# THE EFFICACY OF GYMNASTICS TO IMPROVE MOVEMENT SKILL COMPETENCE IN CHILDREN

**James Rudd**

BSc (Sport and Exercise Science) (Hons)

*A thesis submitted in fulfilment of the requirements for admission*

*to the degree of Doctor of Philosophy*

## ISEAL
VICTORIA UNIVERSITY

Institute of Sport, Exercise and Active Living

College of Sport and Exercise Science, Victoria University

January, 2016

# ABSTRACT

**Background:** Internationally children's movement skill competence levels are low. Cross-sectional evidence, suggests that children participating in gymnastics possess enhanced orientation and stabilisation skills leading to a better understanding of where the body is in space. Therefore gymnastics may offer an excellent opportunity to develop children's movement skill competence. The primary aim of this thesis was to evaluate whether a gymnastics programme embedded within the Physical Education (PE) curriculum could develop children's actual and perceived movement skill competence. In order to achieve the primary aim, it was necessary to gain a greater understanding of the constructs which underpin movement skill competence in children. Consequently, a secondary aim was to evaluate the role that locomotive, object control, stability skills and general body coordination play in the development of movement skill competence in children.

**Method:** Two studies were carried out to assess the efficacy of a gymnastic curriculum on children's movement skill competence and physical self- concept. The first of these studies was a pilot which evaluated the efficacy of a gymnastics curriculum on children from grades 2, 4 and 6 from one primary school. The test battery used to assess movement competence comprised the Test of Gross Motor Development – 2 (TGMD-2) and the Körper-Koordinations test für Kinder (KTK). Children's physical self-concept was assessed using the Physical Self-Description Questionnaire short form (PSDQ-s). The second intervention which was the main study, used a non-randomised control design and followed the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statement for reporting. The main study focused on children from grades 1-4 and was carried out in three primary schools. The test battery for this study

was modified to include stability skills and focused on a single aspect of physical self-concept, a child's perceived movement competence using the Pictorial Scale of Perceived Movement Skill Competence (PMSC) which replaced the PSDQ-s.

**Results:** Movement skill competence in children was found to comprise four discrete constructs, each of which contributes to children's overall movement skill competence. The gymnastics curriculum was found to enhance object control skills and stability skills in lower primary school aged children, without hindering development of locomotor skills, or general non-sport specific coordination, compared to a control group participating in the school's standard PE curriculum. The pilot study found that gymnastics enhanced physical self-concept in all year groups at a faster rate than the schools' standard PE curriculum. However, the main study, which focused on perceived movement competence, found no difference between the gymnastics and standard PE curriculum groups. The final stage of the thesis was to develop a revised model of movement skill competence based upon the data from this research.

**Discussion:** A gymnastics-based PE curriculum was found to have a larger effect upon movement skill competence in comparison to a standard school PE curriculum. This was indexed by larger gains in stability skills and object control skills. In addition, following a period of coach shadowing, the gymnastics curriculum was successfully taught by the regular classroom teacher suggesting this model is sustainable and could be implemented on a larger scale. The improved development of object control skills is important, as children who have mastered object control skills in childhood are more likely to be physically active and fitter in adolescence. A key finding from this thesis is the apparent gap between our theoretical understanding of movement skill competence and the different ways in which it is assessed in the field. This suggests, that in order to

assess children's movement skill competence, a wider range of measurement tools should be employed to assess all four constructs of movement skill competence.

# STUDENT DECLARATION

I, James Rudd, declare that the PhD entitled 'The efficacy of gymnastics to improve movement skill competence in children is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, references, and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature: ███████████████         Date: 13/01/2016

# ACKNOWLEDGEMENTS

Writing this thesis really has been a journey of discovery. A journey to create new knowledge, which is both insightful and pertinent to improving the society we live in, and a very personal journey of self-growth. As I imagine with many others who have trudged down this well-trodden road my journey was punctuated by setbacks and feelings of jittery inadequacy at my ability to complete the task in hand.

I was fortunate to have a fantastic team of supervisors to support and guide me. I enjoyed sharing an office with two of them, JB and Damo, who helped create a relaxed and fun atmosphere, as well as going beyond the call of duty, by supporting me in the field with testing when needed. This was especially true of JB who, in the early days, willingly gave up full days of his precious time to help me out. At the time, I did not realise this support was beyond and above what was required, but looking back I really appreciate it. Damo ensured that I had the resources I needed, and whilst this was vital, it pales in comparison with the value of his feedback during the development of the chapters in this thesis. His feedback was always challenging and thought provoking, urging me to look deeper and achieve a greater understanding. Lisa joined my PhD supervisory team just a few months after I started my PhD and I cannot understate the impact of her arrival. Lisa is a highly respected academic and someone I look to emulate. She has been generous with her time, has encouraged me to develop as an academic and has helped me reach levels I simply did not know I was capable of. Not only is Lisa a formidable academic she is also great fun, I have happy memories of attending conference with her, letting our hair down in fancy dress photo booths and busting out a few moves on the dance floor. The last member of my supervisory team is Remco. Whilst his brightly coloured trousers left something to be desired, his support

and dedication to my development were second to none. Remco is the sole reason I embarked upon this PhD. Having taught me at undergraduate level and as an honours supervisor in the UK, he imparted in me a love of scientific inquiry and a passion for research. Remco, has been with me every step of the way throughout my thesis and this close relationship has continued despite him relocating to the other side of the world six months before my PhD was due to be completed. I miss our weekly rounds of golf and hope we can arrange another trip to Barnbougle in the not too distant future. Remco, perhaps, I should now concede that you have won that bet. I never did manage to beat you at a round of golf during my PhD years, although part of me thinks this was the reason you moved to England - you knew I was getting close!

