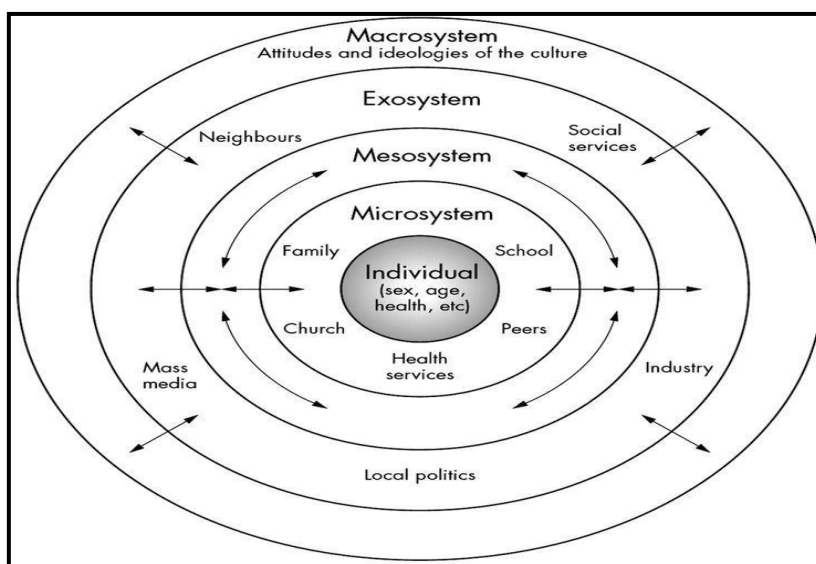


Figure 2.4: Bronfenbrenner's socio-ecological system theory of development

In the *microsystem* the patterns of activities, roles and interpersonal relationships are experienced by the developing child. It takes place in a specific physical environment which involves other persons with character, temperament, personality and belief (Bronfenbrenner, 1995:227). Bronfenbrenner (1995:227) stated that the *mesosystem* is the environment in which a child finds themselves, of which examples are the church, home, friends and the school. Johnson (2008:2) proposed that the mesosystem relates to the dynamic interaction between the child and the parent. Fixed norms, standards and social networks are relevant to the *exosystem* and are influenced by the community (Johnson, 2008:3). The *macrosystem* consists of

overarching patterns of values, beliefs, and ways of life, opportunities and resources (Johnson, 2008:3). The *chronosystem* is a time based dimension where the functioning of all mentioned levels is influenced. This can be long- or short-term time dimensions of the individual. Changes in a child's lifespan or not being proficient in early childhood will lead to inactivity and minimal sport participation in later childhood as well as socio-historical dimensions where the person finds themselves in (Bronfenbrenner, 1979:331; Johnson, 2008:3; Van Staden, 2009:26).

Lejarraga *et al.* (2002:54) confirmed the influence of the environment on development. These researchers reported that the environment in which children grow up play an instrumental role in the development of MP. Maphatane (1994:24), Martina *et al.* (2009:236) and Taylor and Yu (2009:1) also confirmed the influence of SES on the overall development of children. Children who are exposed to poor stimulating environments are more prone to develop poor motor comprehension, noted Robinson and Goodway (2009:539). Findings of a study by Uys and Pienaar (2010:140) also indicated poorer motor development in children between 4 months and 71 months who grow up in a low SES area, compared to children growing up in a high SES area. In addition, Venetsanou and Kambas (2010:320) also reported weaker motor development in children 2 to 6 years of age who lives in a low SES area.

Haywood and Getchell (2005:204) is of the opinion that little access to organized sport and PA for children in low SES areas and the expensive equipment needed for the sport or activity, as well as extensive time needed from their parents to encourage and engage them in activities that will lead to movement skill performance and competence, might be reasons for poorer motor development in low SES areas. Children living in high SES areas are again, exposed to more toys to play with that contribute to improved motor development (Venetsanou & Kambas, 2010:321). SES also shows influences on types of sports and games that children play and participate in (Wrotniak *et al.*, 2006:1758). McVeigh *et al.* (2004:985) reported in this regard that living in high SES areas contributes to higher levels of PF that once again leads to better sport skills development. Parents living in high SES areas are also likely to be more involved in their children's lives than parents living in low SES areas. Therefore, the movement skill socialization process is likely to be more positively influenced in high SES areas (Eccles *et al.*, 1998:1017). In these environments parents are more likely to introduce and guide children through developmental stages of movement skills, while observing and encouraging children to engage in activities that will lead to movement skill performance and competence (Williams *et al.*, 2008:1421). The possibility of motor deficits tends to be general in children that has small spaces to play in and limited access to apparatus, climbing frames, balls and rackets (Goodway & Branta, 2003:36; Pienaar & Lennox, 2006:79; Van Niekerk *et al.*, 2007:168).

Haywood and Getchell (2005:8) also confirmed that the SES area a child grows up in is important for movement development and sport participation. They stated that children in a low SES area experience barriers to proper motor development. Playing is the most important aspect of learning before the formal school years, because during play children learn about their bodies, and through experimenting they learn more about their ability to move. A child's self-confidence also improves when trying new things like climbing, jumping and running activities. While children are playing and inventing their own games they are also developing their cognitive skills (Gallahue & Donnelly, 2007:46). Gabbard (2008:7) is of the opinion that when the environment is not play friendly a child's motor development can be influenced negatively. Gallahue and Donnelly (2007:44) confirmed that playing is important for the development of cognitive skills, affective growth and the development of gross- and fine motor skills. It can be concluded that a restricted environment, because of SES constraints may have a negative impact on overall development, sport participation and can increase MP deficits.

2.8.4. Gender

Various researchers over decades have reported gender differences with regard to MP, PF levels and PA. Studies done by Hardy *et al.* (2010:503), Okely and Booth (2004:358) and Van Beurden *et al.* (2002:244) reported differences between one to nine-year-old-children where boys showed better OCS and girls better locomotor skills. Goodway *et al.* (2010:20) noted in this regard that gender differences can be associated with object control sport skills rather than locomotor skills. Gabbard (2008:329) on the other hand reported that there are minimal gender differences in motor skills before puberty, although some studies do report gender differences. In a study done on 425 children with a mean age of 4.4 in Australia, girls performed better in locomotor skills while boys performed better in OCS (Hardy *et al.*, 2010:505). Malina (2004:59) reported higher proficiency in motor skills in boys with differences increasing with increasing age although some researchers also report higher proficiency in some motor skills in girls. In this regard it is reported that boys show better speed, agility and reaction speed, while girls show better performances in fine motor skills, drawing and typing skills (Burton & Miller, 1998:335; Goodway *et al.*, 2010:22). Boys also show advantages during running, jumping and hitting activities according to Burton and Miller (1998:335). A study by Al-Haroun *et al.* (1988:5) reported better running speed and agility, strength, upper-limb coordination and response speed in boys while girls show better balance, bilateral coordination, visual-motor control, upper-limb speed and dexterity. Spessato (2013:919) however, mentioned better performance in locomotor skills of boys compared to girls.

During early childhood, interests, skills, and confidence in PA are found within family and school contexts according to Gallahue and Ozmun (2006:524) which may contribute to these differences. Malina (2004:62) highlighted differences in the way that boys and girls grow up and that gender differences in motor skills arise as a result which is already evident from the age of three years. Malina (2004:62) motivated these differences during early motor skills development as a result of frequency of training and exposure to instructions of a specific skill. In this regard, Al-Haroun *et al.* (1988:7) furthermore documented that both boys and girls need space, equipment and opportunities to practice, as well as feedback, for their movement skills to develop.

Differences in PA and PF levels are also reported between boys and girls. Wrotniak *et al.* (2006:1762) conducted a study on 8 to 10-year-old children and indicated significant differences between MP and PA of boys and girls. It is found that girls are less active than boys during childhood and adolescence that leads to more inactivity later in their lives (Sallis *et al.*, 2000:967). Luz *et al.* (2017:8) report that girls and boys do not share the same motor activities, where locomotor competence triggers involvement in PA in girls while in boys, locomotor and manipulative motor competence trigger their involvement in PA (Luz *et al.*, 2017:8). Tomkinson (2007:314) studied 25 million 6 to 19-year-olds from 27 countries between 1958 and 2003 and came to the conclusion that aerobic performance has declined globally at a rate of -0.36% per annum since 1970. According to Tomkinson (2007:314), aerobic fitness of boys and girls had a precipitous decline in paediatric aerobic performance that could be due to maximal effort, changes in peak/maximal oxygen uptake, mechanical efficiency and sustainable fraction of peak/maximal oxygen uptake.

2.8.5 Culture

Idang (2015:98)) claimed that culture refers to different ways that people deal with common life issues, how people make a living, how they marry and get along. Different cultures have at least five characteristics in common, namely learned, shared, patterned, adaptive and symbolic issues. Culture is learned by what we do, say or believe. Venetsanou and Kambos (2016:7) state that the cultural context has a strong influence on children's motor development as there are different anticipated roles for the two sexes in different societies. In the Middle Eastern culture, the opportunities for girls to develop movement skills are limited, and in the Chinese tradition boys are physically more active participating in vigorous activities, opposed to girls who are encouraged to participate in sedentary activities (Al-Haroun, 1988:7). According to Micklesfield *et al.* (2014:7) soccer and street soccer are popular among black children and especially black boys in South Africa, and this may contribute to their higher proficiency in the

kicking skills from a young age as reported by Le Roux (2014:90) and Pienaar *et al.* (2015: 309) among grade 1 and 4 learners.

2.8.6 Race

Race refers to a group of people who have differences and similarities in biological traits deemed by society to be socially significant. Barnes *et al.* (1999:342) cautioned that whenever research is conducted on racial differences with regard to motor development, attention should be paid to social and historical forces, which is a crucial component of research of this kind. Racial differences in motor skills are reported, however, limited studies have been conducted in this regard. Pienaar and Viljoen (2010:84-86) reported better performances among 10 to 15-year-old South African white boys in speed, vertical jump and basketball throwing while Pienaar and Kemp (2014:173) declared that black grade 1 South African boys performed significantly better in balance, running speed and agility skills.

2.9 The association between object control skills (OCS), motor proficiency (MP) and physical fitness (PF) and later physical activity (PA)

Most studies are in agreement that participation in PA declines during the adolescent years compared to the childhood years [National association for sport and physical education (NASPE) 2010]; Centre for Disease Control and Prevention (CDC) 2014). Against this background it is important to pay attention to the motor proficiency of children during childhood in order to maintain adherence to PA participation during adolescence. In this regard, Okely *et al.* (2001:1899) and Barnett *et al.* (2009:253) stated that for successful participation in sports and to become physical active children, the mastering of fundamental motor skills during earlier childhood is necessary and will contribute to the learning and mastering of specialized skills during adolescence. Physical activity will again give rise to the maintenance of different aspects of PF that will again help children to make quantitative as well as qualitative changes in their motor proficiency, for example learning new motor skills and making improvements on previously learned motor skills (Haga, 2008:332).

This literature chapter will be concluded with a discussion of literature findings regarding the association between OCS, MP, PF and PA during earlier and later childhood. Findings of cross-sectional and longitudinal studies will now be discussed under separate headings.

2.9.1 Cross-sectional studies

A cross-sectional study is a type of observational study that analyse data collected from a population, or a representative subset at a specific point in time and deals with status.

Cross-sectional and longitudinal studies regarding the association between OCS, MP and PA and to a lesser extent PF are reported in the literature and are of relevance to this study. Various studies involving children and adolescents showed positive associations between MP and PA (Holfelder & Schott, 2014:382; Lubans *et al.*, 2010:1019; Van Niekerk *et al.*, 2016:348), MP and PF (Haga, 2008:329; Stodden *et al.*, 2014:231) and an inverse association between MP, weight and sedentary behaviour. The findings of the following studies regarding associations between MP, PF and OCS will now be discussed in more detail (Okley, 2001; Haga, 2008; Cliff *et al.*, 2009; Hardy *et al.*, 2012; Visagie, 2015; Chagas, 2017; Luz *et al.*, 2017). Two studies also reported on the relationship between PA and PF (Cliff *et al.*, 2009; Okley, 2001) and will also be discussed.

Most research studies confirmed an association between MP and PA. Cliff *et al.* (2009:436) studied the relationship between fundamental motor skills and its components, and PA in preschool children aged 3 to 5 from eleven randomly selected preschools in New South Wales, Australia. They found that fundamental motor skills are positively correlated with objectively measured habitual PA, in preschool boys, and negatively correlated in preschool girls. OCS also holds stronger positive associations for boys with PA than locomotor skills, whereas for girls locomotor skills hold stronger negative associations with habitual PA than OCS. Okley *et al.* (2001:1899) also reported the relationship between PA and fundamental motor skills among adolescents, specifically the relationship of participation in organized and non-organized PA with fundamental motor skills among adolescents. Six fundamental motor skills (run, vertical jump, catch, overhand throw, forehand strike and kick) were tested in male and female grade 8 (M=13.3 years) and grade 10 (M=15.3 years) children. The ability to perform fundamental motor skills was significantly related to participation in organized PA, although only 3% of the variance accounted for their time in non-organized PA. The results showed a direct association between movement skills and participation in organized PA. A study done by Chagas *et al.* (2017:1) compared health outcomes between children with low motor proficiency without developmental coordination disorder and children with average MP. To measure the MP, PA, flexibility and muscular strength or endurance the Körperkoordinationstest für Kinder, a validated administered PA questionnaire, the sit-and-reach test and sit up 60s tests were used. Children, 12 to 14 years of age (N =127 of which 53 were boys and 68 girls) were used. Children with average MP displayed lower levels of body fat and higher levels of PA and muscular strength or endurance than children with lower MP (Chagas *et al.*, 2017:7). Children with low MP without developmental coordination disorder as well as children with very low MP also had worse health outcomes than their peers with average MP.

Studies also confirmed associations between MP and PF. Associations between MP and PF were however, not studied as extensively as the association between MP and PA by researchers. In a study on American children, Luz *et al.* (2017:8) reported that the MP composite and MP components can predict a reasonable amount of health-related fitness (74%), which was higher than the 65% prediction rate that was reported by Stodden *et al.* (2014:231) for American children. Luz *et al.* (2017:8) concluded that MP has an influential role in the development of health-related fitness during childhood, in boys and girls from 7 to 14 years. Luz *et al.* (2017:1) analysed a group of children from schools from different municipalities in the Lisbon district to investigate the association between MP and its components (locomotor skills, OCS skills and stability) with PF in a sample of 546 Brazilian children (278 boys, 50.9%) with a mean age of 10.8 years. MP components proved to be significant predictors of PF with locomotor skills being the strongest predictor. The locomotor component of MP has the strongest association with the PF of girls of all ages while locomotor and manipulative components showed bigger associations in younger boys and skills in older boys. Stability skills were found to be an important predictor of PF with growing age for both sexes. Luz *et al.* (2017:9) concluded that MP and PF are closely related in both boys and girls, from 7 to 14 years of age, and that this association is stable across ages. Haga (2008:330) also studied the relationship between MP and PF in 67, 9 and 10-year-old children, with a mean age of 9.7 years. Children were recruited from a local mainstream primary school in an urban area in the country. The Movement Assessment Battery for Children was used to test the gross motor and fine motor skills of the children while the Test of Physical Fitness was used to assess PF. The Test of Physical Fitness consists of nine test items: standing broad jump, jumping on two feet for a distance of 7m as fast as possible, jumping a distance of 7m on one foot, throwing a tennis ball with one hand, pushing a medicine ball (1kg) with two hands, climbing wall bars, shuttle run, running 20m as fast as possible and the reduced Cooper test. A strong association was found between MP and PF and it was reported that PA levels of children can potentially explain the high association between PF and MP (Haga, 2008:332). In agreement, a study done by Hardy *et al.* (2012:390) on grade 2, 4, 6, 8 and 10 Australian children determined the demographic and health-related PF of school-going children with low mastery of fundamental motor skills. An association between low mastery of fundamental motor skills, weaker health outcomes, low cardio-respiratory fitness, low PA, overweight and obesity (Hardy *et al.*, 2012:395) were reported for all age groups. Findings reported by Robinson (2009:533) also support the association between MP and health-related fitness. Cairney *et al.* (2011:1198) also observed that children with low MP (locomotor skills and OCS) are not that physically active, resulting in lower PF levels. In general, individuals with low MP exhibit inferior overall PF levels than peers with higher MP (Cantell *et al.*, 2008:344). The reasons for this have not been extensively

investigated, although some results indicate that psychological factors, namely perceived MP, may play important roles which may reduce physically active pursuits.

Visagie (2015:199) studied the association between a specific component of MP, namely object control skills and health-related PF in 9 to 10-year-old girls (N=408) in the North-West Province of South Africa. This cross-sectional analysis showed a significant correlation, although only of a small magnitude, between OCS and health-related PF. Higher fitness levels were also significantly associated with improved OCS. The researchers found a small practical significance between OCS and health-related PF in a large number of the non-organized physical activities that they participated in (such as household duties in low SES girls).

Stodden *et al.* (2014:231) proposed in this regard that the relationship between object control skills and health-related fitness increase over time, which furthermore suggests that these skills play a role in the association between MP and health-related fitness.

A recent systematic review by Cattuzzo *et al.* (2016:128) included 44 studies that reported on the association between MP and PF. Strong evidence of an inverse association between MP and body weight and a positive association with MP, cardiorespiratory fitness and musculoskeletal fitness in children and adolescents was found. It was concluded that fundamental motor skills are generally associated with repetitive movement such as locomotor skills, a component of MP that enhances cardiorespiratory development.

2.9.2 Longitudinal studies

A longitudinal study is an observational research method in which data is gathered from the same subjects repeatedly over a period of time. According to Rajulton (2001:170) cross-sectional studies deal with *status* while longitudinal studies deal with *progress* and *change* in status. Longitudinal data implies that it is repeated measures of the same individuals over a time span long enough to encompass a detectable change in the developmental status. The findings of the following studies will be discussed regarding the associations under investigation (Barnett, 2008; Barnett, 2013; Cattuzzo *et al.*, 2016; Hands, 2008; Lubans, 2013).

Barnett *et al.* (2013:163) conducted a longitudinal study starting in 2000 to determine if there were gender differences in mastery and near mastery performance of three OCS and three locomotor skills during childhood and adolescence and the potential difference in MP from childhood to adolescence. The mean age of the sample was 10.06 years at baseline in 2000 and 16.44 years in adolescence (2006-07) when the study was concluded. Barnett *et al.*

(2013:167) found that childhood OCS proficiency helps predict adolescent proficiency. Girls also performed OCS poorly compared to boys.

Hands (2008:155-162) completed a longitudinal study over 5 years starting in 2000 that included one primary school in the Perth metropolitan area of Australia. The purpose of this study was to report results of a subsample of the children's fitness and skill levels. In the year 2000, 564 students participated of which 85 girls (n=33 aged 5 years, n=26 aged 6 years and n=26 aged 7 years) and 101 boys (n=39 aged 5 years, n=28 aged 6 and n=34 aged 7 years) completed a gross motor screening test. The findings suggested that locomotor skills has an impact on the participants' fitness and skill performance over time which supported the findings of other studies (Hammond, 1995) that indicate that children with low MP performed poorer in most fitness items (broad jump, slower speed on 50m run, reduced balance time, short distance throwing and lower cardiorespiratory endurance). Hands (2008:160) furthermore reported a relationship between MP and cardiorespiratory endurance, particularly in girls, and especially in older children. The researchers concluded that children who perform poorly on motor skills or have low fitness when they are young are unlikely to catch up with their peers with age.

A review study was completed by Lubans (2013:67) on longitudinal data over 20 years, starting in 1995. The study aimed to determine whether typically developing children and adolescents, aged 3 to 18, who participated in school-based interventions have sustained outcomes in PA, PF and fundamental motor skills twenty years later. A systematic search of six electronic databases was conducted from 1995 to 26 July 2012. Statistical significant differences were found in the outcomes of interest (PA, PF and fundamental motor skills) between the intervention and control groups at follow-up in the thirteen studies that have physical activity as an outcome. Ten found a sustained impact in one or more of the PA variables whilst only one of the studies that addressed fitness at follow-up, reports a sustained impact on cardiovascular endurance, muscular power and muscular endurance. Both studies assessed fundamental motor skills, report a sustained impact on kicking, throwing, catching, striking, sprinting and jumping (Lubans, 2013:73). This review found that a slight increase in PA is associated with health benefits, especially in high-risk children and adolescents, with an important impact at the population level. Lubans (2013:76) conclude that fundamental motor skills proficiency may be a key determinant of PA behaviour across time and proposed that the synergistic relationships among fundamental motor skills, PA and fitness may strengthen over time which supports the dynamic systems approach model proposed by Stodden (2014:232).

Barnett *et al.* (2008:2138) also conducted a study as part of a longitudinal cohort study known as the PA and Skills Study (PASS), in which 1045 children from 18 randomly selected and

stratified elementary schools in New South Wales (NSW), Australia participated. The purpose of this study was to determine whether childhood fundamental motor skills proficiency predicts adolescent cardiorespiratory fitness. Barnett *et al.* (2008:2141) report that OCS proficiency observed in elementary school predicts fitness levels in adolescents and children from both genders where children with good OCS achieved an additional six laps on the Multistage Fitness Test compared to children with poor OCS. The explanation provided by the researchers for why OCS predicted PF, is that kicking, throwing and catching are often associated with PA experiences which necessitate moderate and/or vigorous physical intensity.

2.10 Conclusion: Chapter summary

This literature review revealed that optimal motor development during earlier childhood is important, especially between 2 to 7 years of age since skills that develop during this period form part of the foundation for more specialized sports skills to be applied during later childhood. This again influences positive participation patterns in sport, and contribute to increased physical activity and physical fitness. All these mentioned aspects are important to again enhance physical literacy in children. When children are motivated to move, confident to move and competent to move which is important physical literacy principals it may not only encourage PA, but with improved PF also lay a solid foundation for more complex or specialised skills used in play and active sport participation.

The influences of different biological (gender) and environmental (SES) aspects were also investigated and showed differences in the mastery patterns of FMS of boys and girls, while also confirming influences of the environment on mastery of FMS. Boys were more advanced in OCS in most studies compared to girls, while the motor proficiency of children growing up in low SES environments were hampered by these environmental influences. The findings of cross-sectional and longitudinal studies were studied regarding associations between OCS, MP and PF, which mostly confirmed such associations in children and adolescents. It is also reported that such associations strengthen over developmental time. Very few longitudinal studies were, however, found that investigated the stability of an association between earlier MP and later application of such performances in more complex environments.

The literature review confirmed that it is important to determine the stability or consistency of basic fundamental motor skills at which a child should be proficient by the age of 9, while longitudinal research in this regard is also recommended. Studies in this regard is therefore needed as it can provide improved understanding of the consistency or stability of motor skill performance across developmental time, which is again important as it can help with intervention to improve motor proficiency.

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CHAPTER 3

CHAPTER 3

THE ASSOCIATION BETWEEN OBJECT CONTROL SKILLS MASTERY DURING EARLIER AND LATER CHILDHOOD: LONGITUDINAL DATA FROM THE NW-CHILD STUDY

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Article 1

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ABSTRACT

Object control skills mastery during early childhood contributes to the successful generalization of these skills during later childhood. This study aimed to determine if an association exists between object control skills mastery in early childhood (6-9 years) and the application of these skills during later childhood (12 years). The North-West Child Health, Integrated with Learning and Development longitudinal study (2010-2016), included a baseline and two time-point measures (2010, 2013, and 2016). We analyzed a total of 374 learners (boys = 178, 47.59% and girls = 196, 52.41%) over their seven primary school years (grades 1, 4 and 7). We used results from the Test of Gross Motor Development, Second Edition in 2010 and 2013 and the Canadian Assessment of Physical Literacy Obstacle Course in 2016 to determine associations between object control skills mastery in early and later childhood by using descriptive statistics, Spearman rank order correlations and stepwise regression analysis. At 6 years, a higher overall and large R^2 (32%) contribution to the variance of the Canadian Assessment of Physical Literacy Obstacle Course skills and time scores at 12 years were found compared to age 9 (28.1%). Object control skills also contributed to the explained variance in the completion time of the Canadian Assessment of Physical Literacy Obstacle Course at age 9 (0.09%; $p < 0.05$). Early object control skills mastery can provide a baseline from where opportunities for progression or transfer of skills can result in more advanced skilful executions.

Keywords: object control skills, early childhood, later childhood

The association between object control skills mastery during earlier and later childhood: the NW-CHILd study

3.1 Introduction

Children should be able to generalize their different motor proficiency (MP) capabilities into sport-specific and specialized skill environments during the childhood years (7 years and older) (Goodway & Branta, 2003). Fundamental motor skills, also referred to as fundamental movement skills are considered to be an important aspect of general motor competence (Stodden et al., 2008). Children's demonstration of competency in motor skills is, therefore, considered to be a cornerstone leading to their future physical and motor skill development (Chen et al., 2016). The association between fundamental motor skills and sport specific outcomes was highlighted by Okely *et al.* (2001) and Barnett *et al.* (2009). Both these authors agree that for successful participation in sport, and to become physically active children, the mastering of fundamental motor skills in earlier childhood may contribute to the learning and mastering of specialized skills during adolescence or later childhood. Most recently Barnett *et al.* (2016) also emphasized the association between fundamental motor skills and sport participation when they described fundamental motor skills as '...basic learnt movement patterns that do not occur naturally and are suggested to be foundational for more complex physical and sporting activities.' Barnett *et al.* (2009) furthermore, reported that fundamental motor skills is a contributing factor to a child's physical, cognitive and social development and provides a foundation for an active lifestyle.

Associations are also drawn between fundamental motor skills, not only laying the foundation for future movement, but also for physical activity (Clark & Metcalfe, 2002; Holfelder & Schott, 2014; Wrotniak *et al.*, 2006), physical fitness (PF) (Cattuzo *et al.*, 2016), improved cognitive outcomes (Haapala, 2013) as well as healthy weight status (Lubans *et al.*, 2010).

In particular, the association between the mastering of object control skills (OCS) which is considered to be a subcategory of fundamental motor skills, and specialized sport-related skills and sports participation have been highlighted in recent studies (Barnett *et al.*, 2008; Barnett *et al.*, 2016; Butterfield *et al.*, 2012; Department of Education Western Australia, 2013; Pienaar et al., 2015). OCS, also referred to as manipulative skills, are described as the handling and controlling of objects with the hand, foot or an implement (bats, racquets or hoops) with exact speed and control (Department of Education Western Australia, 2013). These skills can be regarded as one of the core and baseline skills to provide children with the best possible chance to successfully and continually engage in a range of physical activities and more specifically

health enhancing activities (Barnett *et al.*, 2008; Barnett *et al.*, 2016; Butterfield *et al.*, 2012). Van Beurden *et al.* (2002) noted that children with inadequate OCS tend to avoid participation in sport activities, because they struggle to master advanced skills. Pienaar *et al.* (2015) furthermore stated that, adequate proficiency of OCS, which is influenced by biological and environmental constraints, underlies the development of more complex sport-specific skills. Barnett *et al.* (2008) found in a longitudinal assessment that high levels of perceived sport competence, which was reached through OCS proficiency development during childhood, determined both boys' and girls' physical activity participation and PF, and they subsequently recommended that perceived proficiency of OCS should be targeted and improved. In this regard, Visagie (2015) recommended from her findings involving 408 girls in the North-West Province of South Africa (SA), the appropriate development of OCS and strength in girls in order to prevent non-participation in sport. In a more recent study, Slykerman *et al.* (2016) found that actual rather than perceived skill proficiency is more important than moderate to vigorous intensity physical activity.

Taking the aforementioned background into consideration it is also important to note that the actual improvement of OCS is important since movement skills do not only develop during free play (Logan *et al.*, 2012). Therefore, opportunities for instruction, practice and coaching are important for the mastering of advanced OCS (Gallahue & Ozmun, 2006). During the sport-related movement development phase, that is described as the age period between 7 and 10 years, children become more interested in sport and performance standards, and skills should therefore, be developed into more specialized sport-specific skills which can be applied in different sport codes during this period (Gallahue & Ozmun, 2006).

Competency in fundamental motor skills cannot be considered in isolation. Two factors that should always be taken into consideration concerning sport-related competency, are biological and environmental constraints (Pienaar *et al.*, 2015). Barnett *et al.* (2016) stated that motor development in young children, specifically during the early childhood years, is influenced by biological maturation, and only then the influence of practice and opportunity becomes important. According to various researchers (Lejarraga *et al.*, 2002; Pienaar *et al.*, 2015; Stodden *et al.*, 2008; Van Biljon & Longhurst, 2011; Visagie *et al.*, 2015) environmental influences also play a significant role in movement proficiency. Findings by Maphatane (1994), Kahlenberg (2001), Martina *et al.* (2009) and Taylor & Yu (2009) furthermore confirm the influence of socio-economic status (SES) on the overall development of children.

Biological differences were evident as gender differences in OCS mastery were also reported (Butterfield *et al.*, 2012; Pienaar *et al.*, 2015; Slykerman *et al.*, 2016). Pienaar *et al.* (2015) found that boys were more proficient in applying six OCS in a study conducted among 9 to 10-year-old children from twenty schools in the North-West Province of South Africa. The results of Butterfield *et al.* (2012) also confirmed boy-girl differences in obtaining mature throwing and striking skill patterns by 10 years, with boys the most proficient group. In agreement Slykerman *et al.* (2016) reported that boys had higher actual and perceived OCS proficiency and were more physically active by an average of 19 minutes per day, than girls. These researchers, however, concluded that OCS proficiency is not as important to girls in comparison to locomotor skills, as girls may engage more in physical activities, which do not require OCS mastery. The results of Visagie *et al.* (2017) also confirmed similar findings in 9-year-old-girls where the non-organized activities that they engaged in were not related to their OCS. Contrary to this Cliff *et al.* (2009) found that boys and girls were equally proficient in OCS at the age of 3 to 5 years, although girls scored higher in locomotor skills.

Cliff *et al.* (2009) recommended longitudinal studies to examine subcategories of fundamental motor skills, for a better understanding of these relationships in order for a stronger rationale for the development of fundamental motor skills that promotes physical activity in early childhood. Most studies have studied the association between early OCS and physical activity (Cairney *et al.*, 2011; Chagas *et al.*, 2007; Cliff *et al.*, 2009; Visagie *et al.*, 2015). Lloyd *et al.* (2014) reported in this regard evidence that early MP at the age of 6 years related to long-term physical activity as measured at 26 years of age, but identified the need for more research with larger sample sizes to investigate the full spectrum of MP. The possible association between early mastery of OCS and the application of these skills in more complex sporting environments during later childhood (thus the stability of these skills during childhood) are, however, less studied and also needs better understanding. Lubans *et al.* (2010) and Barnett *et al.* (2016), identified various research questions and stated that future research should continue to examine what needs to be done to promote the development of more physical literate children and whether fundamental motor skills provides the foundation for lifelong skills and health-enhancing forms of physical activity. In this regard, it is important to determine the stability or consistency of basic fundamental motor skills at which a child should be proficient by the age of 9 years, as this is the age period that is considered for full mastery of OCS. This study aims to provide more insight into this knowledge gap, namely to establish via a longitudinal study the association between OCS mastery during earlier and later childhood in children living in the North-West Province of SA. In this study, OCS was assessed during later childhood where time, fast decision-making and accuracy of OCS performance was required in a sport-related

environment. Both fundamental motor skills execution and timing, which introduces the need for higher order movement skills such as dynamic balance, spatial awareness, gross motor coordination, and interceptive timing components, were therefore assessed. This study examined the assumption that being proficient in OCS during earlier childhood will enhance the application of these skills in sport-related activities during later childhood.

3.2 Method

3.2.1 Study design

The study is based on a longitudinal research design and forms part of the North-West Child Health, Integrated with Learning and Development longitudinal study (NW-child study) which spans the primary school period of 7 years and which was conducted from 2010-2016.

The research group was selected by means of a stratified random sample in conjunction with the Statistical Consultation Services of the North-West University, Potchefstroom, SA. To recruit participants, a list of all the schools in the North-West Province of SA was obtained from the Department of Education in the North-West Province of SA. Stratification was done for school districts, schools quintiles (1-5), and gender (male and female). All the schools in this province are grouped into eight educational districts, each consisting of 12 to 22 regions with approximately 20 schools (minimum 12, maximum 47) per region. From four different educational districts, 20 schools, representing five different school quintiles, and children of both sexes, were recruited to take part in the study. The North-West Department of Education in SA used a poverty classification in each province to classify schools in different quintiles (Quintile 1, i.e., school types from low SES backgrounds, to Quintile 5, i.e., school types associated with higher SES backgrounds). The quintile status of South African schools is determined by the National Treasury and according to the National Poverty Table, obtained from the National Census data, including income, dependent ratios, and levels of literacy (Statistics South Africa, 2010). Quintile 1 and 2 schools are the poorest schools and are exempted from paying any school fees (Statistics South Africa, 2010). The North-West Province of SA is characterized by high poverty, especially in rural areas, unequal distribution of income between different population groups, and unemployment (Statistics South Africa, 2010). In 2010 and 2013 data from the Test for Gross Motor Development, Second Edition (TGMD-2) were used to measure fundamental motor skills. In 2016 measurements resulting from the completion of a motor skill competence obstacle course, namely the Canadian Assessment of Physical Literacy Obstacle Course (CAPL) was used as a proxy to determine OCS competency during later childhood. The quantitative data obtained from the TGMD-2 (2010 and 2013), and the CAPL (2016) were integrated into this study to answer the research question.

3.2.2 Participants

The same participants who completed the grade 1 and grade 4 measurements were again assessed in grade 7. In grade 1, 864 children were recruited, and 816 were included in the study after their parents/guardians provided parental permission. This group included 419 boys and 397 girls with a mean age of 6.84 $\pm$ SD years (SD=standard deviation). In their grade 4 year they had a mean age of 9.9 years $\pm$ 0.42 years, with a mean age of 12.9 $\pm$ 0.41 years in their grade 7 year. Of these participants, 374 (178 boys (47.59%) and 196 (52.41%) girls took part in all three time-point measurements, 214 (90 boys and 124 girls) were from quintile 1-3 schools representing low socio-economic status (SES) settings, while 160 participants (88 boys and 72 girls) represented higher SES settings, based on their school status (quintile 1 and 2 schools). The loss of subjects over the study period was 442 (54.1%). Migration from schools, lack of parental consent or absence on the day of testing was the main reasons for this large loss of participants over the seven school years.

3.2.3 Measuring instruments

Test of Gross Motor Development, Second Edition (TGMD-2)

The TGMD-2 is a norm-referenced measure designed to test the gross motor functioning of children 3 to 10 years old. The test consists of twelve motor skills and is divided into two sub-tests, namely locomotor (run, hop, gallop, leap, horizontal jump, and slide) and OCS (overhand throwing, catching, underhand rolling, dribbling, kicking and striking a stationary ball) (Ulrich, 2000). Only the OCS-subtest was used for this study to determine proficiency in six OCS of children aged 6 and 9 years in their grade 1 (2010) and grade 4 (2013) school years. Each of these skills includes several behavioural components presented as performance criteria and in general presents a mature pattern of the skill. If participants performed an action correctly, they received a score of one; if they performed it incorrectly, they received a zero. Each participant received two attempts to perform each skill after a visual demonstration of each skill was performed by the tester. The scores of the two attempts were added together. Standard scores for the sub items were calculated from the raw scores and then combined to obtain a gross total motor score from which a motor quotient was calculated. The Gross Motor Quotient is the best measure of an individual's overall gross motor ability (Ulrich, 2000). Age, gender and a raw score of each child were used to calculate the percentile rank as well as the standard score. A child's performance in comparison with their chronological age group can be obtained by using percentile scales. The descriptive proficiency ratings for subtest standard scores in the TGMD-2 manual is indicated as very superior (17–20), superior (15–16), above average (13–14), average (8–12), below average (6–7), poor (4–5), and very poor (1–3). The TGMD-2 has a

validity of $r=0.89$ (Ulrich, 2000). This test battery was not used during the 2016 measurements as it is only validated for children up to 10 years and was substituted with the CAPL.

Canadian Assessment of Physical Literacy Obstacle Course (CAPL)

A motor skill competence obstacle course protocol that assesses motor competence based on the execution of fundamental motor skills as assessed in the TGMD-2 was used. This protocol was developed in Canada (Canadian Manual for Test Administration, 2013) and was used to assess the participants at the age of 12 years in their grade 7 (2016) year. A Delphi process and the validity (75%) and reliability (95%) of the assessment protocol among children in grades 4 to 6 had been established (Longmuir *et al.*, 2015; Francis *et al.*, 2016). The obstacle course that has to be completed against time include jumping with two feet, sliding, catching a ball, throwing a ball at a target, skipping, hopping on one leg and kicking a ball through cones. Two demonstrations are provided (one performing each skill slowly so that each criterion could be observed clearly and one demonstration completing the whole obstacle course against time). Each participant is allowed two practice trials followed by two timed trials that were scored. Two scores are obtained, namely, a time score to the nearest 0.01 second and a skill score that is calculated by using a checklist where one point is awarded when a performance criterion is met. A total of 14 marks are allocated as follows: two-foot jumping (two marks), sliding (three marks), catching (one mark, if the participant could catch the ball that is thrown to him), throwing (two marks, if the participant threw with an overarm technique and hit the target), skipping (two marks), one-foot hopping (two marks), kicking (two marks, follow through and kicked through the cones). This qualitative assessment of FMS mastery is used to determine the CAPL skills score out of 14. The CAPL obstacle course provides an open, dynamic and authentic environment where the participant's execution is also scored quantitatively against time in seconds. As the CAPL protocol represent a developmentally appropriate open environment setting that considers the interaction of the individual and the environment, it makes it possible to draw associations between OCS mastery during earlier childhood and application of these skills during later childhood. In an open environment setting more complex movements (similar to what is needed during organized play and sport participation activities) are needed and combined (Lloyd *et al.*, 2014) and may, therefore, provide insights into sport-related applications during later childhood.

3.2.4 Procedures

The Health Research Ethical Committee of the Faculty of Health Science at the North-West University, Potchefstroom, SA, granted permission for the longitudinal study (NWU-00070-09-

A1, 2009-2015). Parents/legal guardians consented and re-consented via parental permission in 2010, 2013 and 2016. The parents/legal guardians' permission form thoroughly explains what is to be expected from each participant as well as the risks involved. On the day of field testing, the participants also had to provide written consent after the procedure was explained to them by the principle investigator, and they had time to ask questions. The participants were under no obligation to participate in the research and could withdraw from the research at any time during the testing.

Statistical analysis

Analyses were performed using the 'Statistica for Windows 2017' Statsoft computer program package (Statsoft, 2017). Data were, firstly, analyzed descriptively (percentages, frequency distributions, means and standard deviations (SD) to describe differences between OCS proficiency groups. The Spearman Rank Order Correlation was used to determine the association between OCS during earlier (6 and 9 years) and later (12 years) childhood and to determine the association of gender, SES and the object control skills standard score (OCS SS) to the time and total score obtained in the CAPL. The effect size cut offs as set by Cohen (1988) was used to determine practical significance. An $r \approx 0.1$ interpreted as small effect, $r \approx 0.3$ as a medium / moderate effect, $r \geq 0.5$ as a large effect size. A stepwise regression analysis was then used to determine the association between OCS proficiency during earlier and later childhood. Gender and SES were adjusted for, as possible co-variants in this analysis, where these variables were dummy-coded with boys and low SES were awarded the value of one and girls and high SES the value of zero.

The strength of the association between OCS mastery during earlier and later childhood controlling for gender and SES in the stepwise regression analysis is presented by the percentage variance explained where $R^2 \approx 1\%$ can be interpreted as a small effect, $R^2 \approx 10\%$ as a medium effect, $R^2 \geq 25\%$ as a large effect. For statistical significance, p is set at ≤ 0.05 .

3.3 Results

Table 3.1 provides an overview of the demographic characteristics of the participants of the study. The total number of participants was 374 children of which boys represented 47.59% ($n = 178$) and girls 52.41% ($n = 196$). Regarding SES, 50.57% ($n = 90$) of the boys, and 63.27% ($n = 124$) of the girls fell in the low SES group. The remainder of the boys (49.44% ($n = 88$)) and girls (36.73% ($n = 72$)) represented the higher SES group.

Table 3.1: Characteristics of the participants per gender and per socio-economic school status (*N* = 374)

	Age		Gender		Socio-economic school status			
	<i>M</i>	<i>SD</i>	<i>N</i>	%	Low	%	High	%
Boys								
Grade 1	6.86	0.39						
Grade 4	9.91	0.41	178	47.59	90	50.57	88	49.44
Grade 7	12.92	0.41						
Girls								
Grade 1	6.81	0.38						
Grade 4	9.86	0.42	196	52.41	124	63.27	72	36.73
Grade 7	12.87	0.41						
Total								
Grade 1	6.84	0.39						
Grade 4	9.89	0.42	374	100	214	57.22	160	42.78
Grade 7	12.90	0.41						

Note. *N* - number of total participants; *M* – mean; *SD* - standard deviation; % - percentage; Low - rural environment (low socio-economic status schools); High - urban environment (high socio-economic status schools).

Table 3.2 presents the descriptive statistics of the TGMD-2 OCS SS (object control skills standard score) in the group and per gender in grade 1 and grade 4, and also the skills and timed scores of the CAPL that were achieved in grade 7. The gender specific means in the OCS SS increased for boys from grade 1 (7.15) to grade 4 (8.67) as well as in girls in grade 1 (7.43) to 9.62 in grade 4. In grade 7 boys achieved a statistical and practical significantly higher skill score (11.69) and a time score (16.51 s) than girls (total skill score: 10.06 and time score: 17.36 s).