Victoria University is a wonderful place to complete a thesis; having a critical mass of 100 PhD students in sport and exercise science creates a purposeful, happy and stimulating environment. Over the past three years, I've enjoyed the pleasure of the company of fellow PhD students Ewout, Shelley, Simone, Tim, Georgia, Lyndon and Jade, together we've shared many hilarious moments at work and some, a little hazier, but equally fun times out of office hours. Thanks to my fellow football team mates the 'World Leaders' I 've had a blast playing 'futsal' with you over the last three years. And last but not least, there are two very special people who deserve a mention, Michael and Jackie are two incredibly gifted academics who I have the good fortunate to call friends, their company has sustained me over the years during our many tea and lunch breaks.

A large proportion of my time over the last three years has been spent in primary schools collecting data. I would like to say a special thank you to all of the school staff who have been so supportive in helping facilitate the studies which are the backbone of this thesis. Without their patience, passion and support this thesis would not have been possible. And a very special thank you to all the children who participated in data

# PUBLICATIONS & PRESENTATIONS

Sections of this thesis have been published (or submitted for publication) and/or presented at relevant scientific conferences.

## PUBLICATIONS

Chapter 3

Rudd, J., Butson, M, L., Barnett, L, M., Farrow, D., Berry, J,. Borkoles, E., & Polman, R. (2015) A holistic measurement model of movement competency in children. Journal of Sport Sciences 29, 1-9.

Chapter 4

Rudd, J., Berry, J., Farrow, D., Barnett, L, M., & Polman, R. (in review). Pilot Study – effect of an eight week gymnastics curriculum in developing children's movement competence and physical self-concept. Journal of Teaching Physical Education

Chapter 5

Rudd, J., Barnett, L, M., Butson, M, L., Farrow, D., Berry, J., & Polman, R. (2015) Fundamental Movement Skills Are More than Run, Throw and Catch: the Role of Stability Skills. PloS one 10 (10), e0140224

## OTHER PUBLICATIONS

Bardid, F*., Rudd, J*., Lenoir, M., Polman, R., & Barnett, L, M. (2015) Cross-cultural comparison of motor competence in children from Australia and Belgium. Frontiers in Psychology (6), 964 (* joint first author)

Rudd, J., Polman. R., Farrow, D., & Borkoles, E. (2015) Efficacy of the Launchpad gymnastics program. Industry Report to Gymnastics Australia.

**MEDIA PUBLICATIONS**

Rudd, J. (2015). Can't throw, can't catch: Australian kids are losing that sporting edge Retrieved from https://theconversation.com/cant-throw-cant-catch-australian-kids-are-losing-that-sporting-edge-36822

**KEYNOTE PRESENTATIONS**

Rudd, J. (2015) 'Back to the Future' Reversing the decline in children's Fundamental Movement Skills. *Victorian Australian Council for Health, Physical Education and Recreation (ACHPER) Primary Conference, Melbourne*

**SCIENTIFIC CONFERENCE PRESENTATIONS**

Rudd, J. & Mazarella., A (2012) Implementing Sports Leadership into your school - The new 'hub'. *Victorian (ACHPER) Secondary Conference, Melbourne*

Rudd, J., Farrow, D., Barnett, L, M., Berry, J., Borkoles, E., & Polman R (2013) Sporting Success. *28th ACHPER International Conference, Melbourne*

Polman, R., Farrow, D., Berry J., Rudd J., & Borkoles, E.( 2014) Development of movement literacy test battery for secondary schools: the influence of SES. *International Conference of Applied Psychology, Paris, France*

Rudd, J., Farrow, D., Barnett, L, M., Berry, J., Borkoles, E., & Polman R (2014) The influence of a fundamental movement skill intervention on perceived movement skill competency in primary school children. *International Conference of Applied Psychology, Paris, France*

Rudd, J., Farrow D., Barnett, L, M., Berry, J., Borkoles, E., & Polman, R (2014) Pilot study to evaluate the efficacy of the 'Launchpad' gymnastics programme at developing children's motor coordination and fundamental movement skills. *Sports Medicine Australia Conference Canberra, Australia*

Rudd, J., Borkoles, E., Barnett, L, M., Berry, J., Farrow, D., & Polman R. (2015) Theoretical and practical session demonstrating how the 'Launchpad' gymnastics program can develop fundamental movement skills and overall body coordination in primary school children aged 6-9. *Conference ACHPER 29th Biennial International Conference, Adelaide, Australia*

Bardid, F*., Rudd, J*., Lenoir, M., Polman, R., & Barnett, L, M. (2015) Cross-cultural comparison of motor competence in children from Australia and Belgium. *North American Society for the Psychology of Sport and Physical Activity (NASPSPA) Portland, OR, USA*

Rudd, J., Butson, M, L., Barnett, L, M., Farrow, D., Berry, J., Borkoles, E., & Polman, R. (2015) How should we measure movement competence in children? *Sports Medicine Australia Conference Sanctuary Cove, Australia*

**AWARDS**

Rudd, J. (2014) 3rd place Victoria University Higher Degree by Research Conference (2014)

Rudd, J. (2015) 3rd place Victoria University Higher Degree by Research Conference (2015)

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER - 1  INTRODUCTION &

# OVERVIEW OF THESIS

*The journey of a thousand miles begins with one step.*

*-Lao Tzu*

## 1.1 **Introduction**

Children who can perform basic fundamental movement skills (FMS) such as running, throwing, kicking and catching in a consistent and efficient manner are often referred to as displaying movement skill competence (Gabbard, 2011). Australian studies have found consistently that children are performing poorly at FMS (Barnett, Hardy, Lubans, Cliff, Okely, Hills & Morgan, 2013; Hardy, Barnett, Espinel, & Okely, 2013; Tester, Ackland & Houghtonl., 2014). Movement skill competence has been found to have an inverse relationship with weight status and to be a predictor of higher levels of physical activity. It is therefore important to find more effective ways to develop movement competence in children (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Morgan, Barnett, Cliff, Okely, Scott, Cohen & Luban, 2013).