Table 3.2: Descriptive results of OCS SS (Grade 1, 4 and 7) and CAPL (total score and time in Grade 7) by group and for boys and girls separately

	Group		Boys		Girls				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>P</i>	Effect size
Grade 1									
OCS SS	7.30	2.31	7.15	2.32	7.43	2.30	1.20	0.230	0.12
Grade 4									
OCS SS	9.16	2.38	8.67	2.24	9.62	2.41	3.90	0.001*	0.39
Grade 7									
CAPL skills total (/14)	10.84	2.00	11.69	1.75	10.06	1.90	-8.60	0.001*	0.86
CAPL time (seconds)	16.95	2.46	16.51	2.18	17.36	2.63	3.40*	0.001*	0.34

Note. M – mean; SD - standard deviation; t - t-value; $r \approx 0.1$ small effect, $r \approx 0.3$ medium effect, $r \geq 0.5$ as a large effect, p - p value; $p \leq 0.05$ = statistical significance.

Table 3.3 provide an overview of the possible influences of SES and gender on OCS mastery in grades 1 and 4, and the CAPL skill and time score that were obtained in grade 7. Statistical significant correlations were established between the OCS SS in grades 1 and 4 and the CAPL skills and time scores in grade 7. SES in grade 1, showed a small overall correlation ($r = -0.18$) between the time obtained in the CAPL skills score in grade 7. This correlation between grade 1 OCS SS and the CAPL skills and time scores were of moderate significance for boys ($r = -0.39$ and $r = -0.29$) and of small significance for girls ($r = -0.23$ and -0.18). High SES in grade 1 correlated statistically with both the skills ($r = 0.31$), and the time score ($r = -0.27$) while the correlation with low SES were not significant ($r = 0.13$ and $r = -0.11$). In grade 4, no correlation between high ($r = 0.04$ and $r = -0.16$) and low ($r = -0.18$ and $r = 0.05$) SES were found among girls. A higher relationship between gender and OCS proficiency, as opposed to SES and OCS, was also noticed during later childhood. Associations between OCS SS were also higher between the skills score compared to the time scores of the CAPL.

Table 3.3: Correlations between OCS SS, and the CAPL skills and time scores (Grade 1, 4 and 7)

		Grade 7 CAPL	
Year		Skills Score	Time score
Grade 1	Boys	0.39*	-0.29*
OCS SS	Girls	0.23*	-0.18*
	High SES	0.31*	-0.27*
	Low SES	0.13	-0.11
Grade 4	Boys	0.16*	-0.09
OCS SS	Girls	0.06	-0.10
	High SES	0.04	-0.16
	Low SES	-0.18	0.05

Note. $r \approx 0.1^*$ small effect, $r \approx 0.3^{**}$ medium effect, $r \geq 0.5^{***}$ large effect

The results of two different stepwise regression analyses are reported in Tables 3.4 and 3.5. The percentage contribution to the variance of OCS mastery in grade 1 and 4 (representations of earlier childhood, as determined by the TGMD-2 OCS SS) is depicted, as well as mastery and applying of OCS in grade 7 (which represent later childhood, and as determined by the skills and timed scores of CAPL). Table 3.4 describes the results obtained by stepwise regression analysis regarding the possible association between the OCS skills standard scores that were obtained in grade 1 and 4 with the skills CAPL score in grade 7. The results showed that 32.6% of the variance could be explained by the results in grade 1, where gender contributed to 16.6%, ($p \cdot 0.01$); SES to 11.4% ($p \cdot 0.01$) and OCS to 4.6% ($p \cdot 0.01$) of the variance.

These contributions to the variance can be considered to be of large practical significance as an $R^2 \geq 25\%$ is considered to be a large effect. In grade 4, 28.1% of the variance obtained in the skills CAPL score can be accounted for by regression by gender (16.6%: $p \cdot 0.01$) and SES (11.4%: $p \cdot 0.01$), while the OCS SS did not make any contribution to the variance. These results confirmed that OCS proficiency in grade 1 showed a higher percentage of contribution to the variance to the qualitative performance of the CAPL skills score, compared to grade 4 where OCS SS did not enter as a step in the regression analysis. These contributions to the variance in grade 4 can, however, be deemed to be of large practical significance (since $R^2 \geq 25\%$ is considered as a large effect).

Table 3.4: The results of a stepwise regression analysis of grade 1 and grade 4 OCS SS on grade 7 participants CAPL skills score as adjusted for SES and gender

<i>N</i> = 374	Steps entered	<i>B</i> *	Std. Err. Of <i>b</i> *	<i>B</i>	Std. Err. Of <i>b</i>	<i>p</i> - value	<i>R</i> ² - change
Grade 1 (<i>R</i>² = 0.326)							
Intercept				9.398*	0.344*	0.001*	
Gender	1	0.383*	0.043*	1.533*	0.173*	0.001*	0.166*
SES	2	-0.296*	0.044*	-1.195*	0.177*	0.001*	0.114*
OCS SS	3	0.220*	0.044*	0.191*	0.038*	0.001*	0.046*
Grade 4 (<i>R</i>² = 0.281)							
Intercept				10.665*	0.426*	0.001*	
Gender	1	0.371*	0.046*	1.483*	0.182*	0.001*	0.166*
SES	2	-0.335*	0.045*	-1.351*	0.183*	0.001*	0.114*

Note. *R*²-change - coefficient of determination; *b** - value of the slope; *p*-value - statistical significance; *p* is set at ≤0.05.

Table 3.5 displays the associations between the time to complete the CAPL and the OCS SS of grade 1 and 4. The results showed that 8.1% of the variance in grade 1 could be explained by the steps that entered the regression compared to 4.3% in grade 4. The results also show that OCS mastery in grade 1 explains a higher percentage of the variance (4.5%) of the time to complete the CAPL compared to in grade 4 (0.9%). The contribution of gender to the variances in grade 1 and 4 were very similar, explaining an additional 3.5% and 3.0% of the variance. SES did not enter the stepwise regression in grade 1, while it contributed 0.4% of the variance in grade 4.

As in the contribution to the CAPL score, it can also be seen that OCS mastery in grade 1 showed a bigger contribution to the variation of the time it took to complete the CAPL compared to in grade 4. The contribution to the CAPL time was, however, much smaller than the CAPL skills score. In addition, the contribution to the overall variance of the CAPL time that could be explained by the steps that entered the regression were also only of small practical significance (since *R*² = 10% is considered as a medium effect).

Table 3.5: A stepwise regression analysis of the variance explained by grade 1 and grade 4 OCS SS on grade 7 participants' CAPL time score, controlling for SES and gender

<i>N</i> = 374	Steps entered	<i>b</i> *	Std. Err. Of <i>b</i> *	<i>B</i>	Std. Err. Of <i>b</i>	<i>p</i> - value	<i>R</i> ² - change
Grade 1 (<i>R</i>² = 0.081)							
Intercept				18.940*	0.493*	0.001*	
OCS SS	1	0.216*	0.051*	-0.230*	0.054*	0.001*	0.045*
Gender	2	0.181*	0.050*	-0.892*	0.248*	0.001*	0.035*
Grade 4 (<i>R</i>² = 0.043)							
Intercept				17.984*	0.604*	0.001*	
Gender	1	0.181*	0.053*	-0.891*	0.259*	0.001*	0.030*
OCS SS	2	-0.084	0.053	-0.087	0.055	0.111	0.009
SES	3	0.068	0.052	0.337	0.259	0.194	0.004

Note. *R*²-change - coefficient of determination; *b** = value of the slope; *p*-value - statistical significance; *p* is set at ≤0.05.

3.4 Discussion

This study aimed to determine the association between OCS mastery during earlier childhood (children aged 6) to middle childhood (children aged 9), and later childhood (children aged 12). The mastery and application of OCS were assessed in the CAPL, where OCS has to be applied with accuracy and good timing in order for the participant to perform well. In this obstacle course, fundamental motor skills execution also requires higher order movement skills such as dynamic balance, spatial awareness, and gross motor coordination. Therefore, this research design examined the assumption that being proficient in OCS during earlier childhood will enhance the application of these skills in open ended and more dynamic sport-related environments during later childhood.

Our first finding was that, compared to children aged 9, well mastered OCS skills at a young age (6 years) will have a higher association with the application of these skills at older ages in more complex environments. By analyzing the skills score and the time to complete the CAPL in grades 1, 4 and 7 it was found that well-mastered OCS skills at the age of 6 will have a higher association with the application of these skills at the age of 12 in more complex environments. When comparing the contribution of OCS mastery, SES and gender at the age of 6 in grade 1 with the contribution of these variables at the age of 9 when the group were in grade 4, the

results showed that mastery of OCS at an earlier age explained a higher percentage of the variance at the age of 12. Stepwise regression analysis revealed a 32.6% contribution to the variance at the age of 6 compared to 28.1% at the age of 9. In addition, OCS only contributed to the variance in the CAPL skills score in grade 1 statistically (4.8% $p < 0.01$) and were also of practical significance.

This result might confirm that OCS does not only develop as a result of maturation as reported by Thomas (2001), but that providing opportunities through structured activities to teach OCS, and informal activities to embrace learned activities, is also important and should be prioritized and formalized within the school environment. It is argued in this regard that when children already obtained good OCS in grade 1, it will provide them with confidence to engage in related sport activities during early childhood that can foster and refine the development of these skills even further. In addition, well-developed fundamental motor skills, especially OCS during the early years, also provide better prospects for children to be included in sport teams when they are young, subsequently aiding them in the further development of already mastered skills in sport-specific situations. In South Africa, where this study was conducted, school sports include different sport codes that require good ball skills such as rugby, netball, soccer, and cricket (Department of Sport and Recreation, 2012). The significant and consistent contribution of SES influences to the explained variance in grade 1 and grade 4, also confirmed that environmental opportunities play an important role in the mastery and application of OCS (Pienaar et al., 2015; Thomas, 2001; Wrotniak et al., 2006).

Our second finding concerns the variables that entered into the stepwise regression and influenced the CAPL time scores at the age of 12 years, which was in a way different to what was found regarding the variables influencing the skills score. In this analysis, a lower percentage of the variation could be explained by the OCS SS, at both ages 6 and 9. The contribution to the variance (4.6% and 4.5%) in the time and skills scores was, however, similar at the age of 6. At age 9, OCS entered as the first of two steps while at age 6, OCS entered as the third step. In addition, OCS mastery did not contribute to the variance that was found in the skills score at the age of 9, while it showed a contribution of 0.9% to the time score at age 12. This result may be suggestive of more fine-tuned and accurately performed OCS at the age of 9, which was needed to complete the CAPL obstacle course as quickly as possible. For this result, it was required from the participant in the obstacle course to catch a ball on the run, throw a ball to hit a target and to kick a ball through goal posts accurately, all against time. This finding suggests that well mastered OCS at the age of 9 needs further fine tuning and refinement. Thus, the period between 6 and 9 years (after the OCS was mastered) is rich in opportunities to engage in activities to improve the timing and accuracy requirements of these

skills in sport-related environments. Therefore, it can be argued that children who have further improved their OCS during the period of 6 and 9 years were better able to perform these skills under a time constraint. The speed-accuracy trade off principle thus provides a possible explanation for the difference in the steps that entered at 6 and 9 years to explain the time and total scores at 12. According to Howley (2001), it is possible that when a child has to perform skills against time, more errors can occur in the execution of a skill when it is not mastered well. Possible reasons for this may be that the expected times proficient performances are reached differ between skills. However, between the ages of 5 and 9 years, children are expected to reach specific performance criteria for certain skills to enable them to adapt such skills to obtain specific timing requirements, Griffiths and Billard (2013) reported. Less experience and fine tuning can also lead to a child dropping a ball during catching or making a less accurate kick or throw at a target. Also, a child might have well-mastered OCS, but might not have been as well coordinated, influencing the time of completion of the obstacle course. It should be noted that the obstacle course also included execution of locomotor skills, such as, gliding and jumping that requires body coordination (Bruininks & Bruininks, 2005). From these results, it seems that once OCS is mastered, it will still be important for children to have opportunities to apply these skills in open ended environments, as this is the contexts in which it will be used at older ages.

Our third finding was that gender also contributed significantly to the explained variance and played a role in OCS mastery. Boys showed a superior skills score (11.69 compared to 10.06) and a time score (16.51 s, and 17.36 s) compared to girls at age 12. The contribution of gender to the variance in the skills score stayed high in grades 1 and 4 (16.6% in both). Regarding the timing score, gender also made a similar contribution in grades 1 and 4 (both 3.0%), although much smaller. This superior performance of boys is also confirmed by other studies (Barnett *et al.*, 2010; Butterfield *et al.*, 2012).

The high value that is placed on boys' sport participation in SA, such as rugby, cricket, and soccer (Walter, 2011) could have contributed to these OCS differences. In both skill scores at 6 and 9 as well as the time scores at 6 and 9, gender was the biggest contributor to the variance; although the contribution was much lower in both the time scores (3.5% and 3.0%). In the timing score gender still contributed to the variance at age 6 and 9 with similar percentages (3.0% and 3.4%) although the percentage was lower compared to the skills score. Here the OCS mastery had a higher contribution than OCS at the age of six (4.5%) compared to gender (3.5%) while at age 9, gender entered first in the regression (3%) with OCS (0.9%), and SES with a much smaller contribution (0.4%). Malina (2004) reported that boys are more proficient in motor skills than girls at all ages and that these differences increase with age. It was also reported that boys

perform better in speed, agility, reaction speed, strength, and upper-limb coordination tests, while girls show better performance in fine motor skills (Al-Haroun *et al.*, 1988).

Our final finding concerns the role of SES in the explained variance. The variation explained by SES was only evident in the skills score (Table 3.5) at both 6 and 9 years, where it entered as a second step showing a significant contribution to the variance (11.4%). When time was scored, it did not contribute significantly to timing differences at the age of 6, while only as a third step, and on a non-significant level at the age of 9 (Table 3.5). Our study confirmed a lower correlation in low SES children. Research also showed that fundamental motor skills proficiency generally increases with increasing socio-economic conditions (Armstrong *et al.*, 2011; Booth *et al.*, 1999; Le Roux, 2014; Pope *et al.*, 2011; Pienaar *et al.*, 2015; Walter, 2011). In a study by Pienaar *et al.* (2015) among South African 9-year-olds, mastery of OCS, specifically catching, throwing, rolling and dribbling, generally increased with higher SES.

Although this study had strengths such as the longitudinal nature of the study that enabled an in depth look into the association of obtaining OCS proficiency at a young age and the application of these skills at older ages over seven school years, the study also had shortcomings that need to be highlighted. In order to draw more comprehensive generalizations, similar future studies should be extended to a more representative area as this study was bound to one of nine provinces of SA. A considerable loss of subjects (54.1%) furthermore occurred over the study period which could have influenced the generalizability of the findings. School status was also used as a proxy of SES in this study. This had certain limitations and it is recommended that educational background and income of parents should rather be used as a proxy of SES. Also, the skills score of the CAPL is not a pure OCS SS score, as it also includes assessment of locomotor proficiency, which could, therefore, have influenced the score and should also be taken into consideration. It should also be remembered that movement as such is a complex, integrated, synchronized, interconnected and multi-joined activity, inclusive of neuromotor and biomechanical mechanisms working together. This complexity portrays that many factors can influence the development of MP. Further studies are therefore recommended to improve our understanding of the variances that could not be explained by analyzing the role of OCS, gender and SES in this regard.

In summary, the findings of this study confirm literature indicating that children should be able to generalize different MP capabilities into sport-specific and specialized skill environments during the childhood years, especially after the age of 7, and that competency in motor skills, especially OCS, is an important cornerstone to future physical and motor skill development (Chen *et al.*, 2016; Goodway & Branta, 2003). This study was also one of only a few studies

that analyzed the association between OCS mastery during early childhood and the application of these skills during later childhood, and therefore makes a contribution to an improved understanding of this phenomenon.

3.5 Conclusion

The results confirm that the earlier OCS proficiency can be obtained, the bigger the transfer effect will be to more complex environments. Such early mastery will provide children with more opportunities and time to apply, further improve and fine tune these skills during the middle childhood years. Although OCS is an important component of fundamental motor skills, well mastered OCS cannot alone guarantee positive sport-outcomes or active participation in physical activities. It can, however, provide a firm baseline from where opportunities for progression or transfer of skills can result in more advanced skilful executions. Gender and to a smaller degree, SES, made contributions to the application of OCS during later childhood, and these influences should also be addressed to improve early OCS proficiency.

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CHAPTER 4

CHAPTER 4

THE ASSOCIATION BETWEEN MOTOR PROFICIENCY AND PHYSICAL FITNESS DURING EARLIER AND LATER CHILDHOOD

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Article 2

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ABSTRACT

BACKGROUND: The possible relationship between motor proficiency and physical fitness during the primary school years is especially important for the future health of children, although this relationship is not well researched longitudinally. The study aimed to determine if there is a longitudinal association between motor proficiency competency and physical fitness between earlier childhood (6 and 9-years-old) and later childhood (12-years-old) in children in the North-West Province of South Africa.

METHOD: The North-West Child Health, Integrated with Learning and Development longitudinal study included a baseline and two time-point measures (2010, 2013 and 2016). We analyzed a total of 374 children (boys=178, 47.59% and girls=196, 52.41%) that represented different socio-economic school backgrounds (quintile 1, i.e. schools from low socio-economic status backgrounds, to quintile 5 schools, i.e. schools associated with higher socio-economic status backgrounds over their seven primary school years (grades 1, 4 and 7). The Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (2010, 2013), the Test for Gross Motor Development, Second Edition (2010 and 2013) and the Progressive Aerobic Cardiovascular Endurance Run test (2016), were all used to draw associations between motor proficiency and physical fitness during earlier and later childhood by using Spearman Rank Order Correlations and stepwise regression analyses.

RESULTS: A significant association was found between motor proficiency at age 6 and 9, (representing the early and middle childhood period) and physical fitness at 12-years (representing later childhood in both girls and boys). Among girls, the association with PF at 12 was also influenced by OCS, but to a lesser degree than MP, but not in boys. Socio-economic status made an insignificant contribution to later PF in boys at 6 years, but not in girls.

CONCLUSION: Motor proficiency, including object control skills during the early and middle childhood years can be considered as possible triggers of PA which again, can increase physical fitness during later childhood. Obtaining early proficiency in these developmental areas is therefore important to the future health of children.

Keywords: motor proficiency, physical fitness, earlier childhood, later childhood

The association between motor proficiency and physical fitness during earlier and later childhood

4.1 Introduction

Motor proficiency (MP) and physical fitness (PF) have been identified as determinants of children's physical activity (Clark & Metcalfe, 2002; De Milander, 2011; Graf *et al.*, 2004; Haga, 2008; Milne *et al.*, 2016; Wrotniak *et al.*, 2006). Wrotniak *et al.* (2006) reported a reciprocal link between MP and physical activity, while Chen *et al.* (2018) and Judice *et al.* (2017) positively associated PF with physical activity in youth. In this regard it is stated by Stodden *et al.* (2008) and Welk (1999) that as an enabling factor for physical activity, health-related PF provides the physical foundations for children to enjoy engaging in a variety of physical activities. Thus, if children do not gain motor proficiency during the earlier childhood years, their participation in physical activities and the enjoyment of sport activities later in life might therefore become threatened. A study by Ewrin and Castelli (2007) found that healthy PF was the only significant contributor for elementary school students' participation in physical activities from several factors tested. Cairney (2011) furthermore confirmed that children with a low MP are not physically active, which resulted in lower PF levels. Low motor proficiency can therefore influence the desire to be physical active and physically fit. A lack of MP and low PF levels has also been associated with various undesirable outcomes such as childhood overweight and obesity (Smyth & Anderson, 2000; Welk & Blair 2000). During later childhood good MP and PF are also important when children should be able to generalize different capabilities in sport-specific and specialized skill environments where time, accuracy and fast decision-making and accuracy of performance are required.

MP is defined as the degree of skills performance in a wide range of motor tasks, movement control and coordination underlying a motor outcome (D'Hondt *et al.* 2013), enabling a child to repeatedly apply practiced fundamental motor skills to execute specific objective control skills and locomotor tasks with competency (Rudd, 2015; Sherrill, 2004; Henderson & Sugden, 1992). MP can be affected by strength, motivation, equipment and prior experiences (Goodway & Branta, 2003). The benefits associated with MP is evident since cross-sectional evidence demonstrated the importance of MP to physical activity (Barnett *et al.*, 2009) and physical fitness (Hardy *et al.*, 2012) as well as the subsequent long term health of children (Cattuzo *et al.*, 2016). Good MP also inversely relates to sedentary activity (Wrotniak *et al.*, 2006).