Currently, practitioners and researchers have an incomplete picture of how to develop movement skill competence in children (Giblin, Collins, & Button, 2014). Previous studies aimed at improving children's FMS have utilised different pedagogical approaches of differing intervention lengths and differing doses (Dudley, Okely, Pearson, & Cotton, 2011; Logan, Robinson, Wilson, & Lucas, 2012; Morgan et al., 2013). As a result, no clear pattern of results has emerged to indicate the most effective method for improving children's movement skill competence, and the large variation between research findings has led to researchers offering contrasting advice. In view of this, it is hardly surprising that research has not led to a change in current policy or practice in mainstream physical education (PE) to improve the current low levels of movement skill competence (Hardy, King, Espinel, Cosgrove, & Bauman, 2011; Moneghetti, 1993).

The lack of a coherent approach to FMS research is largely due to differing theoretical perspectives on how movement skill competence develops. Currently, there are two lines of thought in the fields of human movement science (motor learning, motor control and motor development): an information processing model, proposed by Fitts and Posner (1967); and, a dynamical system theory put forward by Newell (1986). The absence of a unified theory has led to a large number of studies being a-theoretical as they lack a strong rationale for why their particular approach or intervention should enhance movement competence. One constant element found across all interventions in Australian and American studies is the assessment method utilised. Measurement has focused on assessing locomotor (e.g. run, gallop, hop, jump, leap, skip) and object control (e.g. over-arm throw, catch, kick, strike, dribble and underarm roll) skills using process (qualitative) based assessment measures such as the Test of Gross Motor Development (TGMD-2) (Ulrich, 2000) or the Victorian Fundamental Movement Skill Teachers Manual (Walkley, Holland, Treloar, & Probyn-Smith, 1993). This has led to researchers developing interventions aimed specifically at enhancing locomotive and object control skills. Whilst locomotive and object control skills are integral constructs of FMS there is a third construct - stability skills. Research currently being undertaken in Australia and America offers little understanding of the role stability skills play in FMS development.

On the other hand, European researchers have focused on evaluating movement skill competence through the assessment of children's general non-sport specific gross coordination which is a product (quantitative) oriented assessment tool (Kiphard & Schilling, 2007; Vandorpe, Vandendriessche, Lefèvre, Pion, Vaeyens, Matthys et al., 2011). The choice of approach might be indicative of the theoretical beliefs held on how

movement skill competence is formulated; for example, in general terms ecological dynamics theorists may favour a process oriented approach whereas a cognitive psychologist may adopt a product approach. However, focussing only on locomotive and object control skills through process measurement is unlikely to develop 'all round' movement skill competence. From this perspective, it is apparent that there is a clear disconnect between the different theoretical understandings of the constructs of movement skill competence and the narrow foci of how researchers measure and design interventions to improve movement skill competence in children. There is therefore a need to revisit the theory in order to develop scientifically based interventions which can develop and nurture the breadth of children's movement skill competence.

Another important aspect to consider when enhancing a child's movement skill competence is their perceived competence to successfully execute a skill. Barnett, Van Beurden, Morgan, Brooks, Zask and Beard (2009) found perceived movement skill competence mediated actual object control competence and self-reported physical activity in adolescence. Stodden et al., (2008) suggest that children who have low skill levels may be drawn into a "negative spiral of disengagement" as low skill level contributes to low perceived movement skill competence and low physical activity levels, raising the risk of obesity. They suggested that as children mature these relationships will become stronger, therefore children's own perceptions of their movement skill competence is an area worthy of investigation at primary school age.

Despite its intuitive appeal, there is a dearth of research examining the capacity of gymnastics to develop movement skill competence. There are a range of issues that need to be addressed, these include whether learning gymnastics can improve known aspects of movement skill competence and whether these improvements can be detected

by assessing locomotor and object control skills. What is known, from cross-sectional evidence, is that children participating in gymnastics possess enhanced postural control through improved orientation and stabilisation skills leading to a better understanding of where the body is in space (Garcia, Barela, Viana, & Barela, 2011). Orientation and stability skills are essential for learning all FMS, especially the more complex skills such as object control, as they are known to enhance a child's sensory integration capabilities (Gallahue, Ozmun, & Goodway, 2012). Object control skills have consistently been found to be difficult to master and it has been suggested that this is due to these skills requiring greater perceptual demands (Morgan et al., 2013). The potential for gymnastics to develop children's stability skills may therefore offer an important opportunity for enhancing multiple aspects of children's movement skill competence as well as developing the complex skills which have been found to be essential for ongoing participation in physical activity. Further research is therefore required to understand how gymnastics can develop movement skill competence in children.

## 1.2 Aims of the Dissertation

### 1.2.1 *General Aims*

This thesis aims to evaluate the impact of a gymnastics curriculum taught in primary school PE on children's development of movement skill competence. Furthermore, this thesis aims to extend our current understanding of the constructs which underpin movement skill competence.

### 1.2.2 *Specific Aims*

- To evaluate the effectiveness of a gymnastics intervention in improving children's movement skill competence relative to the school's standard PE curriculum.

- To evaluate the effectiveness of a gymnastics intervention in improving physical self-concept with a particular focus on the subset of perceived movement skill competence.

- To gain a greater insight into the constructs which underpin movement skill competence, specifically general coordination, locomotive, object and stability skills. To create an assessment tool to measure stability skills in primary school children.

### 1.3 **Chapter Organisation**

Chapter 1 introduces the topic of the dissertation by providing a brief rationale for the research and sets out the specific aims of the thesis.

Chapter 2 provides a critique of the research encompassing the study of movement learning and movement development in children, with a specific focus on the development and measurement of movement skill competence in children.