Health-related fitness is described by Howley (2001) as cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility which is usually related to disease

prevention and health promotion. PF is therefore a physiological state of well-being that reduces the risk of hypokinetic disease; and sets a basis for participation in sports and good health which enables one to be physical active. The health-related benefits associated with PF are numerous since PF is positively associated with physical health (Hillman *et al.*, 2008); psychological well-being (Eveland-Sayers *et al.*, 2009), academic achievement (Coe *et al.*, 2013; Du Toit *et al.*, 2011) and both cognitive vitality (Clarke, 1958) and cognitive functioning in school-aged youth (Donnelly *et al.*, 2016).

Research highlighted the reciprocal and interrelated nature of various enablers in the human movement echelon. In this regard, the association between MP and physical activity has been confirmed by various studies whilst the association between MP and PF is currently less clear and limited. Cardio-respiratory fitness, power, muscle strength and endurance are however, positively associated with MP (Cattuzo *et al.*, 2016; Rivilis *et al.*, 2011), while De Milander (2011) and Pica (2011) reported that PF also contributes to MP. Haga (2008) and Hardy *et al.* (2012) came to the conclusion that MP components are significant predictors of PF and that physical activity levels can explain the association between MP and PF. Luz *et al.* (2017) recently also affirmed the positive relationship between MP and PF across childhood and early adolescence. In this cross-sectional study completed on Brazilian children aged 7 to 14, Luz *et al.* (2017) analysed children representing schools from different municipalities in the Lisbon district regarding the association between MP and its components (locomotor skills and object control skills (OCS) and PF. Components of MP proved to be significant predictors of PF with locomotor skills being the strongest predictor (Luz *et al.*, 2017). Gender differences were reported since the locomotor component of MP had the strongest effect on PF in girls of all ages (7 to 14 years) while locomotor and OCS showed larger effects in younger boys, and stability indicated significant effects in older boys (Luz *et al.*, 2017). Stodden (2014) completed a study on 253 boys and 203 girls (aged 4 – 13 years) and found a dynamic relationship between MP and PF performance and that it may change across childhood; and that the correlation between manipulative skills and health-related fitness increase over time. The researcher specifically noted that the development of OCS in childhood may be important for the development and maintenance of health-related fitness across childhood and into adolescence.

Apart from gender influences, socio-economic status (SES) also seems to play a significant role in the outcome of research studies on MP and PF. Pertaining to the reciprocal, interlinked and enabling nature of MP and PF, studies reflecting on the impact of SES on physical activity were also noted. Elgar *et al.* (2015) and Muthuri *et al.* (2014) confirmed, amongst other things, the influence of socio-economic inequalities on physical activities. The HAKSA (2010:5) report card

also indicates lower fitness levels in children from disadvantaged backgrounds as found in a national youth fitness survey involving 10 000 children aged 7 to 13 years.

Research studies analyzing the association between MP and PF were mostly done cross-sectionally (Haga, 2008; Hardy *et al.*, 2012; Luz *et al.*, 2017) and therefore Luz *et al.* (2017) recommended more longitudinal studies across developmental ages. This study will address this gap in knowledge by conducting a longitudinal (2010, 2013 and 2016) investigation pertaining to the long term association between MP and PF during earlier (grades 1 and 4, ages 6 to 9) and later childhood (grade 7, age 12) in children of both sexes residing from different SES backgrounds (quintile 1 (low) - quintile 5 (high) school types) over their seven primary school years (grades 1, 4 and 7) in the North-West Province of South Africa (SA).

4.2 Method

4.2.1 Study design

This study forms part of the North-West Child Health, Integrated with Learning and Development longitudinal study (NW-CHILD Study). A longitudinal research design was used and data was collected over a period of seven school years (2010-2016) in the North-West Province of the SA. This made available follow-up data of six years, including one baseline and two time-point measurements, namely in 2010 (grade 1: 6-years-old), 2013 (grade 4: 9-years-old) and in 2016 (grade 7: 12-years-old).

The research group was selected by means of a stratified random sample in conjunction with the Statistical Consultation Services of the North-West University, Potchefstroom, SA. To recruit participants, a list of all the schools in the North-West Province was obtained from the Department of Education in the North-West Province. Stratification was done for school districts, schools quintiles (1-5), and gender (male and female). All the schools in this province are grouped into eight educational districts, each consisting of 12 to 22 regions with approximately 20 schools (minimum 12, maximum 47) per region. Twenty schools from four different educational districts, representing five different school quintiles, and children of both sexes, were recruited to take part in the study. The North-West Department of Education used a poverty classification in each province to classify schools in different quintiles (quintile 1, i.e. school types from low SES backgrounds, to quintile 5, i.e. school types associated with higher SES backgrounds). The quintile status of a school is determined by the National Treasury and according to the National Poverty Table, obtained from the National Census data which include income, dependent ratios, and levels of literacy (Pienaar *et al.*, 2015). Quintile 1 and 2 schools are the poorest schools and are exempted from paying any school fees (Statistics South Africa, 2010). The North-West Province of SA is characterized by high poverty, especially in rural

areas, unequal distribution of income between different population groups, and unemployment (Statistics South Africa, 2010).

The association between earlier childhood - which comprised of grade 1 (6-year-old children) and grade 4 (9-year-old children) and later childhood which included grade 7 (12-year-old children) - was made by using various measurements to measure different components. The measuring instruments used over the seven year period during the measures (2010, 2013 and 2016) were the Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF) and the TGMD-2 test.

TGMD-2 is a test of gross motor functioning in the age group 3-10 years which is done in static environments, but does not reflect an open, dynamic and authentic environment in which 12-year-olds usually have to present their motor proficiency. In an open environment setting more complex movements (similar to what is needed during organized play and sport participation activities) are needed and combined (Lloyd *et al.*, 2014) and may, therefore, provide insights into sport-related applications during later childhood. The CAPL protocol used represent a developmentally appropriate open environment setting that considers the interaction between the individual and environment, making it possible to draw associations between OCS mastery during earlier childhood and application of these skills during later childhood.

4.2.2 Participants

The number of participants that were part of the baseline (2010) and two time-point measures (2013 and 2016) was 374 participants ($N = 374$) including 178 boys (47.59%) and 196 (52.41%) girls in their grade 7 year with a mean age of 12.9. The loss of subjects over the study period was 442 (54.1%). Migration from schools, lack of parental consent or absence on the day of testing were the main reasons for such a large loss of participants over the seven year school period. Out of the 374 participants included in the study, 214 children (90 boys and 124 girls) were in quintile 1-3 schools representing low SES settings, while 160 children (88 boys and 72 girls) represented higher SES school settings (quintile 4 and 5). The same participants who completed the grades 1 and 4 measurements were again assessed in grade 7. The mean age of the participants varied between 6.80 and 12.91 from grade 1 to grade 7. In grade 1 864 children were recruited and 816 were included in the study after their parents provided permission. This group included 419 boys and 397 girls with a mean age of 6.84. All these children were invited to participate in their grade 4 year when they had a mean age of 9.9 years and a standard deviation of 0.42, and again in their grade 7 year at a mean age of 12.9 years and a standard deviation of 0.41.

4.2.3 Measuring instruments

4.2.3.1 Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF)

BOT-2SF (Bruininks & Bruininks, 2005) was used to test the children's MP during the baseline and two time-point measures (2010, 2013 and 2016). This test battery was individually administered to determine the fine and gross motor skills of children. This norm-based instrument is suitable for 4 to 21-year-olds (Bruininks & Bruininks, 2005). The BOT-2SF evaluates motor skills in four area components and consists of the following: fine motor skills (divided into fine motor precision and fine motor integration); hand coordination (divided into hand agility and upper limb coordination); body coordination (divided into bilateral coordination and balance); and the strength and agility component (divided into running speed, agility and strength). The BOT-2SF, which is validated against the full version and consists of 14 items, together with sections of the complete version (subtest 6 - running speed and agility and subtest 8 - strength) was used to evaluate the MP skills. The results may be a number of objects or events, or length of time. Each item was scored on a graded scale that was constructed to span the widest possible range of performance.

4.2.3.2 Test for Gross Motor Development, Second Edition (TGMD-2)

The TGMD-2 is a norm-referenced measure designed to test gross motor functioning of children 3 to 10 years old. The test consists of 12 motor skills and is divided into two sub-tests, namely locomotor (run, hop, gallop, leap, horizontal jump and slide) and OCS (overhand throwing, catching, underhand rolling, dribbling, kicking and striking a stationary ball) (Ulrich, 2000). Only the OCS subtest was used for the purpose of this study to determine proficiency in six OCS of children aged 6 and 9 in their grade 1 (2010) and grade 4 (2013) school years. Each of these skills included several behavioural components presented as performance criteria and in general presents a mature pattern of the skill. If participants performed an action correctly, they received a score of 1; if they performed it incorrectly, they received a 0. Each participant received two attempts to perform each skill after a visual demonstration of each skill was performed by the tester. The scores of the two attempts were added together. Standard scores for the sub-items were calculated from the raw scores and then combined to obtain a gross total motor score from which a motor quotient was calculated. The gross motor quotient is the best measure of an individual's overall gross motor ability (Ulrich, 2000). Age, gender and the raw score of each child were used to calculate the percentile rank as well as the standard score. A child's performance in comparison with chronological age group can be obtained by using percentile scales. The descriptive proficiency ratings for subtest standard scores in the TGMD–

2 manual is indicated as very superior (17–20), superior (15–16), above average (13–14), average (8–12), below average (6–7), poor (4–5), and very poor (1–3). The TGMD-2 has a validity of $r=0.89$ (Ulrich, 2000). This test battery was not used during the 2016 measurements as it is only validated for children up to 10 years.

4.2.3.3 Progressive Aerobic Cardiovascular Endurance Run test (PACER)

Aligned with a systematic review done by (Cattuzzo *et al.*, 2016) the PF of the participants (ages 6 to 13) was measured using a shuttle run, namely the Progressive Aerobic Cardiovascular Endurance Run (PACER). The PACER is a multi-stage progressive cardio-respiratory/aerobic endurance test that is part of the FITNESSGRAM testing protocol (Plowman & Meredith, 2013). For this study, the test was used during the two time-point measures in 2013 and 2016. Children have to run across a 20-meter distance back and forth and turn on the sound of a beep. The test begins with an easy pace and becomes progressively more difficult as the time between the beeps becomes shorter. A participant has to run until failure occurs to reach the line at the sound of the beep for a second time. The recorded score is the total amount of laps completed which is then used to determine the aerobic fitness of the participant on a norm scale according to their age and gender.

4.2.4 Procedures

The Health Research Ethical Committee of the Faculty of Health Science at the North-West University granted permission for extension of the longitudinal study (NWU-00070-09-A1 2009-2015) before the final measurements commenced in 2016. Parental or legal guardian permission was obtained prior to the testing via the signing of a consent form. The parental or legal guardian permission form was explained thoroughly as well as what was expected from each participant including the risks involved. On the day of field testing the participants, whose parents or legal guardian granted consent, completed an assessment before they were allowed to participate in the research project after the procedures were explained to them by the physical instructor, and questions of the participants had been answered. The participants were under no obligation to participate in the research and were allowed to withdraw at any time during the testing. The testing procedures were conducted at school during the mornings of a school week as arranged and confirmed by the headmaster of the school.

4.2.4.1 Statistical analysis

Analysis were performed using the “Statistica for Windows 2016” Statsoft computer program package (Statsoft, 2016). Data was first analyzed descriptively (percentages, frequency

distributions, means and standard deviations) to describe the group and MP and PF characteristics. The Spearman Rank Order Correlation was used to determine the association between MP and PF during earlier (6 years), middle (9 years) and later (12 years) childhood and to determine association with gender and SES. The effect size cut-offs as set by Cohen (1988) was used to determine practical significance. An $r \approx 0.1$ interpreted as small effect, $r \approx 0.3$ as a medium / moderate effect, $r \geq 0.5$ as a large effect size. The strength of the association between MP and object control skills mastery and PF during earlier and later childhood including gender and SES in the stepwise regression analysis is presented by the percentage variance explained where $R^2 = 1\%$ can be interpreted as small effect, $R^2 = 10\%$ as medium effect, $R^2 \geq 25\%$ as large effect. For statistical significance, p is set at ≤ 0.05 .

4.3 Results

Table 4.1 provides the demographic characteristics of the participants in the study. 374 subjects participated in the study of which boys represented 47.59% ($n = 178$) and girls 52.41% ($n = 196$). Of the boys, 50.57% ($n = 90$) represented low SES schools, and 63.27% ($n = 124$) of girls, while the remainder of the boys 49.44% ($n = 88$) and girls 36.73 % ($n = 72$) represented participants from high SES schools.

Table 4.1: Characteristics of the participants per gender and per SES school

AGE		GENDER		SES (SCHOOL STATUS)				
<i>M</i>	<i>SD</i>	<i>N</i>	%	Low	%	High	%	
Grade 9.91	4: Grade 4: 0.41	Boys	178	47.59	90	50.57	88	49.44
Grade 12.92	7: Grade 7: 0.41							
Grade 9.86	4: Grade 4: 0.42	Girls	196	52.41	124	63.27	72	36.73
Grade 12.87	7: Grade 7: 0.41							
Grade 9.89	4: Grade 4: 0.42	Total	374	100	214	57.22	160	42.78
Grade 12.90	7: Grade 7: 0.41							

Note. N - number of total participants; M – mean; SD - standard deviation; % - percentage; Low - rural environment (low socio-economic status schools); High - urban environment (high socio-economic status schools).

Table 4.2: Descriptive results of the BOT-2SF standard score (grades 1, 4 and 7), the TGMD-2 (grades 1 and 4) and the PACER (grades 4 and 7) per gender (boys and girls) and per group

Grade	Gender /Group	<i>M</i>	<i>SD</i>	Min	Max
BOT-2 SF standard score					
Grade 1	Boys	44.43	5.99	32.00	63.00
	Girls	39.25	6.06	26.00	63.00
	Group	41.72	6.55	26.00	63.00
Grade 4	Boys	51.46	7.25	35.00	75.00
	Girls	48.56	8.01	34.00	73.00
	Group	49.94	7.78	34.00	75.00
TGMD-2 (Grade 1 and 4)					
Grade 1	Boys	7.15	2.32		
	Girls	7.43	2.30		
	Group	7.30	2.31		
Grade 4	Boys	8.67	2.24		
	Girls	9.62	2.41		
	Group	9.16	2.38		
PACER					
Grade 1		N/A- Not measured in Grade 1			
Grade 4	Boys	25.46	13.85	4.00	74.00
	Girls	17.91	8.79	2.00	59.00
	Group	21.56	12.11	2.00	74.00
Grade 7	Boys	37.76	17.57	7.00	83.00
	Girls	21.78	12.83	5.00	80.00
	Group	29.40	17.22	5.00	83.00
VO₂ Max					
Grade 1		N/A- Not measured in Grade 1			
Grade 4	Boys	43.53	4.92	35.70	60.30
	Girls	40.88	3.03	35.70	54.60
	Group	42.15	4.25	35.70	60.30
Grade 7	Boys	44.45	6.17	33.10	60.30
	Girls	38.90	4.62	32.60	59.10
	Group	41.54	6.07	32.60	60.30

Note. M – mean; SD - standard deviation; Min – minimum; Max – maximum; *CAPL skills total was calculated out of a total of /14.

Table 4.2 displays the descriptive statistics of the BOT-2 and the TGMD-2 that were used in grade 1 and 4 to determine general motor proficiency and object control skills. The aerobic endurance results of the group obtained by the PACER in grades 4 and 7 are also displayed. In grades 1 and 4 the BOT-2SF was used to determine the MP and the TGMD-2. Boys compared, to girls, displayed higher mean standard scores in the BOT-2SF in grade 1 (44.43 vs 39.25) and grade 4 (51.46 vs 48.56). The gender specific object control skills standard score (OCS SS) increased in boys from grade 1 (7.15) to grade 4 (8.67) as well as among girls from grade 1 (7.43) to grade 4 (9.62). The boys also displayed a higher number of PACER levels in grade 4 (25.46 vs 17.91) and grade 7 (37.76 vs 21.78) as well as VO₂ max values (43.53 vs 40.88 grade 4) and (44.45 vs 38.90, grade 7) compared to girls.

Table 4.3 displays the results of a correlation analysis to determine the relationship between MP and PF in the group in grade 4 at the age of 9 and in grade 7 at 12-years-old, and also per gender. Statistically significant correlations were found between the BOT-2SF and PF scores in grades 4 and 7. MP showed a small, but significant relationship with PF at the age of 9 ($r = 0.26$) while this relationship increased to moderately significant ($r = 0.35$) at the age of 12. Girls showed a small but significant relationship between MP and PF at ages 9 ($r = 0.16$) and 12 ($r = 0.31$). This relationship was stronger and moderate in boys at both ages ($r = 0.31$) and ($r = 0.38$).

Table 4.3: Correlations between MP (BOT-2SF standard scores) and PF (PACER) between grade 4 (2013) and grade 7 (2016) as per gender and per group

Measure	Year	2013	2016
		PACER (r)	PACER (r)
BOT-2SF SS 2016	Boys	0.31*	0.38*
	Girls	0.16*	0.31*
	Group	0.26*	0.35*

Note. $r \approx 0.1$ small effect, $r \approx 0.3$ medium effect, $r \geq 0.5$ as a large effect.

Table 4.4 reports the results of a stepwise regression analysis that was done to determine the contribution of MP mastery in grades 1 and 4 to PF in grade 7. PF of participants were not measured in grade 1; therefore this analysis was only performed on the data obtained in grades 4 and 7. The results showed that 27.1% of the variance that was found in the physical fitness of grade 7 participants can be explained by their results at age 6, where gender makes a

significant contribution of 21.5% to the variance, the BOT-2SF SS an additional 4.7% ($p < 0.05$) and the OCS SS add an additional 0.9% ($p < 0.05$). In grade 4, 24.8% of the variance in PF in grade 7 can be ascribed to gender (21.4%), MP mastery (2.8%) and the OCS SS, 0.6%. The contribution of OCS was however not significant at age 9. The strength of the association between MP and PF at age 6 and 9 years and later childhood including gender in the stepwise regression analysis, showed a large significant effect' ($R^2 \geq 25\%$).

Table 4.4: A stepwise regression analysis of the variance explained in the PACER in grade 7 by MP, OCS, gender and SES of the participants in grades 1 and 4

<i>N</i> =374	Steps entered	<i>b</i> *	Std. Err. Of <i>b</i> *	<i>B</i>	Std. Err. Of <i>b</i>	<i>p</i> -value	<i>R</i> ² -change
Grade 1 on Grade 7 PACER ($R^2 = 0.271$)							
Intercept				-3.510	5.116	0.493	
Gender	1	0.395*	0.049*	13.604*	1.715*	0.001*	0.215*
BOT-2SF SS	2	0.189*	0.053*	0.497*	0.139*	0.001*	0.047*
OCS SS	3	0.104*	0.490*	0.785*	0.370*	0.035*	0.009*
Grade 4 on Grade 7 PACER ($R^2 = 0.248$)							
Intercept				-0.138	5.513	0.980	
Gender	1	0.451*	0.048*	15.513*	1.636*	0.001*	0.214*
BOT-2SF SS	2	0.150*	0.047*	0.332*	0.105*	0.002*	0.028*
OCS SS	3	0.084	0.047	0.607	0.345	0.079	0.006

Note. R^2 -change - coefficient of determination; *b** - value of the slope; *p*-value - statistical significance; *p* is set at ≤ 0.05 .

As gender showed a main influence on the overall explained variance at ages 6 and 9, (21.5% and 21.4%) the following stepwise regression analysis (Tables 5 and 6) was done on girls (Table 4.5) and boys (Table 4.6) separately. These analyses showed that early MP is associated with PF in both boys and girls.

Table 4.5 reports the results of a stepwise regression analysis for girls. OCS at 6 years significantly explained 4.2% of the variance that was found at age 9 in PF while MP and SES showed no association. Both MP (step 1) and OCS (step 2 at 6 years) entered as significant steps in the regression analysis to explain PF at 12 years. The contribution of these variables to PF at 12 years showed that 8.6% of the overall variance in PF can be significantly ascribed to

general motor proficiency (6.2%) and object control skills (2.4%) while SES did not enter in the regression analysis.

Table 4.5: Results of stepwise regression analysis of the variance explained by MP at ages 6, 9 and 12 of PF in girls

N=196	Steps entered	b*	Std. Err. Of b*	B	Std. Err. Of b	p-value	R²-change
Grade 1 girls on Grade 4 PACER ($R^2=0.042$)							
Intercept				12.161*	2.107*	0.000*	
OCS SS	1	0.204*	0.071*	0.772*	0.270*	0.005*	0.042*
Grade 1 girls on Grade 7 PACER ($R^2=0.086$)							
Intercept				-0.979	5.871	0.868	
BOT-2SF SS	1	0.192*	0.074*	0.404*	0.156*	0.010*	0.062*
OCS SS	2	0.164*	0.074*	0.935*	0.420*	0.027*	0.024*
Grade 4 girls on Grade 7 PACER ($R^2=0.061$)							
Intercept				0.845	6.049	0.889	
BOT-2SF SS	1	0.204*	0.072*	0.326*	0.115*	0.005*	0.051*
OCS SS	2	0.101	0.072	0.539	0.386	0.164	0.009

Note. R²-change - coefficient of determination; b* - value of the slope; p-value - statistical significance; p is set at ≤ 0.05 .

The contribution of the same variables at age 9 to the variation that was found in PF at age 12 was slightly lower (6.2%) and included MP (5.1%, $p<0.05$) and OCS (0.1%, $p<0.05$). SES showed no contribution to the explained variance in girls, although the MP entered higher during later childhood while object control skills entered during early and later childhood. It can be seen that good OCS probably contribute to girls' higher MP at 9 years, because both MP and OCS contributed to PF of 12-year-old girls.

Table 4.6 reports the same results for boys. OCS did not enter at six years while in girls it explained 4.1% of the variance at 6 years. In boys, 2.5% of the variance is explained by MP at 6 years. SES also made a contribution to the explained variance in boys ($p>0.05$), although only at a young age and for a short time period (only until grade 4). The contribution of MP at age 6 in boys and girls was the same at 12 years (6.2%). However, MP and OCS both had an influence on girls' PF. MP and OCS's contribution to PF in girls was greater at 12 years (8.6% vs 6.2%). MP also made similar high and significant contributions to the explained variance at ages 6 and 9 to explain PF at age 12 in boys (2.5% and 2.6% respectively). The percentage

variance explained in boys and girls were both more than $R^2 = 1\%$ which can be interpreted as a small significant effect.

Table 4.6: Results of stepwise regression analysis of the variance explained by MP at ages 6, 9 and 12 years of PF in boys

N=178	Steps entered	b*	Std. Err. Of b*	B	Std. Err. Of b	p-value	R²-change
Grade 1 boys on Grade 4 boys PACER ($R^2=0.041$)							
Intercept				2.976	8.530	0.728	
BOT-2SF SS	1	0.201*	0.078*	0.464*	0.181*	0.011*	0.025*
SES	2	0.133	0.078	3.700	2.165	0.092	0.016
Grade 1 boys on Grade 7 boys PACER ($R^2=0.062$)							
Intercept				5.438	9.603	0.572	
BOT-2SF SS	1	0.249*	0.073*	0.728*	0.214*	0.001*	0.062*
Grade 4 boys on Grade 7 boys PACER ($R^2=0.033$)							
Intercept				14.183	9.880	0.153	
BOT-2SF SS	1	0.141	0.076	0.342	0.185	0.066	0.026*
OCS SS	2	0.088	0.076	0.691	0.599	0.250	0.007

Note. R^2 -change - coefficient of determination; b* - value of the slope; p-value - statistical significance; p is set at ≤ 0.05 .

4.4 Discussion

The aim of this study was to determine if an association exists between motor proficiency in earlier childhood (6 and 9-years-old; grades 1 and 4) and PF during later childhood (12-years-old; grade 7), as assessed by means of the PACER aerobic test.

The findings from this study confirmed that MP at a young age (during earlier childhood), is related to PF during later childhood in both boys and girls. These findings are supported by both the correlation analysis and the stepwise regression that were performed, including gender as part of the stepwise regression analysis. The findings confirmed that gender contributed largely and consistently to the explained variation of PF from early childhood at age 6, and also during middle childhood, at age 9 (21.5% and 21.4%, Table 4). The fact that gender made such a large contribution made it necessary to do separate stepwise regression analyses for boys and girls. The contribution of general motor proficiency as assessed by the BOT-2 (MP), and object

control skills as assessed by the TGMD-2 and SES, were analyzed in the stepwise regression analyses. These analyses (Table 4.5 and 4.6) showed that MP during earlier and middle childhood plays a small ($R^2 > 1.0$), although a significant role in PF during later childhood in both boys (6.2%) and girls (6.2%). This significant contribution of early MP to PF during later childhood was found to be similar in both boys and girls (6.2%), although the OCS of girls at 6 years made an additional 2.4% contribution to the explained PF association during later childhood at 12 years, where an overall explained variance of 8.6% were found in girls, which was not the case among boys. In boys, OCS did show a small association up to age 9 years, as it entered the stepwise regression during middle childhood at age 9, although only on a non-significant level (0.07%). Very few longitudinal studies have been done in this field to compare this study's results with. The finding of an association between MP and PF in this study is, however, consistent with the cross-sectional findings of Luz *et al.* (2017) stating that the relationship between overall MP and health-related PF is strong and stable across childhood and early adolescence in both boys and girls. This association is also confirmed through a systematic review by Cattuzzo *et al.* (2016) showing strong evidence of an inverse association between MP and body weight and a positive association between MP, cardiorespiratory fitness and musculoskeletal fitness in children and adolescents. A cross-sectional study done by Cairney *et al.* (2011) and Cantell *et al.* (2008) on 110 participants divided in three age groups (8 to 9, 17 to 18 and 20 to 60 years) also confirmed that individuals with low MP exhibit inferior overall PF levels compared to peers with higher MP. Other studies that were also of cross-sectional nature, reported that cardio-respiratory fitness, power, muscle strength and endurance are all positively associated with MP (Cattuzzo *et al.*, 2016; Rivilis *et al.*, 2011) while it is also reported that PF contributes to MP (De Milander, 2011; Pica, 2011). In addition, Haga (2008) and Hardy *et al.* (2012) came to the conclusion that MP components proves to be a significant predictor of PF and that PA levels can explain the association between MP and PF. Our results also confirmed the model presented by Stodden *et al.* (2008) indicating that the relationship between MP and PF becomes more reciprocal in nature during later childhood and adolescence.

The contribution of each of these variables was found to be slightly different in boys and girls over the shorter time period from early to middle childhood. In girls, OCS was the only step that entered in early childhood at age 6 to play a role in their PF during middle childhood (age 9) (4.2%). This finding illustrates the overarching and subsequently important role of OCS, especially in girls, to trigger physical activity and thereby put girls early in their lives on an active trajectory that is conducive to their fitness. It is suggestive that such skills aid girls at younger ages to play ball skill related games which might again contribute to vigorous play and activity and subsequently PF. In South Africa, school sport includes netball and is played by girls from

an early age (Department: Sport and Recreation, 2009). It is a sport that requires catching and throwing skills. Mini-netball is already introduced to girls in grade 1. As a result, young girls can become part of netball teams, where participation in team sport is found to be conducive to improve PF (Lee *et al.*, 1995; Rose *et al.*, 1994). This early influence of OCS on girls remained, although its influence declined, while the influence of general MP became increased among girls over a longer period of time. Over the follow-up period from grades 1 to 7, the role of general motor proficiency strengthened and entered as a first step showing a 6.2% contribution to PF, while OCS made a 2.4% additional contribution to the explained variance. The cross-sectional findings of Luz *et al.*, (2017) on 546 Brazilian children, aged 7 to 14 showed that girls need locomotor MP to trigger their involvement in physical activity while boys need both locomotor and OCS and motor proficiency for involvement in motor activities. In our longitudinal study this conclusion might be more relevant to the findings of girls as OCS showed a different but also higher and significant association, not only between early and middle childhood (4.2%), but also between earlier and later PF (2.4%) than in boys. The results of Luz *et al.* (2017), however, confirmed this study's findings regarding the relationship between MP and PF. The poorer association between early OCS and later PF in boys compared to girls can possibly be ascribed to a higher interest among all boys in doing movement skills associated with OCS (both by themselves and parents), and applying these skills during play which might contribute to more vigorous physical activity and subsequently improved PF in most boys. Malina (2004) reported differences in this regard in the way that boys and girls grow up, resulting in differences in frequency of training and exposure to instructions of a specific skill. Okely and Booth (2004) and Van Beurden *et al.* (2002) also reported differences between 1 to 9-year-old children where boys showed better OCS and girls better locomotor skills. Although speculative, based on the above reasons, but also on results reported by Cairney (2011) that showed that children with low motor proficiency are not physically active, there might be a bigger differentiation between girls that are object control proficient compared to those with poorer OCS mastery. This can be the cause of girls with poorer OCS not being included in early team sport, leading to less exposure to environments where such skills can improve and subsequently lesser vigorous physical activity that is conducive to PF. In general, studies reported declining physical activity levels in girls from 10 years (Sallis *et al.*, 2000) which is not conducive to their PF and subsequently their health. Ewrin and Castelli (2007) found in this regard that healthy PF was the only significant contributor to elementary school students' participation in physical activity from several factors tested. Our findings highlight that it is especially important to equip all girls with optimal OCS at a young age as this motor skills repertoire can again motivate them to participate in sport and active play which again can trigger physical activity, and subsequent PF. Active participation and increased physical activity among boys and girls are associated with sport participation (Lee *et al.*, 1995; Rose *et al.*,

1994). In this regard, Cozett (2014) and Katzmarzyk *et al.* (2013) reported that boys are more likely to belong to a sports team than girls, and may impact on their PF levels which are regarded as an enabling factor for physical activity and *vice versa* providing the physical foundations for children to enjoy engaging in a variety of physical activities (Stodden *et al.*, 2008; Welk, 1999).

SES only showed an association with the PF of boys up to middle childhood, as it entered the stepwise regression as a second step, although on a non-significant level (0.016%, table 6). This finding is confirmed by results from Pienaar *et al.* (2015) that showed a significant interaction effect between gender and low and high SES environments, where large practical significant differences were found between the OCS proficiency of boys from low (poorer) and high socio-economic status school environments. However, these findings are based on 9-year-old children.

The longitudinal nature of this study is considered to be a strength of the study since it is one of few studies of this nature that enabled an in-depth look, spanning seven school years, into the association between MP and PF during earlier and later childhood. The current findings are informative for practice since earlier childhood activities and interventions which can enhance motor proficiency of children are associated with improved PF during later childhood. This association suggests that early general motor proficiency, but especially OCS proficiency in girls, is key to influence positive sport participation and sport achievement and thereby promote a healthier lifestyle associated with an abundance of advantages. Practitioners and researchers should therefore pay more attention to the role of these associations in promoting an active lifestyle during later childhood in boys and girls which can result in improved sport participation and improved quality of life. The importance of early OCS mastery to later PF in girls, as found in this study, urge that this important relation should receive attention in practice. Since childhood is a critical period for the development of MP and PF (Luz *et al.*, 2017) it is fundamental to promote MP and PF to benefit the healthy development of children. If children, adolescents and adults have equal opportunities to develop their motor proficiency which contributes to PF, a broader selection base for inclusion in sport programs and sport teams will again be possible, leading to improved PF. The findings also contributed to improved knowledge of scientists and health practitioners about the long term influences and subsequent importance of adequate general motor proficiency at a young age. This contribution is regarded as an asset of this study. Knowledge in this regard can be used in the development of appropriate strategies to improve fundamental movement skills in children. It is anticipated that

the knowledge gained will bring to the fore the importance of enhancing the MP and PF in children as important building blocks for increased physical literacy, health and well-being.

The limitations of this study should, however, be acknowledged. The study was bound to one of nine provinces of SA. In order to draw more comprehensive generalizations, similar studies should in future be extended to a more representative area. The loss of subjects over the study period was considerable (54.1%) and had an influence on the generalization of the results. A further limitation was that only the object skill subset of the TGMD-2 was used and not the locomotor subset. If the locomotor proficiency subset would also have been included, these results would have been better comparable with the results reported by Luz (2017). School status was used as a proxy of SES in this study which also had certain limitations. It is recommended that educational background and income of parents should rather be used as SES indicators. More similar and especially longitudinal studies are therefore recommended, based on our findings, in order to improve our understanding of the other variances that can also explain PF in primary school children, which could not be explained by this study's findings.

4.5 Conclusion

Motor proficiency at young age in a range of motor abilities as assessed in the BOT-2SF, which include fine motor skills, hand coordination skills, upper limb-, body-, and bilateral coordination, balance, strength, running speed and agility, was found to be a significant predictor of PF during later childhood. The pathway to improved PF is most probably through increased physical activity as motor proficient children have greater chances on becoming involved in sport. The results confirmed that obtaining proficiency in motor skills, but also in object control skills during earlier childhood is important as it will enhance application of these skills in sport-related activities during later childhood and consequently contribute to improved PF in children. According to past studies, improved aerobic fitness is not only associated with positive health, but also contribute to improved academic outcomes (Du Toit *et al.* 2011). Well-mastered fundamental motor skills can therefore provide an important baseline from where opportunities for progression or transfer of skills can result in more advanced skilful executions leading to positive outcomes in child well-being.

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CHAPTER 5

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Early proficiency in motor skills is considered to be a key cornerstone of future physical and motor skill development. Fundamental motor skills, which develop during childhood, are considered to be essential building blocks of motor proficiency upon which sport-specific and specialised skills are built.

The study had two objectives. Firstly to determine the association between object control skills mastery during earlier (6 and 9-years-old) and later (12-years-old) childhood in children living in the North West Province of South Africa. The second objective was to determine the association between motor proficiency and physical fitness during earlier (6 and 9-years-old) and later (12-years-old) childhood in children living in the North West Province of South Africa. Chapter 1 includes the problem statement, objectives and hypotheses of this study.

Chapter 2 contains a literature review of research findings pertaining to associations between object control skills, motor proficiency and physical fitness during the earlier and later childhood period. Sport participation statistics regarding children in the age period 9 to 13 years, living in South Africa and the importance of sport participation for a healthy lifestyle later in life was also provided as a background to the objectives of this study. In addition, a scientific background relating to the well-being and development of a child, namely typical phases of motor development in children, different phases of object control skills development and factors leading to a decline in object control skills mastery, motor proficiency, and physical fitness and physical activity levels of children, were also discussed. Results from both cross-sectional and longitudinal studies, relating to the age groups applicable to this study, were reviewed and discussed.

Aspects found to be influential to the associations between object control skills during earlier and later childhood and the association between motor proficiency and physical fitness during earlier and later childhood were gender, physical activity of children, socio-economic status (SES), the environment in which a child grows up, opportunities to participate in or whether a child receives coaching in different sports. The literature review furthermore revealed a significant link between basic object control skills and sport participation and fundamental motor skills, which is referred to as the foundation of body movement, which again serves as the

foundation for more complex or specialised skills used in play and sport specific applications. The literature review also indicated that the development of object control skills is important, especially in the age group between 2 to 7 years, since skills developing during this period form part of the foundation on which more specialized sport skills develop.

The literature review on findings of cross-sectional and longitudinally studies regarding the possible association between motor proficiency and physical fitness revealed that the association between motor proficiency and physical fitness was studied to a limited extent. The limited studies that were found, did however, show a possible association between motor proficiency and physical fitness in boys and girls during earlier and later childhood and in adolescence. According to scientific proof children who are motor proficient, are more physically fit than children who are not motor proficient. Researchers link this association to the fact that children with low motor proficiency less often participate in sport, resulting in a more sedentary lifestyle which in turn leads to being unfit. It was also found that early and later childhood motor proficiency has an influential role in the development of health related fitness in boys and girls. Longitudinal studies found that early childhood object control skills have an influence on motor proficiency in adolescence and that girls perform poorer in object control skills compared to boys. It was also reported that children who perform poorly in motor skills or have low fitness levels when they are young are unlikely to catch up with their peers with age. The review furthermore disclosed that being motor proficient and physically fit is important, because of the beneficial effects it has on growth and balanced healthy physical, social, cognitive and psychological development, which again can result in active living. All these aspects lay the foundation for improved well-being and physical advancement in children. Most associations between MP, OCS and PF were studied in cross-sectional analyses with fewer studies completed longitudinally. These studies found that fundamental movement skills were generally associated with repetitive movement such as locomotor skills, a component of motor proficiency which enhances cardiorespiratory development. It was also revealed that fundamental movement skills proficiency may be a key determinant of physical activity behaviour across time. Childhood object control skills proficiency were also found to predict adolescent proficiency, which is indicative that early childhood object control skills has an influence on motor proficiency in adolescence.

Chapter 3 was prepared in article format with the title *The association between object control skills mastery during earlier and later childhood in children living in the North West Province of South Africa* and was submitted for consideration for publication to the *Journal of Perceptual and Motor Skills*. This article contains the results of a longitudinal analysis of the association

between object control skills mastery during earlier childhood (6 and 9 years) and later childhood (12 years). This study formed part of the seven school year NW CHILD study that included twenty randomly selected schools, representing low and high socio-economic status schools in the North West Province of South Africa. A stratified random sample of participants (N = 374) presenting both genders (boys=178, 47.59% and girls=196, 52.41%) were part of the study and were tested at baseline (grade 1), in grade 4 and again in grade 7. Of these, 214 (90 boys and 124 girls) were from quintile 1 to 3 schools representing low socio-economic status settings, while 160 participants (88 boys and 72 girls) represented higher socio-economic status settings.

The Test of Gross Motor Development, Second Edition (TGMD-2) was used in 2010 (grade 1) and 2013 (grade 4) to determine object control skills mastery during early and middle childhood (6 and 9-years-old), while the Canadian Assessment of Physical Literacy Obstacle Course (CAPL) was used in 2016 (grade 7) during later childhood (12-years-old) to assess the application of object control skills in an open, dynamic and authentic environment in which 12-year-olds usually have to present their motor proficiency. The 'Statistica for Windows 2017' Statsoft computer program package was used to analyse the data. The group was analysed descriptively by using percentages, frequency distributions, means and standard deviations, while Spearman Rank Order Correlations and stepwise regression analyses were used to analyse associations between object control skills during earlier (6 and 9-years-old) and later (12-years-old) childhood. Gender, socio-economic status and object control skills standard scores (OCS SS) were included in the stepwise regression analyses. At 6 years, a higher overall and large R^2 (32.6%) contribution to the explained variance was found compared to at age 9, during middle childhood (grade 4). Gender contributed to 16.6%, socio-economic status 11.4% and the object control skills standard score to 4.6% of the variance that was found in the CAPL skills score. The object control skills standard score furthermore contributed to 4.5% and gender 3.5% to the overall explained variance of 8.1% in the CAPL time score. Object control skills also contributed to the explained variance in the time completion of the CAPL at age 9 (0.09%; $p > 0.05$). In grade 4, 28.1% of the variance obtained in the CAPL skills score could be accounted for through regression by gender (16.6%: $p > 0.01$) and SES (11.4%: $p > 0.01$), while the OCS SS did not make any contribution to the explained variance. The contribution of gender to the variance in the skills score stayed high in grades 1 and 4 (16.6% in both). Regarding the time score, gender made a similar contribution in grades 1 and 4 (both 3.0%). The significant contribution of socio-economic status confirmed that environment and opportunities play an important role in the mastery and application of object control skills. The importance of mastering object control skills during early childhood is clear from these findings. As both

gender and to a lesser extent socio-economic status also made contributions to the application of object control skills during later childhood, these influences should be addressed to improve early object control skills proficiency.

Chapter 4 was also presented in article format. The title of the article is *The association between motor proficiency and physical fitness during earlier and later childhood in children living in the North-West Province of South Africa*. This article was submitted for consideration for publication to the *Journal of Sports Medicine and Physical Fitness*. The same research design was used as in Chapter 3 although in this chapter the association between motor proficiency and physical fitness mastery during earlier childhood (6 and 9-years-old; grades 1 and 4) and later childhood (12-years-old; grade 7) was investigated.

Two assessment batteries were used to determine motor proficiency during earlier childhood. In grade 1 and grade 4, The Bruininks-Oseretsky Test for Motor-Proficiency, Second Edition Short Form (BOT-2SF) was used to determine general motor proficiency and the Test for Gross Motor Development, Second Edition (TGMD-2) was used to determine proficiency in object control skills. The Progressive Aerobic Cardiovascular Endurance Run (PACER) was used to determine physical fitness levels of the participants in grade 7. To draw associations between motor proficiency and physical fitness during early and later childhood Statistica for Windows (2017) was used to analyse the data descriptively while Spearman Rank Order Correlation and stepwise regression analyses were used to determine the association between motor proficiency and physical fitness during earlier (9 years) and later (12 years) childhood. The contribution of gender, MP, OCS, and SES were analysed and showed that 27.1% of the variance that was found in the PF of the group in grade 7, could be explained by their results at 6 years in grade 1, where gender made a significant contribution of 21.5% to the variance, general motor proficiency an added 4.7% ($p < 0.05$) and object control skills an additional 0.9% ($p < 0.05$, 24.8%). The variance in PF was also associated with gender (21.4%), general motor proficiency (2.8%) and object control skills (0.6%) in grade 4. In separate stepwise analyses for boys and girls, it was found that the contribution of general motor proficiency at age 6 in boys and girls was the same at 12 years (6.2%). However, both MP and OCS were associated with the PF of girls. The contribution to PF in girls of MP and OCS was therefore greater at 12 years (8.6% in girls) vs. 6.2% in boys. The results showing a $R^2 \geq 25\%$, also indicated that the strength of the association between motor proficiency and physical fitness during earlier and later childhood can be interpreted as a large significant effect. Thus, the results confirm that general motor proficiency at a young age is related to physical fitness during later childhood.