Chapter 3 focuses on how movement skill competence in children is measured. There are two aims: first to investigate whether the TGMD-2 (used to assess locomotor and object control skills) and the KTK (which measures non-sport specific skills) are measuring the same constructs of children's movement skill competence; and secondly, to examine the factorial structure of the TGMD-2 and KTK to ensure both are valid instruments to be used with an Australian cohort of children.

Chapter 4 describes a pilot study - the first of two field-based interventions. Its aim was to investigate whether a gymnastics based curriculum improves children's movement skill competence - specifically locomotive, object control skills and non-sport specific coordination. In addition, this pilot study investigated how a gymnastics curriculum affects children's physical self-concept. Study results confirmed that a gymnastics curriculum developed object control skills in lower primary school children. It was also found that gymnastics improved overall physical self-concept in all primary school children compared to a control group completing a typical standard PE curriculum.

Chapter 5 has two parts: Part 1 describes the validation of a test battery to assess the construct of stability skills in children; and Part 2 seeks to understand how stability skills fit into the previously known model of FMS (locomotor, object control). The aim was to find a better interpretation of the third and least understood construct of FMS, the role of stability skills in children. It was thought that the significant increase observed for object control skills in children who had participated in gymnastics curriculum during the pilot study might have been the result of enhance stability skills. The findings set out in chapter 5 provide a strong rationale for the inclusion of stability skills in the FMS assessment tools which are widely used in schools and research across Australia and consequently it was decided to incorporate stability skills into the assessment battery used in the main study.

Chapter 6 describes the evaluation of the main study. The study's findings are similar to the findings from the pilot with children following the gymnastics curriculum demonstrating superior object control skills, relative to the cohort following the standard PE curriculum. In addition, it was found that the gymnastics cohort demonstrated accelerated stability skills. This suggests that accelerated learning of

stability skills may support the development of more complex movement skills such as object control skills, without hindering the development of locomotor skills and non-sport specific coordination. Children participating in the gymnastics curriculum showed no significant advantage or disadvantage in their perception of their locomotive or object control skills ability compared to the children participating in their normal PE curriculum.

Chapter 7 offers a research informed model of how movement skill competence develops through primary school years. This model is called the Longitudinal Model of Movement competence (LMMC) and utilises pre and post data as a foundation for the hypothetical model.

Chapter 8 summarises each chapter, discusses the theoretical, practical and methodological implications of the thesis, as well as providing directions for future research.

Please note that the majority of chapters in this dissertation have been written with the intention to publish and in some cases have already been published. As a consequence, the definitions of key terms (e.g. movement skill competence, fundamental movement skills) and the importance of this area of research maybe repeated in several chapters.

# CHAPTER - 2  LITERATURE REVIEW

*"It is a shame to grow old without seeing the beauty and strength of which*

*the body is capable"*

*Socrates*

Movement skill competence is easily recognised in the myriad of activities humans perform on a daily basis, from jumping over a puddle in the street, to catching a ball at full stretch on the sports field. It should be mentioned that in the context of this review the term "skill" refers to coordinated, accurate and relatively error-free perceptual movement performance (Anson, Elliott, & Davids, 2005). Over the past few decades, decreased levels of movement skill in primary school children have been reported in a number of western countries (Bös, 2003; Hardy, Barnett, Espinel, & Okely, 2013; Okely & Booth, 2004; Tester, et al., 2014; Vandorpe et al., 2011). These findings are of major concern as children with high movement skill levels have been linked with positive outcomes in both physical activity participation and weight status (Lubans et al., 2010). Furthermore, high levels of movement skill competence predict high levels of physical activity and physical fitness in adolescence (Barnett et al., 2008; Jaakkola, Yli-Piipari, Huotari, Watt, & Liukkonen, 2015; Lopes, Rodrigues, Maia, & Malina, 2011). Research findings suggest that early intervention programmes are needed (McDaid, 2011) and that improving children's movement skills could have a marked effect on health outcomes in childhood and in later life.

Movement scientists have become highly proficient at measuring the coordination and control of movements described as skilled but they have developed few evidence-based interventions to enhance movement skills. Moreover, where interventions have been implemented they have been a-theoretical in nature, meaning that interventions have been designed without a theoretical basis. This has led to contrasting perspectives on how skills are acquired or learned across the areas of motor development, motor control and motor learning. This lack of clarity has given rise to differing pedagogical approaches and diverse methodologies for measuring, developing and defining

movement skills which has led to confusion regarding the definition of skills needed for a child to be considered movement competent.

The primary aim of this review of the literature is to examine the construct of movement skill competence and its theoretical and empirical underpinning. A secondary aim is to critically review previous intervention studies which have tried to improve aspects of movement skill competence in primary school aged children.

## 2.1      Movement Skill Competence

### 2.1.1 *Definition of movement skill competence*

The ability to perform various movement skills (e.g. running, kicking, jumping, throwing) in a skilful manner, is often defined as movement skill competence (Gallahue et al., 2012; Haga, Pedersen, & Sigmundsson, 2008). Gallahue, et al. (2012) state that these skills can be separated into three discrete constructs: locomotor (run, hop, jump, slide, gallop, leap); object control (strike, dribble, kick, throw, underarm roll, catch); and stability skills (non-locomotor skills such as body rolling, bending, and twisting). Collectively, these are known as FMS and are considered to be the foundation skills that enable the specialised sequences of movement required for participation in many organised and non-organised physical activities for children and adolescents (Seefeldt, 1980). To assess mastery of these skills, researchers have developed a number of different assessment batteries.

The premise that mastery over FMS equals movement skill competence has been critiqued over the last few years (Almond, 2014; Pot & van Hilvoorde, 2014). According to Almond (2014) FMS has a weak conceptual base, as not all of its constituents are fundamentally necessary for children to be physically active and to

participate in the many sporting opportunities available in modern society. Alternatively, it is argued that the current list of FMS is not broad enough and that the existing classification of FMS will lead to children participating in only a limited number of sports and activities and these will, as a result, have limited transfer capability (Almond, 2014; Afonso, Coutinho, Araújo, Almond, & Pot, 2014). The other criticism directed at the conceptual base of FMS is that skills are developed predominantly though experience and do not require explicit teaching (Afonso, et al., 2014). Almond (2014) does not provide an alternative definition of movement comptence, however, their perspective is aligned with the way Western European countries have approached the measurement of movement skill competence. For example, Belgium and Germany have not focused on specific movement skills, but have instead investigated a child's general body coordination. Motor coordination refers to the cooperation between muscles or muscle groups to produce a purposeful action or movement (Turvey, 1990). This can be likened to the ability to modulate movement behaviours to achieve consistent performance outcome goals in a dynamic environment (Davids, Button, & Bennett, 2008).

### 2.1.2 *Movement skill competence key aspect of physical literacy*

Movement skill competence is an integral component of physical literacy, which has been defined as having the movement skill competence, knowledge, skills and attitudes to live a healthy life and to be an advocate for others to do the same (Whitehead, 2007).

Physical literacy has become an important focus of PE curricula (Mandigo, Francis, Lodewyk, & Lopez, 2009) and in the promotion of physical activity (Whitehead, 2001). For example, the PE curricula in England (Department of Education, 2013) and the United States of America (SHAPE, 2013) aim to promote lifelong participation in

physical activity through the development of physical literacy, with a focus on developing movement skill competence in children and through the development of self and social awareness, self-regulation and responsible decision making, to foster overall personal well-being. The result being a physically educated person with the ability to use these skills in everyday life and developing a disposition towards purposeful physical activity being an integral part of daily living (Castelli, Centeio, Beighle, Carson, & Nicksic, 2014). Though not explicitly included in the Australian Curriculum and Authority (2012) curriculum, the lead author of this curriculum has stated that in future iterations of the curriculum there are possibilities for physical literacy to be included as a general capability (Macdonald & Enright 2013). However, in the effort to create physically literate children it is important that the concept of movement skill competence is better understood and defined.

Almond (2014) has dismissed the inclusion of FMS as being a strong indicator of movement skill competence stating it as a dualist approach that neglects the essential embodied nature of learning. The issue Arnold (2015) is referring to is the perceived narrow focus on learning fundamental motor skills can neglect other important learning objectives. Dudley (2015) further explains that the controversy of using FMS as a measure of movement skill competence in physical literacy is the attempts to rationalise a list of skills into a single resource or test battery as this fails to capture the broader physical literacy components of moving for play, enjoyment, recreation, health, or fitness. Dudley (2015) however acknowledges and advocates the inclusion of FMS and has put forward an FMS taxonomy that break movement skill competence into land based or water based and has provided four categories of skills, locomotor, stability,

object control and object locomotor. Such a multi-dimensional conceptualisation of movement skill competence is common in the human movement literature.

Overall, however there is still a lack of consensus about what movement skill competence encompasses. An important reason for this disagreement is the variation in measurement methods (Giblin, Collins, & Button, 2014). There are two dominant theories, Dynamical Systems Theory and cognitive psychology. Both provide a multi-dimensional taxonomy of movement skills to describe movement skill competence, however they offer differing hypotheses of how movement competence is developed (Burton et al., 1998; Fleishman, 1975). These will be discussed in the next section.

## 2.2 Theoretical Perspectives of Movement Skill Competence

In general, two theoretical perspectives have emerged to explain movement skill development in both motor learning and motor control literature. These are known as the information processing approach, which was derived from cognitive and experimental psychology; and the ecological approach to skill acquisition, which has emerged from ecological psychology and dynamical systems theory. These differing approaches need to be better understood both individually and collectively in order to achieve a greater synergy in how we define and assess movement skill competence and motor coordination in children.

### 2.2.1 *Information processing approach*

Traditional maturation and cognitive models of motor learning and development have categorised movement skills as either phylogenetic or orthogenetic movement patterns (Magill, 2011). Phylogenetic movement patterns develop without assistance, being integral for interaction with our surroundings and essential for the survival of the human

species. Orthogenetic motor skills, on the other hand, reflect socially driven motor skills which are not required in order to function in normal everyday activity and, as a result, are more affected by practice (Magill, 2011). Under this premise, motor patterns that develop with little environmental involvement are known as phylogenetic (e.g. walking), whilst complex perceptual-motor movements would be classified as orthogenetic skills (e.g. a tennis serve). As pointed out by Robertson (1984) it becomes hard to distinguish between phylogenetic and orthogenetic skills once a child has mastered walking. This is particularly the case for skills classified as being FMS. For example, throwing has been has categorised as a phylogenetic skill in the first edition of the Espenschade and Eckert (1967) motor skill development textbook, however, in their second edition (1980) it was labelled as an orthogenetic skill. A possible reason for this confusion, as pointed out by Langendorfer and Roberton (2002), is that phylogenetic skills are driven by genetics and a rudimentary throwing technique would therefore be regarded as predominantly phylogenetic, while a masterful throwing pattern would be considered orthogenetic. This perspective could be applied to all FMS outlined by Gallahue, Ozmun, and Goodway (2012) with research providing evidence that opportunities for practice, instruction and modelling are important to the development of FMS (McKenzie, Alcaraz, Sallis, & Faucette, 1998).

From an information-processing perspective, the human mind is a system that processes information according to a set of logical rules and limitations similar to those of computer software (Adams, 1971). The theories emerging from this approach are relatively similar, in that they suggest that information enters through the sensory system and is encoded and stored in either short-term memory or long-term memory, depending upon the importance of the information. The central nervous system acts as

the 'hardware' whose function is to order, monitor, select, and organise the information which dictates our movement. The information processing approach offers a top down approach to movement with a construct located inside the brain, such as a schema or a trace, which is built-up or strengthened as a result of the learning process (Fitts & Posner, 1967). According to these theories, skills develop as a consequence of repeating the movement skill over and over again, and the skill tracks through set stages of development until a masterful pattern emerges.