5.2 Conclusion

The results as summarized, were used to test the hypotheses of this study. Based on the above results of this study, the following conclusions were drawn.

Hypothesis 1 states that there will be a significant association between OCS mastery during earlier and later childhood in children living in the North West Province of South Africa. The results confirmed a low (4.5%), but significant association between well mastered OCS skills at a young age (6-years-old) with application of these skills during later childhood. The association between OCS proficiency in grade 1 with application of these skills at the age of 12, was higher compared to at the age of 9, as OCS did not enter the stepwise regression at the age of 9 as evidence of a contribution to the skills score at age 12 years. The association of object control skills to the timing score in the CAPL at age 12 also entered significantly in grade 1 (4.6%), but also in grade 4 although on a much lower (0.9%) and non-significant level. Based on these findings of a low, but significant association between early mastery (especially at 6 years) and application of object control skills later in more complex environments, as determined by a skills and times scores test at the ages of 6 and 9, hypothesis 1 is **accepted**.

Hypothesis 2 states that there will be a significant association between motor proficiency and physical fitness during earlier and later childhood in children living in the North West Province of South Africa. General motor proficiency made a significant but a similar contribution to the explained variance in the grade 1, and also the grade 4 analyses, to explain PF in grade 7 (6.2 % respectively in boys and girls in grade 1). The explained variance of motor proficiency in physical fitness in boys and girls was therefore similar in the separate stepwise analyses for boys and girls, while SES also made a contribution to the explained variance, although only at young age and a shorter time period (only until grade 4), and also only in boys. Object control skills mastery again also contributed to the association established between grades 1 (2.4%) and grade 7. Physical fitness in girls which added up to a 8.6% explained variance in girls, which further strengthens the association found between early motor proficiency and later physical fitness in girls. Based on the results of the study, this hypothesis is **accepted**.

Conclusion: General findings

The findings of this study provided valuable information as it is one of only a few studies that longitudinally analysed the association between early object control skills, general motor proficiency and physical fitness during early and later childhood. The findings included results obtained during the early, middle and later childhood years, and to a great extent improved the researchers' understanding of the influences of these phenomena during the childhood years.

The improved knowledge that was obtained through this study should make scientists and health practitioners more attentive about the long term influences and subsequent importance of adequate general motor proficiency, but also well mastered object control skills at a young age. The results confirmed that good motor proficiency and well mastered object control skills during early childhood will contribute to the physical competence of young children. This again, will foster application of these skills in sport-related activities during later childhood while also contributing to improved physical fitness in children at older ages. The findings thereby also confirmed literature indicating that children should be motor proficient at an early age, as they need to generalize different motor proficiency capabilities into sport-specific and specialized skill environments during the childhood years, especially after the age of 7. Proficiency in motor skills at an early age is therefore an important cornerstone to future physical and motor skill development.

Young children should therefore be exposed to opportunities where they can improve their motor proficiency in structured and unstructured environments. Children should furthermore be provided with ample opportunities to play outside and to explore the environment during the early developing years. The learning of motor skills is especially a result of play before the formal school years, but also in the early elementary school grades, as play provide them with the opportunity to learn how their bodies work and about their ability to move. Exposure to structured movement programs are also important to teach young children the fundamental motor skills, especially object control skills that is often more difficult to master than locomotor skills. Our findings also showed that early motor proficiency provide children with more opportunities to refine these abilities and to apply it in sporting environments. This will enable them as they grow older to transfer these motor proficiencies to be used in more complex environments at older ages.

Improved fitness as a result of improved motor proficiency will also benefit children to engage in activities that can improve their activity levels and subsequently their health. Physical activity should therefore incorporate activities that can improve cardiorespiratory fitness while also enhancing motor skills.

The current findings are also informative for practice in the sense that early childhood activities and interventions to enhance object control skills, motor proficiency and physical fitness can be associated with improved execution during later childhood. This may impact positively on engagement in sport activities and sport performance and may also promote a healthier lifestyle and healthy living which is associated with numerous advantages. Practitioners and teachers should therefore pay attention to these associations and make sure that children are provided with the necessary opportunities to improve their motor proficiency and object control skills at a

young age. This will result in promoting an active lifestyle during later childhood which again can result in improved sport participation and improved quality of life to support children who lack proficiency in these areas. In addition, object control skills and motor proficiency skills intervention programmes during early childhood is important.

5.3 Recommendations

The longitudinal nature of the study is regarded as a strength since it enabled an in-depth look into the association of obtaining object control skills proficiency and being motor proficient at a young age and the application of these skills at older ages. The study spanned over seven school years. Notwithstanding that everything possible was done during the conducting and planning of this study to present sound and impeccable scientific findings in an ethically sound and respectful way, limitations associated with the study were found that is acknowledged and should be brought to the attention of the reader. In order to be able to extend the generalization of the results and to enhance future credibility of similar studies, the limitations that were found and possible recommendations on how to avoid future reoccurrence will be the following.

5.3.1 The current study has been restricted to the North West Province of South Africa which is only one of nine provinces of the country. In order to draw more comprehensive generalisations of the findings, the study should be extended to more regions or provinces of South Africa.

5.3.2 A considerable loss of subjects over the study period was found, namely 54.1%. Migration from schools, lack of parental consent or absence on the day of testing was main reasons for this large loss to follow-up of participants over the seven year school period. However, the number of subjects that could be utilized for this study still provided enough power to analyze the data in such a way that it provided valid results. Although this loss of subjects was out of control of the researchers, it is recommended that a larger sample group should initially be included in future similar longitudinal studies to prevent invalid results.

5.3.3 The skills score of the CAPL is not a pure object control skills score, as it also includes assessment of locomotor proficiency which could therefore have influenced the skills and time scores of this assessment and should be taken in consideration when interpreting the results. Against this background, it is acknowledged that it was a limitation to the study that only the object skills subset of the TGMD-2 was used and not the full test battery that also includes a locomotor subset of tests. As this study

was performed within the larger NW-CHILD study, this was out of the researchers' control. Time to complete all the measurements that were part of this overarching longitudinal research project which included many measurements, prevented the research team to fully test the TGMD-2 during the project. The CAPL test also only became available for use after the baseline and first follow-up measurements of the NW-CHILD study were already completed. If the CAPL test is used in future similar studies it is recommended that the TGMD-2 test battery be tested in full.

- 5.3.4 Gender and to a lesser extent socio-economic status played a role in the associations found in this study. Future research is therefore recommended to study these influences in more detail.
- 5.3.5 School status was used as a proxy of SES in this study which had certain limitations. It is recommended that educational background and income of parents should rather be used as indicators of SES.
- 5.3.6 This was a quantitative study and therefore only quantitative data interpretations were made. Future studies may also consider applying a mixed method approach where qualitative explorations can also be added to similar studies in order to enhance mixed method research where participants can reflect on their actual sport participation, success and involvement.
- 5.3.7 This study improved the researchers' understanding of only a few aspects that are associated with children's engagement in physical activity behaviour at older ages, such as motor and object control proficiency at a young age. Future studies are also recommended to improve our understanding of other variances that could not be explained or investigated, but which may have played a role in the associations between object control skills in early and later childhood and motor proficiency and physical fitness during the same time frame.
- 5.3.8 This study was one of only a few longitudinal studies that were performed, especially regarding the role of physical fitness in motor behaviour at an older age. Future studies are therefore recommended in this regard, especially longitudinal studies, since it brings about valuable insights and a better understanding of the impact of early childhood and activities on sport participation and other aspects of healthy living.

5.3.9 The contribution of early motor proficiency and object control skills in later motor proficiency and physical fitness was found to be important in both genders. The influence of early intervention studies to improve later motor proficiency and the studying of transfer effects of such interventions are therefore also recommended. It is recommended that such interventions should target both genders.

This chapter then concludes the study by linking the specific research objectives to what has been achieved. The limitations of the study and recommendations for future research were also provided. The objectives of the study were hereby met.

ANNEXURES

ANNEXURE A:

CAPL

Annexure A: CAPL

The sequence of steps that were followed in this study in completing the CAPL record form is based on the Canadian Assessment of Physical Literacy (Canadian Assessment of Physical Literacy, Healthy Active living and Obesity Research Group, 2013).

The obstacle course (see Figure 1 for the layout of the obstacle course) includes jumping with two feet, sliding, catching a ball, throwing a ball at a target, skipping, hopping on one leg and kicking a ball through cones. Two demonstrations are provided (one slowly performing each skill so that each performance criterion is demonstrated clearly and a second one demonstrating the performance against time). Each participant is then allowed two practice trials followed by two timed trials that are scored. The skill component of the obstacle course score evaluates fundamental movement skills, while the timing component assesses performance of the complete obstacle course against time. Verbal prompts as provided in the protocol should be given and immediate verbal corrections for any mistakes should also be provided. Two scores are obtained namely a time score to the nearest 0.1 seconds and a motor performance score that is recorded by using a checklist where one point is awarded when a criterion is met. A total of 14 marks for the skill were allocated as follows: two feet jumping (two marks), sliding (three marks), catching (one mark, if the participant was able to catch the ball that is thrown to him), throwing (two marks, if the participant threw with an overarm technique and hit the target), skipping (two marks), one foot hopping two marks), kicking (two marks, follow through and kicked through the cones).

Preparation:

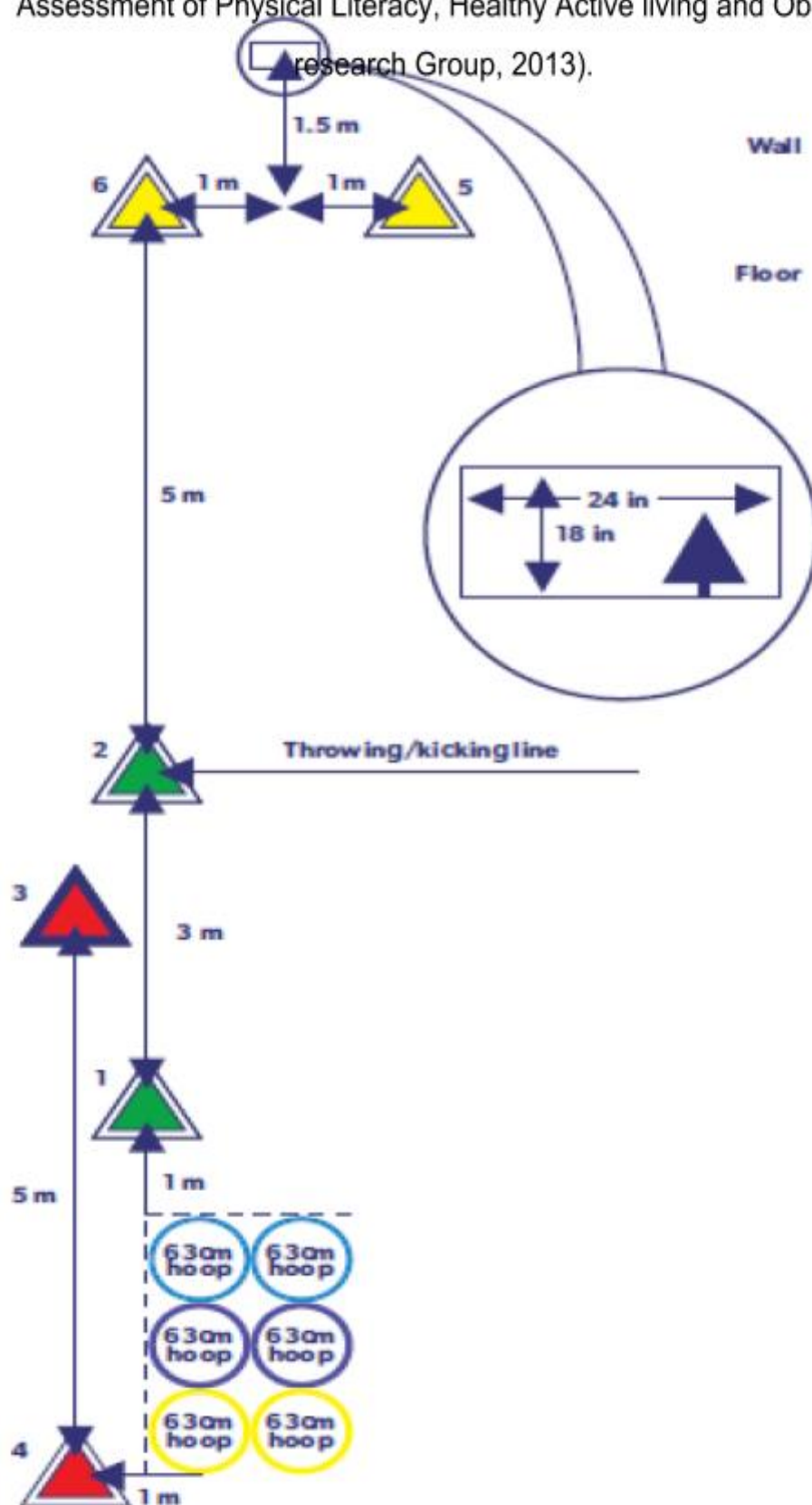
1. Mount the target (60.96cm wide x 45.72cm high cardboard) on the wall, top of the target 1.5m above the floor.
2. Measure 1m to the left and right from the centre of the target and place cones #5 and #6 on the markers.
3. Measure perpendicular to the target wall a distance of 5m from cone #6. Mark and place cone #2 on the marker. Mark the throwing/kicking line (2m) on the floor so it runs parallel to the wall target.
4. From cone #2, measure perpendicular to the target wall a distance of 3m. Mark and place cone #1 on the marker.
5. Measure 1m from cone #1 and mark this spot.
6. Align the left edge of the red hula hoop with the line of the target wall (in line with the cone #1, cone #2 and cone #6).
7. Place the remaining hula hoops in 3 rows of 2 each.

8. Measure 1m from the centre of the left yellow hoop towards the left of the hoop, parallel to the target wall. Mark this spot and place cone #4 on this mark.
9. Measure 5m from cone #4 back towards and perpendicular to the target wall. Mark this position and place cone #3 on this mark.

Instructions for the participants are as follow:

1. Begin standing stationary in front of the right hand side yellow hoop.
2. Complete three two-foot jumps (from the right yellow hoop to the right blue hoop to the right red hoop then out past the red hoop). Run to cone #1 and turn sideways to face the appraiser #1.
3. Slide sideways to cone #2 and touch the cone. Then reverse direction (remain facing the appraiser) to slide back to cone #1 and touch that cone.
4. Start running toward the throwing line, catch the ball as it is thrown by the appraiser, and throw it at any point before the line.
5. Run across the line and around cone #2 to reach the outside of cone #3. Skip from cone #3 to cone #4 before running around the cone #4 and going back to the hoops.
6. After reaching cone #4 and making sure you go around it, you come to the hula hoops and begin 1foot hopping in each hula hoop.
7. After leading in the last hoop, run to the kicking line and kick the ball toward the target.

Canadian Assessment of Physical Literacy Obstacle Course (Canadian Assessment of Physical Literacy, Healthy Active living and Obesity research Group, 2013).



ANNEXURE B:

TGMD 2

Annexure B: TGMD-2

The sequence of steps that were followed in this study in completing the TGMD-2 record form:

1 *Completion of demographic data*

Before administration of the standardized test can take place, all relevant information was entered on the cover of the record form. These include: the child's name, age, gender, address, school and grade; the test taker's name and the test date. The child's chronological age was then worked out.

2 *Point allocation to individual items*

- Precede assessment with an accurate demonstration and verbal request.
- Provide a practice trial to assure that the participant understands what to do.
- Provide one additional demonstration when the participant does not appear to understand that task.
- If participants performed an action correctly, they received a score of one; if they performed it incorrectly, they received a zero.
- Each participant received two attempts to perform each skill.
- The scores of the two attempts were added together.
- The descriptive proficiency ratings for subtest standard scores in the *TGMD–2* manual is indicated as very superior (17–20), superior (15–16), above average (13–14), average (8–12), below average (6–7), poor (4–5), and very poor (1–3).
- The raw scores had to be converted for boys and girls separately.
- The percentiles that had to be used for the object control skills subset, is also different and on different tables.

3 *Completing the qualitative data of each motor activity*

Observations of the child's behaviour during the evaluation had to be made by the researcher. Particular attention had to be paid to how the child approaches the activities and how the child responds to success and failure.

ANNEXURE C:
BOT 2 SF

Annexure C: BOT-2 SF

1 *Completion of demographic data*

Before administration of the standardized test could take place, all relevant information was entered on the cover of the record form. These included: the child's name, age, gender, address, school and grade; the test taker's name; subject number; and the test date. Then the child's chronological age had to be worked out. The BOT-2SF evaluates motor skills in four area components and consists of the following: Fine motor skills (divided into fine motor precision and fine motor integration); hand coordination (divided into hand agility and upper limb coordination); body coordination (divided into bilateral coordination and balance); and the strength and agility component (divided into running speed, agility and strength). The BOT-2SF, which is validated against the full version and consists of 14 items, together with sections of the complete version (Subtest 6 - running speed and agility; Subtest 8 - Strength) was used to evaluate the MP skills.

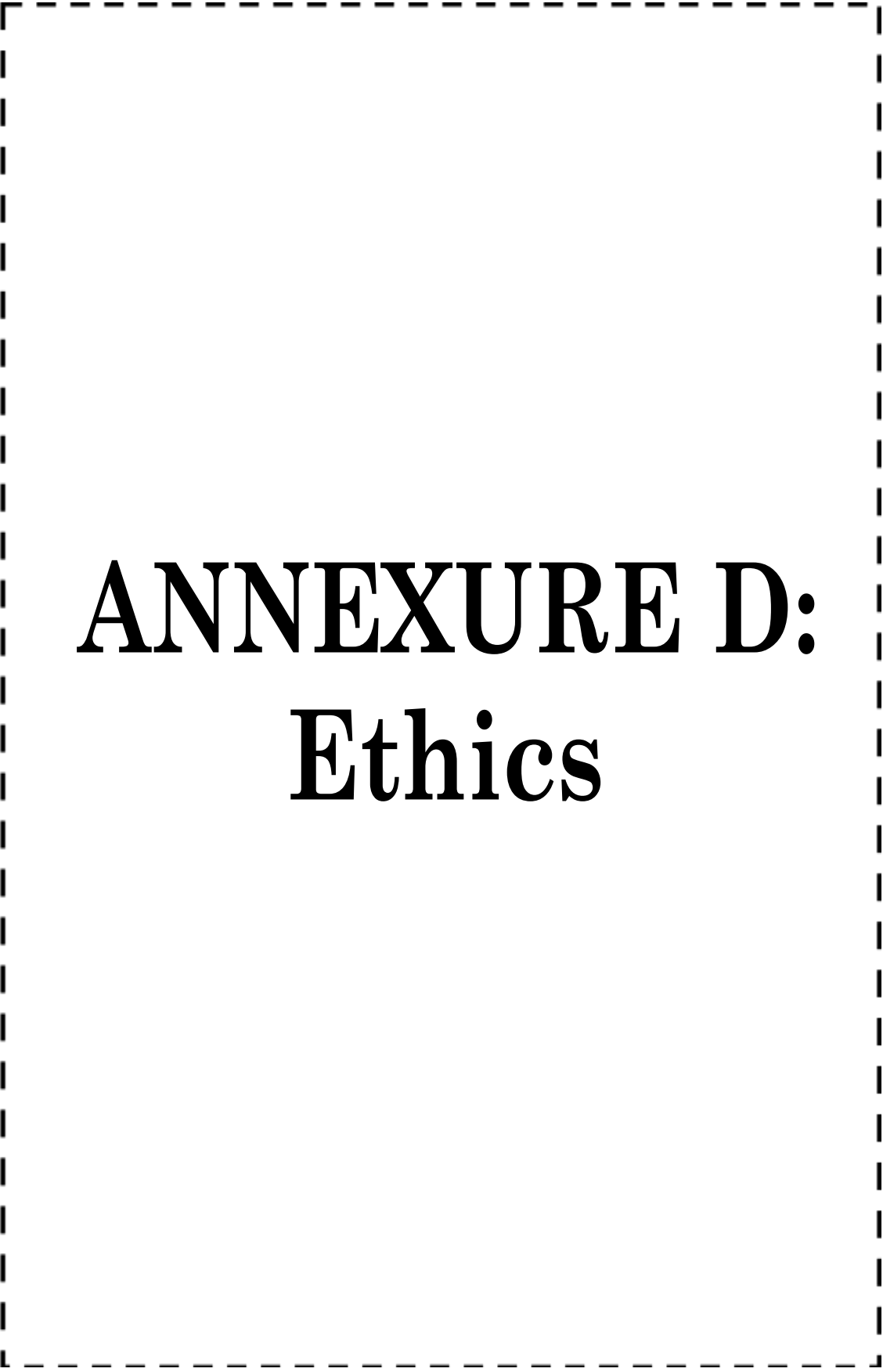
2 *Point allocation to individual items*

Each item was scored on a graded scale that was constructed to span the widest possible range of performance.