The information processing perspective has led to a predominately quantitative assessment approach which involves measuring the product or outcome in order to understand skill learning and the stage of developmental process. This includes assessment of accuracy, for example the ability to hit a target when executing an over-arm throw. The information processing approach does not usually address the question of what can be changed during the course of learning. This is possibly because most research carried out using this approach focuses on the final outcome (performance parameters) rather than the underlying processes involved (Whiting & Vereijken, 1993).

Fitts and Posner (1967) proposed that the acquisition of sensorimotor skills proceeds in three distinct stages: (1) a verbal cognitive stage in which individuals strive to comprehend task requirements and strategies; (2) associative motor stage, in which response patterns are gradually formed with the help of sensory feedback; (3) an autonomous stage, in which those patterns are integrated into larger sequences that can be run off with little demand on attention.

Using Fitts and Posner's (1967) three stage model it becomes relatively easy to plan and prepare an intervention to develop movement skill competence, as one can support

children through each stage in developing the various movement skills in the stability, locomotive and object control domain as proposed by Gallahue, et al. (2012). For example, children in the cognitive stage of skill acquisition require considerable cognitive activity and movements are controlled in a relatively conscious manner. As such the use of self-talk, cue cards and feedback will help take the learner step-by-step through the execution of the skill to enable them to move onto the motor stage. During the verbal cognitive phase, learners often experiment with different strategies to find out which ones work or don't work in bringing them closer to the movement goal (hypothesis testing). The verbal cognitive phase is also characterised by high attentional demands to execute the motor skill whilst execution is characterised as effortful, erratic and full of errors. In the motor stage the performer reduces errors and the movement is executed in a more fluent and efficient manner with reduced attentional demands. The autonomous phase is characterised by fluent and seemingly effortless motion. To challenge a learner during this stage there should be increased external stressors, and distractions from other activities happening within the surrounding environment (Beilock, Carr, MacMahon, & Starkes, 2002).

The work by Fitts and Posner (1967) is independent of factors which may influence the development of perceptual movement skills such as strength, underlying coordination and agility. These aspects, within the information processing model, were defined as abilities and are genetically predetermined characteristics of our movement development. Fleishman, (1975) created the ability taxonomy based on the premise that there is a finite set of human abilities that underlie all performances of a task. These were placed into two broad domains, perceptual motor abilities and physical motor abilities. In total, 11 perceptual motor abilities were included such as, how one

coordinates multiple limbs at a given time, or precision of the response, and reaction time. The other nine motor abilities are largely physical abilities and comprise static strength, dynamic strength, explosive strength, trunk strength, dynamic flexibility, gross body equilibrium and stamina (Fleishman, 1975). The list of abilities is not exhaustive as the goal was to create the smallest list of abilities possible which underlie a broad spectrum of tasks.

A limitation to Fitts and Posner and Fleishman's work is that they are considered independent of each other. However, it has been found that, as an infant's walking gait is constrained by weight and leg strength this will have a noticeable effect on their walking ability. This suggests that motor abilities are not underlying or separate from perceptual skill development but are in fact intertwined into the learning process. An additional limitation is the lack of clarity around the principle of changes in the hypothetical cognitive structure (trace, schema) and that it may only be inferred through correlated changes in performance that occur with practice (Kelso, Case, Holroyd, Horvath, Rączaszek, Tuller, et al., 1995; Whiting & Vereijken, 1993). This is known as the 'black box' approach, however, it fails to identify where in the brain particular skills are stored and updated. This limitation has been addressed partially by recent advancements in neural imaging technologies which have indicated that both sensory and motor areas of the brain reveal a high degree of plasticity and are capable of sending signalling to the central nervous system to undertake complex skills (Blake, Byl, & Merzenich, 2002; Mogilner et al., 1993). An additional limitation of the information processing approach is that these theories are based on highly controlled experiments and manipulation of individual variables which are not representative of the real world setting (Vilar, Araújo, Davids, & Renshaw, 2012). An alternative

approach focuses on how the underlying mechanisms interact and change during the course of learning, this is called the Dynamical Systems Approach to Human Movement (Shaw & Alley, 1985).

### 2.2.2 *Dynamical systems approach*

The dynamical systems theory perspective is that the human movement system is a highly intricate network of co-dependent sub-systems (e.g. respiratory, circulatory, nervous, and perceptual) that are comprised of a large number of complex interacting components (e.g. blood cells, oxygen molecules, bone). The dynamical systems approach is a bottom up approach to skill learning. It suggests that the learning of skills involves shifting the balance between behavioural information and intrinsic dynamics (capacity that exists at the time a new task is to be learned) so that the behavioural or environmental information dominates and the system becomes attracted towards the required pattern (Wallace, Stevenson, Spear, & Weeks., 1994). This occurs through processes of self-organisation found in physical and biological systems. It is the passage from one organised state of the system to another (Kelso et al., 1995). Observed changes in movement skill behaviour, in this respect, are a function of the system itself (self-organisation), with no prior authority controlling or prescribing the behaviour. Once the learning has taken place, this becomes an attractor state, a stable state for the overall dynamic system. Learning does not just strengthen the memory traces or the synaptic connections between inputs and outputs, as presented in the information processing theories, but changes the whole system (Kelso et al., 1995).

The dynamical systems approach often uses the terms 'coordination', 'control' and 'skill' to describe the transition in skill level from novice to expert performance. Coordination refers to the process by which movement system components are

assembled and brought into proper relation with each other during goal-directed activity (Turvey, 1990). Control refers to the acquired ability of the individual to vary the parameters of the movement pattern, such as force, speed and duration, to suit specific performance constraints. Skill is referred to as the ability to meet the demands of the environment through the creation of movement skills which meet task demands and utilise environmental inertia to optimise the performance (Newell, 1986).