- After recording the raw score for each item, the raw score had to be converted into a point score.
- The point score is a type of standard score and enables the researcher to evaluate the performance on a graded scale.
- To find the point score for an item, the raw to point score conversion table was used that corresponds to that item, located just to the right of the raw score column. In the row labelled "raw", the range corresponding to the examinee's raw score was then located.
- The higher of the two raw scores was converted.
- On all the subtests, the subtest total point score was obtained by adding the point score of the individual items that make up the subtests.

3 *Completing the qualitative data of each motor activity*

The researcher had to observe the child's behaviour during the evaluation. It was important to pay attention to how the child approached the activities and how the child responded to success and failure.



ANNEXURE D:

Ethics

PARTICIPANT INFORMATION LEAFLET AND PARENTAL PERMISSION FORM FOR 12 TO 13-YEAR OLD PRIMARY SCHOOL CHILDREN IN THE NORTH-WEST PROVINCE

TITLE OF THE RESEARCH PROJECT:

A longitudinal analysis of health risk factors, growth and development among 7-13-year-old children: NW-CHILD study. ETHICS NUMBER: NWU-00070-09-A1

PRINCIPAL INVESTIGATOR:

Prof Anita Pienaar

ADDRESS:

North-West University
Faculty of Health Sciences
Private bag X6001
Potchefstroom
2520

CONTACT NUMBER:

(018) 299 1796

Your child is invited to take part in the final measurements of the on-going research project, namely the NW-CHILD Study, A longitudinal analysis of health risk factors, growth and development among 7-13-year-old children. You have already consented for your child to be part of this NW-CHILD longitudinal study that started in 2010 when he or she were in grade 1 but we need your on-going/re-consent due to the ongoing nature of the research. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how your child will be involved. Also, your child's participation is entirely voluntary and he/she is free to decline to participate. If you say no, this will not affect your child's negatively in any way whatsoever. Your child is also free to withdraw from the study at any point, even if he/she initially agrees to take part.

This study has been approved by the **Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (NWU-00070-09-A1)** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki and the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.

➤ **What is this research study all about?**

- This final part of this study will be conducted again in the 20 primary schools that were selected randomly for the study in the North-West Province of South Africa in 2010 and will involve measurements that will determine the on-going effects of health risk factors over a period of 6 years in 7-13 year old children. It will be investigated *by experienced health researchers trained* in Kinderkinetics. 675 participants will be included in this final measurement of the study.
- The main objectives of this study were to determine the prevalence of and the relationship between health and developmental risk factors such as overweight and obesity, blood pressure, underweight, sport skills, motor proficiency and physical activity and fitness barriers identified among 7-year-old children, 3-years later at the age of 10-years, and again 7 years later at the age of 12-13-years.
- The long term effects that the above health risk factors will have on children's physical activity behaviour and scholastic success will be determined but more importantly strategies will be developed to improve identified health enhancing, sport promoting and academic restricting factors that influence the quality of life and optimal development of 6- to 13-year-old children. The following measurements will be taken to evaluate these risk factors: Growth measurements that will be taken in a private area will include weight, height, three skinfolds, one on the back of the arm, one on the back under the shoulder blade and one on the lower leg (calf), and upper arm and waist circumference. Blood pressure and physical activity and nutrition questionnaires will be completed in the school hall while motor proficiency and physical fitness testing will be done in a classroom or on the sports grounds of the school. Perceptual-motor proficiency and physical fitness status will be measured by using different field tests such as balancing on one leg, catching, kicking or dribbling a ball, or running a specified distance.

➤ **Why have your child been invited to participate?**

- Your child has been invited to participate because he/she is attending a school in the North-West province where the research is going to be conducted and you have already

consented for your child to be part of this NW-CHILD on-going study that started in 2010 when he or she were in grade 1 or grade 4 during the first follow up measurements.

➤ **Your child have also complied with the following inclusion criteria:**

Your child was part of the study in 2010 and or in 2013 and because this study is based on follow-up measurements your child is now invited to participate again in the final measurements.

- Your child will be excluded from the study if he or she cannot move in a normal manner because of any physical problems which might be a barrier for him/her to do his/her best. He/she will also be withdrawn from the study in the instance of injury or illness.
- Your child will be excluded if you do not submit his/her informed consent form before the testing procedures commence.

➤ **What will your child's responsibilities be?**

- It will be expected of your child to participate in all the measurements of the study. The measurements will be done during school hours on one morning and time as approved and arranged by the headmaster. The testing will start at 8:00 in the morning until all testing are completed which can take the whole morning, but your child will be send back to his/her class as soon as he/she is finished. Your child will be allowed to have his/her lunch box from home during the official break times of the school.

➤ **Will your child benefit from taking part in this research?**

- The direct benefits to the child will be that the school will receive feedback with regard to the testing of each of the children in the form of guidelines, which you will be able to obtain from the school.
- If you are interested, we can supply you with your child's testing information on request.

➤ **Are there risks involved in taking part in this research?**

- The risks in this study are minimal, such as a short disruption of class time to measure the child's health and movement status. Teachers are aware of the measurements that will take place and they will make sure that your child receives the necessary learning materials that they have missed during the measurements.
- The measurements that the child will be involved in are not dangerous and are easy to perform and children normally enjoy taking part in this kind of testing.
- I am one of the Faculty of Health Sciences' established and skilled health researchers with significant experience in conducting research in the community.
- All the researchers that are involved in this research are also trained to work with children and will be able to adapt to the developmental needs of the children.

The benefits outweighs the risk

- We consider the benefits of becoming involved in this research, to outweigh the risks, which is minimal, such as a short disruption of class time, which justifies the research project. The direct benefits to a child are that his/her results can be made available to him/her that can be used to show them their strengths or to improve their shortcomings. The indirect benefits of this research are that it will provide researchers with knowledge to develop strategies to minimize health risks that can influence the health and well-being of children negatively.

➤ What will happen in the unlikely event of some form of discomfort occurring as a direct result of your child taking part in this research study?

No risks or harm are anticipated as a result of this research. However, if your child brings it to the attention of the researchers' that he or she has some form of discomfort, such as tiredness we will immediately try to solve the problem or ask a teacher to assist us in solving the problem. If the language of your child presents a problem for him/her to understand the instructions, a translator or a teacher will assist the researcher to explain the instructions to your child.

- Should you have the need for further discussions after the data collection an opportunity will be arranged for you to speak to me about your child's results or to contact me in person at the included contact details.

➤ Who will have access to the data?

We assure you that only the researchers will have access to the information that will be obtained from your child, and we assure you of the confidentiality of all the information that are obtained from your child who will only be identified by a subject number. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected.

What will happen with the data/samples?

- This is an on-going study that will end in 2016 and the collected data will be transferred and stored on a computer at the Potchefstroom Campus of the North-West University from where it will be analysed by the researchers. The results will be published in the form of post graduate studies and in scientific articles. The hard copies of the data will be destroyed after seven years by means of a paper shredder. We request that we can use the data of your child in future studies that are planned for post graduate studies.

Will your child be paid to take part in this study and are there any costs involved?

No remuneration or costs will be involved in the project. Children will receive a snack on the day of testing as a sign of gratitude for their participation.

Is there anything else that you should know or do?

- You can contact **Prof Anita Pienaar** at **(018) 299 1796** if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2089; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

The school will receive feedback with regard to the testing of each of the children in the form of guidelines, which you will be able to obtain from the school. You may also attend the testing, if you want to.

Declaration by parent/legal guardian

By signing below, I agree for my son/daughter to take part in a research study entitled: “A longitudinal analysis of health risk factors, growth and development among 7-13 year old children.”

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and that my child has not been pressurised to take part.
- My child may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- My child may be asked to leave the study before it has finished, if the researcher feels it is in his or her best interests, or if he or she does not follow the study plan, as agreed to.

Signed at (*place*) on (*date*) 20....

Signature of parent/legal guardian Signature of witness

➤ **Declaration by person obtaining consent**

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) on (*date*) 20....

Signature of person obtaining consent Signature of witness

➤ **Declaration by researcher**

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) on (*date*) 20....

Signature of researcher

Signature of witness

PARTICIPANT INFORMATION LEAFLET AND ADOLESCENT ASSENT FORM FOR 12 TO 13-YEAR OLD PRIMARY SCHOOL CHILDREN IN THE NORTH-WEST PROVINCE

TITLE OF THE RESEARCH PROJECT:

A longitudinal analysis of health risk factors, growth and development among 7-13-year-old children: NW-CHILD study.

REFERENCE NUMBERS:

NWU-00070-09-A1

PRINCIPAL INVESTIGATOR:

Prof Anita Pienaar

ADDRESS:

North-West University
Faculty of Health Sciences
Private bag X6001
Potchefstroom
2520

CONTACT NUMBER:

(018) 299 1796

You are invited to take part in the final measurements of the on-going research project, namely the NW-CHILD Study, A longitudinal analysis of health risk factors, growth and development among 7-13-year-old children. You have already agreed through your parents to be part of this NW-CHILD longitudinal study that started in 2010 when you were in grade 1 and you also participated when you were in grade 4 but we need your on-going permission due to the nature of the research to participate in the final measurements that will take place today. Please ask your parent or the researcher any questions about any part of this project that you do not fully understand. It is very important that you are sure that you clearly understand what this research entails and how you will be involved. Also, your participation is entirely your own decision and you are free to decline to participate. If you say no, this will not affect you negatively in any way

whatsoever. You are also free to withdraw from the study at any point, even if you initially agree to take part.

This study has been looked at by a **Committee at the North-West University (NWU-00070-09-A1) which made sure that the study** will be conducted according to guidelines which will respect you as a child. This ethics committee can also inspect the research records to make sure that we adhere to these principles.

➤ **What is this research study all about?**

- This is the final part of this study and children of the same age as you in 20 primary schools in the North-West Province participated in the study since they were in grade 1. We are interested as researchers in factors that can have a negative influence on the health and well-being of children and we want to come up with solutions to improve the health of children. In order to be able to do so we need measurements of the same child at different ages. An example is to see how your length and body mass increased from grade 1 to grade 7 and in what kind of physical activities you choose to participate at different ages. All the measurements will be done by experienced health researchers trained in Kinderkinetics. 675 children from 20 different primary schools who were already part of the study in their grade 1 and or grade 4 years will be invited to take part in this final measurements of the study.
- We as researchers know little about the health status of children in primary schools in South Africa, therefore the main reasons of this study are to get more knowledge about the status and prevalence of and the relationship between health and developmental risk factors such as overweight, blood pressure, sport skills, motor proficiency, physical activity and fitness barriers identified among 7-year-old children, 3 years later at the age of 10- years, and again 3-years later at the age of 12-13 years. You can help as to achieve these goals if you agree to participate in the measurements.
- Once we have obtained the measurements we can use the results to see what we can do to improve children's health and sport readiness as we will have a better understanding of things that need to be changed, especially at different ages. We can then make plans to help children to become more active, while we can also give parents and teachers guidance on how to help children to be more active. The following measurements will be taken to evaluate the risk factors that we are interested in: Growth measurements that will be taken in a private area that will include, height, weight, three skinfolds, one on the back of the arm, one on the back under the shoulder blade and one on the lower leg (calf), and upper arm and waist circumferences. Blood pressure will

be taken and physical activity and nutrition questionnaires will be completed in the school hall while motor proficiency and physical fitness testing will be done in a classroom or on the sports fields of the school. Perceptual-motor proficiency and physical fitness status will be measured in the school hall or on the sports field by using different field tests such as balancing on one leg, catching, kicking or dribbling a ball, or running a specified distance.

➤ **Why have you been invited to participate?**

- You have been invited to participate in the measurements because you are attending one of the 20 primary schools in the North-West province where the research is going to be conducted.
- **You have also complied with the following inclusion criteria:**
- You were part of the study in 2010 and or in 2013 and because this study is based on follow-up measurements that are taken on the same child as he or she gets older you are now invited to participate again in this final measurements that will take place today. Your parent gave parental permission for us to invite you to participate in the measurements today.
- You will be withdrawn from the study if you cannot move in a normal manner because of any physical problems which might be a barrier for you to do your best. You will also be withdrawn from the study in the instance of injury or illness.
- You will be excluded if you do not submit your parental permission consent form before the testing procedures commence.

➤ **What will your responsibilities be?**

- It will be expected of you to participate in the measurements and activities that are appropriate for your age group on the day that the research team visits or school. The measurements will be done during school hours on one morning and time as approved and arranged by your headmaster. The testing will start at 8:00 in the morning until all testing are completed which can take the whole morning, but you will be send back to your class as soon as you are finished with all the measurements. You will be allowed to have your lunch box from home during the official break times of the school.

➤ **Will you benefit from taking part in this research?**

- Your school will receive feedback with regard to the test results of each of the children in the form of guidelines, which they can use to help other children and your parent will also be able to obtain it from the school.

- If you are interested, we can supply you with your personal test information on request, which you can then use as you would like, for instance to improve your sport performance. Your parent is also free to contact us for more information on your test results.

➤ **Are there risks involved in your taking part in this research?**

- The risks in this study are minimal, such as a short disruption of your class time. Teachers are however aware of the measurements that will take place and they will make sure that you receive the necessary learning materials that you have missed during the measurements.
- The measurements that you will be involved in are not dangerous and are easy to perform and children normally enjoy taking part in this kind of testing. If you are injured in any way although the possibility is slight, the researchers are trained to assist you immediately with first aid procedures.
- I am a skilled health researcher with significant experience in conducting research in the community and especially with children.
- All the researchers that are involved in this research are also trained to work with children and will be able to adapt to the any of your needs on the testing day.

The benefits outweighs the risk

- We consider that the benefits of becoming involved in this research are more than the risks, which is minimal, such as a short disruption of class time, which justifies the research project. The direct benefits to you are that these results can be made available to you which can be used to show your strengths or to improve your shortcomings. The indirect benefits of this research are that it will provide researchers with knowledge to develop strategies to minimize health risks that can influence the health and well-being of children negatively.

➤ **What will happen in the unlikely event of some form of discomfort occurring as a direct result of you taking part in this research study?**

No risks or harm are anticipated as a result of this research. However, if you brings it to the attention of the researchers' that you have some form of discomfort, such as tiredness or a slight injury we will immediately try to solve the problem or ask a teacher to assist you with solving the problem.

If the language presents a problem for you to understand the instructions, a translator or a teacher will assist the researcher to explain the instructions to you.

- *Should you have the need for further discussions after the data collection an opportunity will be arranged for you to speak to me about your results or to contact me in person at the included contact details*

➤ **Who will have access to the data?**

We assure you that only the researchers will have access to the information that will be obtained from you, and we assure you of the confidentiality of all the information that are obtained from you. You will only be identified by a subject number. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected.

What will happen with the data/samples?

- This is an on-going study that will end in 2016 and the collected data will be transferred and stored on a computer at the Potchefstroom Campus of the North-West University from where it will be studied by the researchers. Your school will receive guidelines based on the results, and your parent may request an interpretation of your results. The results will be published in the form of post graduate studies of university students and as articles that are read by researchers. The hard copies of the data will be destroyed after seven years by means of a paper shredder. We want to request you that we may use your data in on-going studies of researchers.

Will you be paid to take part in this study and are there any costs involved?

You will not have to pay to be involved in the project or receive any payment for your participation but a snack and water will be given to you on the day of testing as a sign of our gratitude for your participation.

Is there anything else that you should know or do?

- Your parent can contact **Prof Anita Pienaar** at **(018) 299 1796** if you have any further queries or encounter any problems.
- Your parent can also contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2089; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

The school will receive feedback with regard to the testing of each of the children in the form of guidelines, which your parent will be able to obtain from the school.

Declaration by the participant

By signing below, I agree to take part in a research study entitled: "A longitudinal analysis of health risk factors, growth and development among 7-13-year old children."

I declare that:

- I have read this information and permission form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to my parent and the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary (my own decision) and that nobody forced me to do so.
- I may choose to leave the study at any time and will not be penalised or discriminate against in any way.
- I may be asked to leave the study before it is finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (place) on (date) 20....

Signature of child Signature of witness

➤ Declaration by person obtaining consent

I (name) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.
- I asked permission to take photos during the measurements.

Signed at (place) on (date) 20....

Signature of person obtaining consent Signature of witness

➤ **Declaration by researcher**

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) on (*date*) 20....

Signature of researcher

Signature of witness

14 Maart 2016

NAVORSINGSPROJEK – Omgewingsinvloede en gesondheidsrisikofaktore se effek op die Gesondheid, Sport en Akademiese vordering van kinders woonagtig in die NW provinsie van SA ‘n 6-jaar opvolgondersoek

Hierdie navorsingsprojek is goedgekeur deur die Departement van Basiese Onderwys sowel as die Etiese komitee van die Noordwes-Universiteit, Potchefstroomkampus (NWU_00070-09-A1). Toestemming is ook by u skoolhoof verkry om voort te gaan met die navorsing.

U kind is deel van die groep wat geselekteer is om aan bogenoemde navorsingsprojek deel te neem, en het reeds die eerste metings in sy/haar graad 1 jaar in 2010 ondergaan. Die navorsingsprojek behels drie opvolgmetings op u kind oor die tydperk van sy/haar laerskooljare (graad 1, 2010), 2013 en in 2016).

Die doel van hierdie navorsingsprojek is:

om inligting te bekom oor laerskoolkinders se groei en liggaamsamestelling, perseptueel-motoriese, fisieke, visuele vermoëns, akademiese vordering, basiese sportvaardighede en fiksheid ten einde 'n profiel te kan daarstel van hierdie eienskappe van kinders woonagtig in die NW provinsie van SA, *maar meer* belangrik ook om strategieë te kan ontwikkel ter verbetering van geïdentifiseerde gesondheidsbevorderende, sportbevorderende en akademiese belemmerende faktore wat kinders tussen die ouderdom van 6 en 13 jaar se lewenskwaliteit en verdere ontwikkeling kan belemmer.

Alle toetsings en metings sal deur gekwalifiseerde navorsers uitgevoer word, is veilig om aan deel te neem, is ouderdomgepas en verg min inspanning van die kind. Elke kind wat aan die studie deelneem word anoniem hanteer en kan sleg deur 'n proefpersoonnommer geïdentifiseer word.

Deur u kind tydens hierdie opvolgmeting weer aan die bogenoemde navorsingsprojek te laat deelneem, kan dit nie net vir u kind tot voordeel wees nie, maar ook vir ouers, onderwysers en ander kundiges, inligting verleen wat gebruik kan word om belemmerende faktore in kinders se ontwikkeling vroegtydig te identifiseer, maar ook kinders van hierdie ouderdom se ontwikkeling te optimaliseer. Ons vra dus dat u dit sterk sal oorweeg om hom/haar weer te laat deelneem

aan die navorsing. U is uiteraard geregtig om u kind op enige stadium, sonder enige verduideliking, te onttrek van die studie. Terugvoering sal aan u kind se skool gegee word nadat alle toetsings wat op een oggend tydens skoolure, soos gereël met die skoolhoof sal geskied, afgehandel en die inligting verwerk is. Vind asseblief aan die agterkant van hierdie brief 'n vorm wat u asseblief moet teken en die volgende dag aan die skool moet terugbesorg. U kan enige tyd insae in die resultate van u kind vra. Vir enige verdere inligting oor die projek, is u welkom om my persoonlik te kontak by onderstaande kontakgegevens.

Prof. A.E. Pienaar Projekleier

(Skool vir Biokinetika, Rekreasie en Sportwetenskap)

(018) 299 1796 (W)

Stuur asseblief hierdie vorm die VOLGENDE DAG terug skool toe, hetsy dit ingevul is al dan nie.

Ek as ouer verstaan dat ek onder geen verpligting is om my kind aan die navorsingsprojek te laat deelneem nie. Ek verstaan dat daar geen skade aan my kind berokken gaan word, hetsy fisies of geestelik nie. Ek verstaan ook dat daar geen kostes verbonde is aan die evaluering nie en dat dit ook nie sal inmeng met my kind se skoolaktiwiteite nie.

Hiermee gee ek _____

ouer/wettige voog van _____ (Kind

se volle name en van)

_____ (Geboortedatum) toestemming dat hy/sy aan die navorsingsprojek mag deelneem.

Handtekening

Datum

14 March 2016

RESEARCH PROJECT – The effect of environmental influences and health risk factors on the Health, Sport and Academic progress of children living in the North-West Province of South Africa: A 6-year follow-up study

This study has the approval of the Department of Basic Education as well as the Ethical Committee of the North-West University, Potchefstroom Campus (NWU_00070-09-A1). Permission has also been obtained from your school principal to proceed with this research.

Your child is part of a group that has been selected to participate in this research project in 2013. The research project comprises three follow-up testing sessions over the course of the primary school years (grade 1, 2010, 2013 and in 2016).