Bernstein, (1967) was hugely influential in the field of motor control and motor learning, as his research investigated how the central nervous system (CNS) is able to adequately coordinate and control movements. Bernstein conceived movement skill development to be a coordination problem with progressive mastery of redundant degrees of freedom. First, the individual solves this problem by "freezing out" a portion of the degrees of freedom. This strategy allows a reduction of the control constraints, as the skill is practiced the degrees of freedom are progressively released and incorporated into a larger functional unit, labelled coordinative structures. Finally, mastery appears through the search for movement efficiency. The individual tends to exploit optimally passive forces to produce a more efficient and effective skill (Vereijken, Emmerik, Whiting, & Newell, 1992).

Children have been found to struggle to exhibit a masterful overarm throw action (Booth et al., 1999). Learning such a skill is a truly monumental task which, our brain and body struggle to deal with as it involves aspects of locomotion, rotation and sequencing multiple parts of the body to exploit optimal passive forces. To put this complexity into context, if we take a simple task such as reaching for a glass of water, our central nervous system has to integrate the degrees of freedom in the shoulder joint, such as extension (one degree of freedom), adduction and rotation (two degrees of

freedom). The elbow joint adds flexion (one degree of freedom), whilst the wrist contributes pronation, and flexion (two degrees of freedom); in total this amounts to our central nervous systems dealing with six degrees of freedom. Whilst this sounds plausible, other factors which are integral to reaching for a glass of water, quickly multiply the degrees of freedom our CNS must coordinate and control. For example, depending on the position of the movement, some muscles will be more dominant in the movement than others. Each of these muscles is made up of hundreds of muscle fibres grouped into motor units, depending on distance, force and timing must be provided to each motor unit during a successful reaching action. This means there are potentially millions of degrees of freedom that must be controlled to perform such a simple action. If we then apply the same process to a whole body movement pattern such as the overarm throw our CNS would have to deal with a near infinite number of degrees of freedom. The way our bodies deal with this is to first freeze out non-essential movements and then gradually release. This process will result in the eventual development of a skilled performance where, one not only masters the degrees of freedom within the body, but also uses environmental factors such as gravity and inertia to maximise distance and accuracy of an overarm throw.

One area of difference between the dynamical systems approach and the information processing approach is in how the construct of movement variability is considered. The dynamical systems approach perceives movement variability as functional and an indication of the development of skill, whereas the information processing approach perceives movement variability as noise in the system and, according to this view, development of skill should be associated with less movement variability.

The dynamical systems and information processing theories are not however without their similarities. Within the dynamical systems approach, learners become attuned to selecting the key information variables that specify movements from the myriad of variables that do not. During practice, they minimise the information needed to regulate movement from the enormous amount available in the environment (Jacobs & Michaels, 2002). This process of information reduction and synthesis appears similar to the cognitive stage in Fitts' and Posner's model. Secondly, learners calibrate actions by tuning movement to a critical information source and, through practice, institute and sustain information-movement couplings to regulate behaviour. The calibration process and accompanying practice is not dissimilar to the characteristics of the motor stage in Fitts and Posner's three-stage model. Both approaches support the view that movement competence is multidimensional. They also agree to varying degrees that movement skill competence is a hierarchical phenomenon that integrates many components and cannot be developed though maturation alone.

### 2.2.3 *Lack of a unified theory has hindered understanding of movement skill competence*

The contrasting views of how children become movement competent put forward by the dynamical systems theory and information processing approach has probably hindered rather than helped researchers' understanding of movement skill competence (Newell, 1986). The lack of agreement has led to contention in the literature concerning whether the skills chosen to measure children's movement skill competence are actually representative of children's movement repertoire (Afonso, Coutinho, Araújo, Almond, & Pot, 2014). Different test batteries have emerged around the world, all testing slightly different forms and groups of skills (Cools, Martelaer, Samaey, & Andries, 2009). In

Australia, assessment batteries such as the Test of Gross Motor Development, Second Edition (TGMD-2; Ulrich, 2000), are generally used to measure children's movement skill competence. This includes the assessment of locomotive and object control skills using a process measure giving children an overall movement skill competence score. This method has stimulated a significant amount of FMS based research which has found that children's level of competence is associated with many health behaviour outcomes at a population level (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). The underlying assumption is that children who have mastered skills such as kicking, running, catching and dribbling are more likely to participate in physical activities within their society, such as the different football codes (e.g. rugby, AFL or soccer).

Almond et al. (2014) scrutinised this form of assessment and concluded that these test batteries do not necessarily include all the skills that one might consider fundamental for participation in sport activities such as skate-boarding, surfing or BMX cycling. These skills rely on whole body coordination and balance, and it is argued that these skills should also be included in FMS test batteries. Gallahue et al. (2012) and Jaakkola and Washington (2013) do classify balance and/or stability as a third dimension of FMS. Stability skills can be defined as the ability to sense a shift in the relationship of the body parts that alter one's balance, as well as the ability to adjust rapidly and accurately to these changes with the appropriate compensating movements (Gallahue, et al. 2012). The system responsible for the ability to maintain balance and sense shifts in our balance is called postural control. Postural control enables the body's positioning in space for the dual purposes of stability and orientation. Postural stability refers to the ability to maintain, achieve or restore a specific state of balance, whereas postural

orientation is the competence to maintain an appropriate relationship between the body and the environment for a task (Horak, 2006).

To gain further insights into the construct of stability skills, a better understanding is required of our sensory system, as this plays a critical role in motor control, coordination and the timing of movements and it is also involved in motor learning and cognition (Fiez, 1996).