The aim of the research project is:

to obtain information on the growth and body composition, perceptual-motor, physical, visual abilities, academic progress, basic sport skills and fitness of primary school children in the North-West Province of South Africa, but *more important* to develop strategies to improve identified health enhancing, sport promoting and academic restricting factors that influence the quality of life and optimal development of 6- to 13-year old children.

All tests and measurements will be performed by qualified researchers, is safe to participate in, age appropriate and is not taxing to the child. Each child that participates in the study will be anonymous and will be only identifiable by a test subject number.

By allowing your child to participate in this testing in the abovementioned research project, it will not only be advantageous to your child, but also for parents, teachers and other specialists, as it will not only provide information that can be used to early identify restrictive factors in children's development, but also to aid in the optimal development of children of this age. We therefore request that you strongly consider allowing your child to participate in this study. You, however, have the right to withdraw your child from the study at any stage, without any explanation. Feedback will be given to your child's school principal after completion of the testing and after all the results have been analysed. Testing will occur one morning during school hours, as arranged with the school principal. The test results of your child will be available for your perusal at any time, on request. For any further information on the project, please feel free to contact

me on the details below. Please find at the back of this page a form that you have to complete and send back to the school as soon as possible.

Prof. Anita E. Pienaar

Project leader

(School of Biokinetics, Recreation and Sport Science)

(018) 299 1796 (W)



NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOMKAMPUS

Please send this form back to school the NEXT DAY, whether it is completed or not.

I, as parent, understand that I am under no obligation to allow my child to participate in this research project. I understand that no harm will come to my child, either physically or mentally. I also understand that there are no costs involved in the evaluation and that these tests will not interfere with my child's school activities.

I _____ parent/legal
guardian

of _____ (child's full name and
surname) _____ (Date of Birth) hereby give permission for
him/her to

participate in the research project.

Signature

Date

Please send this form back to school the NEXT DAY.

I, as the parent understand that I am under no obligation to let my child participate in this research project. I understand that my child would not be harmed in any way, physically or spiritually. I understand that there would be no costs involved in the evaluation and that the programme will not interfere with my child's school work.

Hereby I _____parent/
legal

caregiver of _____(full name of
child)

_____(Date of birth) give permission that he/she may participate in
the research project.

Signature

Date

ANNEXURE E:
Journal of
Perceptual
and Motor
Skills
guidelines

Annexure E: Journal of Perceptual and Motor Skills submission guidelines

Preparing your manuscript

Formatting your article

When formatting your references, please ensure you check the reference style followed by your chosen journal. Here are quick links to the [SAGE Harvard](#) reference style, the [SAGE Vancouver](#) reference style and the [APA](#) reference style.

Other styles available for certain journals are: [ACS Style Guide](#), [AMA Manual of Style](#), [ASA Style Guide](#), [Chicago Manual of Style](#) and [CSE Manual for Authors, Editors, and Societies](#).

Please refer to [your journals' manuscript submission guidelines](#) to confirm which reference style it conforms to and for other specific requirements.

Equations should to be submitted using Office Math ML and Math type.

Word template and guidelines

Our tailored [Word template](#) and [guidelines](#) will help you format and structure your article, with useful general advice and Word tips.

(La)TeX guidelines

We welcome submissions of LaTeX files. Please download the [SAGE LaTeX Template](#), which contains comprehensive guidelines.

If you have used any .bib files when creating your article, please include these with your submission so that we can generate the reference list and citations in the journal-specific style. Review our [LaTeX Frequently Asked Questions](#). If you still need additional help, please email SageTeXsupport@sagepub.com

Artwork guidelines

Illustrations, pictures and graphs, should be supplied with the highest quality and in an electronic format that helps us to publish your article in the best way possible. Please follow the guidelines below to enable us to prepare your artwork for the printed issue as well as the online version.

- **Format:** TIFF, JPEG: Common format for pictures (containing no text or graphs).
EPS: Preferred format for graphs and line art (retains quality when enlarging/zooming in).
- **Placement:** Figures/charts and tables created in MS Word should be included in the main text rather than at the end of the document.
Figures and other files created outside Word (i.e. Excel, PowerPoint, JPG, TIFF, EPS, and PDF) should be submitted separately. Please add a placeholder note in the running text (i.e. "[insert Figure 1.]")

- **Resolution:** Rasterized based files (i.e. with .tiff or .jpeg extension) require a resolution of at least **300 dpi** (dots per inch). Line art should be supplied with a minimum resolution of **800 dpi**.
- **Colour:** Please note that images supplied in colour will be published in colour online and black and white in print (unless otherwise arranged). Therefore, it is important that you supply images that are comprehensible in black and white as well (i.e. by using colour with a distinctive pattern or dotted lines). The captions should reflect this by **not** using words indicating colour.
- **Dimension:** Check that the artworks supplied match or exceed the dimensions of the journal. Images **cannot** be scaled up after origination
- **Fonts:** The lettering used in the artwork should not vary too much in size and type (usually sans serif font as a default).

Image Integrity

Figures should be minimally processed and should reflect the integrity of the original data in the image. Adjustments to images in brightness, contrast, or color balance should be applied equally to the entire image, provided they do not distort any data in the figure, including the background. Selective adjustments and touch-up tools used on portions of a figure are not appropriate. Images should not be layered or combined into a single image unless it is stated that the figure is a product of time-averaged data. All adjustments to image data should be clearly disclosed in the figure legend. Images may be additionally screened to confirm faithfulness to the original data. Authors should be able to supply raw image data upon request. Authors should also list tools and software used to collect image data and should document settings and manipulations in the Methods section.

English language editing services

Authors seeking assistance with English language editing, translation, or figure and manuscript formatting to fit the journal's specifications should consider using SAGE Language Services. Visit [SAGE Language Services](#) on our Journal Author Gateway for further information.

ANNEXURE F:
Journal of
Perceptual
and Motor
Skills
submission

Annexure F: Journal of Perceptual and Motor Skills submission confirmation

Perceptual and Motor Skills <onbehalf@manuscriptcentral.com>

Sun, Nov 4, 2018, 8:02 PM



to anita.pienaar, me, 20376138 ▾

04-Nov-2018

Dear Miss Gericke:

Your manuscript entitled "The Association between Object Control Skills Mastery during Earlier and Later Childhood Longitudinal Data from the NW-CHILD Study" has been successfully submitted online and is presently being given full consideration for publication in Perceptual and Motor Skills.

Your manuscript ID is PMS-18-0403.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to ScholarOne Manuscripts at <https://mc.manuscriptcentral.com/pms> and edit your user information as appropriate.

You can also view the status of your manuscript at any time by checking your Author Center after logging in to <https://mc.manuscriptcentral.com/pms>.

As part of our commitment to ensuring an ethical, transparent and fair peer review process SAGE is a supporting member of ORCID, the Open Researcher and Contributor ID (<https://orcid.org/>). We encourage all authors and co-authors to use ORCID iDs during the peer review process. If you already have an ORCID iD you can link this to your account in ScholarOne just by logging in and editing your account information. If you do not already have an ORCID iD you may login to your ScholarOne account to create your unique identifier and automatically add it to your profile.

Thank you for submitting your manuscript to Perceptual and Motor Skills.

Sincerely,
Perceptual and Motor Skills Editorial Office

ANNEXURE G:
Journal of
Sports Medicine and
Physical
Fitness
guidelines

Annexure G: Journal of Sports Medicine and Physical Fitness submission guidelines

The Journal of Sports Medicine and Physical Fitness publishes scientific papers relating to the area of the applied physiology, preventive medicine, sports medicine and traumatology, sports psychology. Manuscripts may be submitted in the form of editorials, original articles, review articles, case reports, special articles, letters to the Editor and guidelines.

Manuscripts are expected to comply with the instructions to authors which conform to the Uniform Requirements for Manuscripts Submitted to Biomedical Editors by the International Committee of Medical Journal Editors (<http://www.icmje.org>).

Articles not conforming to international standards will not be considered for acceptance.

Submission of manuscripts Papers should be submitted directly to the online Editorial Office at the Edizioni Minerva Medica website: <http://www.minervamedicaonlinesubmission.it>

Authors are requested to choose a corresponding author delegated to communicate with the journal during the manuscript submission, peer review and publication process. Although for technical and organizational reasons the corresponding author has primary responsibility for correspondence with the journal, copies of the most significant correspondence will be sent to all listed authors.

Duplicate or multiple publication Submission of the manuscript means that the paper is original and has not yet been totally or partially published, is not currently under evaluation elsewhere, and, if accepted, will not be published elsewhere either wholly or in part.

Splitting the data concerning one study in more than one publication could be acceptable if authors justify the choice with good reasons both in the cover letter and in the manuscript. Authors should state what new scientific contribution is contained in their manuscript compared to any previously published article derived from the same study. Relevant previously published articles should be included in the cover letter of the currently submitted article.

Permissions to reproduce previously published material Material (such as illustrations) taken from other publications must be accompanied by the publisher's permission.

Copyright The Authors agree to transfer the ownership of copyright to The Journal of Sports Medicine and Physical Fitness in the event the manuscript is published.

Ethics committee approval All articles dealing with original human or animal data must include a statement on ethics approval at the beginning of the methods section, clearly indicating that the study has been approved by the ethics committee. This paragraph must contain the following information: the identification details of the ethics committee; the name of the chairperson of the ethics committee; the protocol number that was attributed by the ethics committee and the date of approval by the ethics committee.

The journal adheres to the principles set forth in the Helsinki Declaration (<http://www.wma.net/en/30publications/10policies/b3/index.html>) and states that all reported research concerning human beings should be conducted in accordance with such principles. The journal also adheres to the International Association of Veterinary Editors' Consensus Author Guidelines on Animal Ethics and Welfare (<http://www.veteditors.org/consensus-author-guidelines-on-animal-ethics-and-welfare-for-editors>) and requires that all research on animals be conducted in accordance with these principles.

Patient consent Authors should include at the beginning of the methods section of their manuscript a statement clearly indicating that patients have given their informed consent for participation in the research study. Every precaution must be taken to protect the privacy of patients. Authors should obtain permission from the patients for the publication of photographs or other material that might identify them. If necessary a copy of such permission may be requested.

Conflicts of interest Authors must disclose possible conflicts of interest including financial agreements or consultant relationships with organizations involved in the research. All conflicts of interest must be declared both in the authors' statement form and in the manuscript file. If there is no conflict of interest, this should also be explicitly

stated as none declared. All sources of funding should be acknowledged in the manuscript.

Authorship and contributorship All persons and organizations that have participated to the study must be listed in the byline of the article (authors) or in the notes (contributors). The manuscript should be approved by all co-authors, if any, as well as, tacitly or explicitly, by the responsible authorities of the institution where the work was carried out. Authors and contributors must meet the criteria for authorship and contributorship established by the Uniform Requirements for Manuscripts Submitted to Biomedical Editors by the International Committee of Medical Journal Editors (<http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html>).

Authors' statement Papers must be accompanied by the authors' statement (<http://www.minervamedica.it/en/journals/sports-med-physical-fitness/index.php>) relative to copyright, originality, authorship, ethics and conflicts of interest, signed by all authors.

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Publication of manuscripts is free of charge. Colour figures, linguistic revision, and excessive alterations to proofs will be charged to the authors. Authors will receive instructions on how to order reprints and a copy of the manuscript in PDF.

For further information about publication terms please contact the Editorial Office of The Journal of Sports Medicine and Physical Fitness, Edizioni Minerva Medica, Corso Bramante 83-85, 10126 Torino, Italy - Phone +39-011-678282 - Fax +39-011-674502

E-mail: journals6.dept@minervamedica.it.

ARTICLE TYPES

Instructions for the most frequent types of articles submitted to the journal.

Editorials. Commissioned by the Editor in Chief or the Managing Editor, editorials deal with a subject of topical interest about which the author expresses his/her personal opinion. The text must not be subdivided. No more than 1000 words (3 typed, double-spaced pages) and up to 15 references will be accepted.

Original articles. These should be original contributions to the subject. The text should be 3000-5500 words (8 to 16 typed, double-spaced pages) not including references, tables, figures. No more than 50 references will be accepted. The article must be subdivided into the following sections: introduction, materials (patients) and methods, results, discussion, conclusions. The introduction should describe the theoretical background, the aim of the study and the hypothesis to be tested. The materials and methods section should describe in a logical sequence how the study was designed and carried out, how the data were analyzed (what hypothesis was tested, what type of study was carried out, how randomization was done, how the subjects were recruited and chosen, provide accurate details of the main features of treatment, of the materials used, of drug dosages, of unusual equipments, of the statistical method ...). In the results section the answers to the questions posed in the introduction should be given. The results should be reported fully, clearly and concisely supported, if necessary, by figures, graphs and tables. The discussion section should sum up the main results, critically analyze the methods used, compare the results obtained with other published data and discuss the implications of the results. The conclusions should briefly sum up the significance of the study and its future implications. For randomised controlled trials it is

suggested to the authors to follow the guidelines reported by the CONSORT statement (<http://www.consort-statement.org>).

Review articles. These articles are commissioned by the Editor in Chief or the Managing Editor. They should discuss a topic of current interest, outline current knowledge of the subject, analyze different opinions regarding the problem discussed, be up-to-date on the latest data in the literature. Systematic reviews and meta-analyses must be subdivided into the following sections: introduction, evidence acquisition, evidence synthesis, conclusions. For systematic reviews and meta-analyses it is suggested to the authors to follow the guidelines reported by the PRISMA statement (<http://www.prisma-statement.org>). The text should be 6000-12000 words (17 to 34 typed, double-spaced pages) not including references, tables, figures. No more than 100 references will be accepted.

Case reports. These give a description of particularly interesting cases. The text should be 2000-3000 words (6 to 8 typed, double-spaced pages) not including references, tables, figures. No more than 30 references will be accepted. The article must be subdivided into the following sections: introduction, case report or clinical series, discussion, conclusions. It is suggested to the authors to follow the guidelines reported by the CARE statement (<http://www.care-statement.org>).

Special articles. These are articles on the history of medicine, health care delivery, ethics, economic policy and law concerning sports medicine. The text should be 3000-7000 words (8 to 20 typed, double-spaced pages) not including references, tables, figures. No more than 50 references will be accepted.

Letters to the Editor. These may refer to articles already published in the journal or to a subject of topical interest that the authors wish to present to readers in a concise form. The text must not be subdivided and should be 500-1000 words should be 500-1000 words (1 to 3 typed, double-spaced pages) not including references, tables, figures. No more than 5 references will be accepted.

Guidelines. These are documents drawn up by special committees or authoritative sources.

The number of figures and tables should be appropriate for the type and length of the paper.

PREPARATION OF MANUSCRIPTS

Text file Manuscripts must be drafted according to the template for each type of paper (editorial, original article, review, case report, special article, letter to the editor, guidelines).

The formats accepted are Word (.DOC) and RTF. The text file must contain title, authors' details, abstract, key words, text, references, notes, tables and titles of tables and figures. Figures should be submitted as separate files. The file should not contain active hyperlinks.

Title and authors' details Short title, with no abbreviations. First name in full, middle name's initial, surname of the authors. Collective name, if any, as last author. Corresponding author marked with an asterisk. Affiliation (section, department and institution) of each author. Name, address, e-mail of the corresponding author.

Abstract and key words Articles should include an abstract of between 200 and 250 words. For original articles, the abstract should be structured as follows: background (what is already known about the subject and what the study intends to examine), methods (experimental design, patients and interventions), results (what was found), conclusions (meaning of the study). For systematic reviews and meta-analyses, the abstract should be structured as follows: introduction, evidence acquisition, evidence synthesis, conclusions. Key words should refer to the terms from Medical Subject Headings (MeSH) of MEDLINE/PubMed. No abstracts are required for editorials or letters to the Editor.

Text Identify methodologies, equipment (give name and address of manufacturer in brackets) and procedures in sufficient detail to allow other researchers to reproduce results. Specify well-known methods including statistical procedures; mention and provide

a brief description of published methods which are not yet well known; describe new or modified methods at length; justify their use and evaluate their limits. For each drug generic name, dosage and administration routes should be given. Brand names for drugs should be given in brackets. Units of measurement, symbols and abbreviations must conform to international standards. Measurements of length, height, weight and volume should be given in metric units (meter, kilogram, liter) or their decimal multiples. Temperatures must be expressed in degrees Celsius. Blood pressure must be expressed in millimeters of mercury. All clinical chemistry measurements should be expressed in metric units using the International System of Units (SI). The use of unusual symbols or abbreviations is strongly discouraged. The first time an abbreviation appears in the text, it should be preceded by the words for which it stands.

References It is expected that all cited references will have been read by the authors. The references must contain only the authors cited in the text, be numbered in Arabic numerals and consecutively as they are cited. Bibliographical entries in the text should be quoted using superscripted Arabic numerals. References must be set out in the standard format approved by the International Committee of Medical Journal Editors (<http://www.icmje.org>).

Journals Each entry must specify the author's surname and initials (list all authors when there are six or fewer; when there are seven or more, list only the first six and then "et al."), the article's original title, the name of the Journal (according to the abbreviations used by MEDLINE/PubMed), the year of publication, the volume number and the number of the first and last pages. When citing references, please follow the rules for international standard punctuation carefully.

Examples:

- Standard article.

Sutherland DE, Simmons RL, Howard RJ. Intracapsular technique of transplant nephrectomy. *Surg Gynecol Obstet* 1978;146:951-2.

- Organization as author

International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. *Ann Int Med* 1988;108:258-65.

- Issue with supplement

Payne DK, Sullivan MD, Massie MJ. Women's psychological reactions to breast cancer. *Semin Oncol* 1996;23(1 Suppl 2):89-97.

Books and monographs

For occasional publications, the names of authors, title, edition, place, publisher and year of publication must be given.

Examples:

- Books by one or more authors

Rossi G. *Manual of Otorhinolaryngology*. Turin: Edizioni Minerva Medica; 1987.

- Chapter from book

De Meester TR. Gastroesophageal reflux disease. In: Moody FG, Carey LC, Scott Jones R, Ketly KA, Nahrwold DL, Skinner DB, editors. *Surgical treatment of digestive diseases*. Chicago: Year Book Medical Publishers; 1986. p. 132-58.

- Congress proceedings

Kimura J, Shibasaki H, editors. *Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology*; 1995 Oct 15-19; Kyoto, Japan. Amsterdam: Elsevier; 1996.

Electronic material

- Standard journal article on the Internet

Kaul S, Diamond GA. Good enough: a primer on the analysis and interpretation of noninferiority trials. *Ann Intern Med* [Internet]. 2006 Jul 4 [cited 2007 Jan 4];145(1):62-9. Available from:

<http://www.annals.org/cgi/reprint/145/1/62.pdf>

- Standard citation to a book on CD-ROM or DVD

Kacmarek RM. *Advanced respiratory care* [CD-ROM]. Version 3.0. Philadelphia: Lippincott Williams & Wilkins; ©2000. 1 CD-ROM: sound, color, 4 3/4 in.

- Standard citation to a homepage

AMA: helping doctors help patients [Internet]. Chicago: American Medical Association; ©1995-2007 [cited 2007 Feb 22]. Available from: <http://www.ama-assn.org/>.

Footnotes and endnotes of Word must not be used in the preparation of references.

References first cited in a table or figure legend should be numbered so that they will be in sequence with references cited in the text taking into consideration the point where the table or figure is first mentioned. Therefore, those references should not be listed at the end of the reference section but consecutively as they are cited.

Notes Conflicts of interest; mention of any funding, research contracts; authors' contribution statement; list of the members of the collective name (author's name in full, middle name's initial in capital letters and surname, with relevant affiliation); contributors' names; dates of any congress where the paper has already been presented; acknowledgements.

Tables Tables should be submitted in the text file. Each table should be created with the Table menu of Microsoft Word table editor, by selecting the number of rows and columns needed. Tabulations are not allowed. Each table must be numbered in Roman numerals and accompanied by the relevant title. Each table must include heading, body and notes, if needed, at the foot of the table. Tables should be referenced in the text sequentially.

Figures Each figure should be submitted as a separate file. Formats accepted: JPEG set at 300 dpi resolution preferred; other formats accepted are TIFF and PDF (high quality). Figures should be numbered in Arabic numerals and accompanied by the relevant title. Titles of figures should be repeated also in the text file. Figure should be referenced in the text sequentially.

Reproductions should be limited to the part that is essential to the paper.

Histological photographs should always be accompanied by the magnification ratio and the staining method. If figures are in color, it should always be specified whether color or black and white reproduction is required.

ANNEXURE H:
Proof of
language
editing

Maretha Botes

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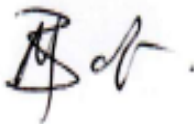
2019-03-11

To whom it may concern

Confirmation of editing the dissertation of Ms Carli Gericke

This letter confirms that I, Maretha Botes, freelance language practitioner, proofread and edited the dissertation of Ms Carli Gericke. My services included marking and editing language errors and reconstruction of paragraphs and sentences where necessary.

Yours sincerely



Maretha Botes

Freelance journalist and language practitioner