### 2.2.4 *Sensory development and its role in movement skill competence*

The development of several sensory systems is essential for typical movement development during childhood (Magill, 2011). The development of stability, locomotor and object control skills requires visual, vestibular, kinaesthetic, tactile and auditory information. The sensory system is known to develop during gestation, and new born babies are capable of taking in multiple sources of sensory information (Lecanuet & Schaal, 1996, 2002). This suggests that our everyday behaviour is controlled by a simple coupling between an action and specific information picked up by our sensory system (Horak, 2006). According to Gallahue et al. (2012), children will have mastered stability skills by the age of six, and these skills are integral to learning locomotor and object control skills. However, the view that stability skills are mastered by the age of six is only partially shared by experts in the area of motor control (Barela, Jeka, & Clark, 2003; Garcia et al., 2011).

Vision has been found to be the dominant sensory information to maintain postural control (Bertenthal, Boker, & Xu, 2000). When postural control has been examined with the inclusion of visual information, it has been suggested that an infant's postural control system is not fundamentally different to the adult system (Bertenthal et al.,

2000). This was observed when participants received misleading visual information, as a result of moving the walls of a room but keeping the ground fixed (swinging room paradigm). Postural sway measurements of infants, children and adults were found to share similarities as they all relied on visual information being received to control their balance (Barela, Whitall, Black, & Clark, 2000; Lee & Thomson, 1982). The idea of children having a mature postural control system similar to that of adults does not hold true, however, if the primary mechanism for postural control (vision) is excluded and participants have to rely on other sensory systems such as haptic feedback and muscle spindle activity to guide postural control. Barela et al. (2003), for example, found that children demonstrated a weaker coupling of positional information and higher variability in postural sway compared to adults during a two foot standing task. The authors suggested that children may have greater difficulty integrating the information from multiple sources to implement sufficient postural control. In other words, children seemed to struggle with the ability to integrate and arrange sensory information from multiple sources compared to adults. Similarly, it was found that children aged 7 -12 years could use visual cues for postural control in a similar way to adults, but had more difficulty than adults using somatosensory cues to stabilise posture when the visual information conflicted with the somatosensory cues (Sparto, Redfern, Jasko, Casselbrant, Mandel & Furman, 2006). Bair, Kiemel, Jeka, and Clark, (2007) investigated this conflict in children aged 4 -10 years and found older children were able to reduce the importance of visual information by down weighting this in relation to other sensory inputs, compared to younger children. In summary, whilst children and adults possess the same capabilities in feedback processes, the feed-forward mechanism

which allows them to integrate and downgrade certain sensory inputs are immature throughout childhood.

There is evidence that the integration of multi-sensory information can be improved through certain types of activities and, as such, the development of stability skills can be enhanced. Garcia et al. (2011) found that gymnasts possessed superior bipedal (static upright two foot stance) postural control at 5 -7 years old compared to non-gymnasts. However, they did not find a difference between gymnasts and non-gymnasts aged 9-11. The authors suggested that participation in gymnastics promoted improvements in the performance of postural control of younger children due to a greater use of the available sensory cues to better estimate body dynamics which led to significantly improved postural control performance. These training effects were not present in the older cohorts providing evidence that older children have developed the ability to reweight sensory inputs (see Bair et al., 2007 for similar findings). Garcia et al. (2011) however, considered that there could still be postural differences between the older cohort of gymnasts and non-gymnasts, because the quiet stance may fail to elicit postural stability deficiencies because of the relative ease of the testing procedure resulting in ceiling effects. This was not a new limitation as others have also suggested that static measures of balance have limitations and that dynamic measures should be used instead (Riemann, Myers, & Lephart, 2002).

Dynamic clinical measures have been developed to overcome some of the shortcomings of static measures of postural control. For example, Riemann et al. (2002) subjectively assessed multiple single-leg hop tests. An important limitation of this test was the lack of objective assessment criteria. Similarly, the Biodex Stability System (Biodex Medical Systems, Shirley, NY) objectively measures the degree and time of tilt about

unstable axes (Arnold & Schmitz, 1998). However, maintaining balance on an unstable platform does not represent activities of daily living and as such has limited ecological validity (Wikström, 2005). In addition, the Biodex Stability system is laboratory based and relatively expensive. It appears that currently there is no field based dynamic balance test available for the assessment of stability skills in children. Stability skills are the least understood construct in the FMS family and there is a real need to unlock their secrets in order to achieve a better understanding of children's movement skill competence.

### 2.2.5 *Locomotor and object control skills*

FMS (locomotor and object control skills) have been shown to be the foundation skills that enable the specialised sequences of movement required for participation in many organised and non-organised physical activities for children and adolescents (Seefeldt, 1980). These predictions are loosely based upon Thorndike's (1914) identical elements theory of transfer. This theory states that all learning is specific and many situations appear to be general only because the new situations/acts contain elements similar to elements of old situations/acts. In essence, the identical elements theory states that transfer occurs because of similarities between elements of the previously learned skill and the new skill. A more detailed understanding of transfer has been proposed by Langendorfer, Roberton, and Stodden, (2013) which highlights that the timely coordination among body segments exhibited in more complex coordination and control tasks, can be learned and enhanced through mastery of throwing, kicking and striking activities. This is due to perceptual motor integration, development of high angular velocities of multiple joints, optimal relative timing of segmental interactions, optimal

inter- and intra-muscular coordination and optimal transfer of energy through the kinetic chain.

Locomotion is a fundamental aspect of a child's development to move from point A to point B. Children acquire a repertoire of basic locomotor skills allowing them to interact efficiently and effectively with the world. Whilst engaged in physical activity, children transition between locomotor skills automatically, for example, when descending a slope or running down stairs, the movement pattern will most likely change to the form of a gallop, whilst stopping suddenly can result in a hopping step. A lack of mastery over these skills could result in injury (Davids et al., 2008). According to Gallahue, et al. (2012) locomotor skills can be further broken down into two sub categories. These are: basic locomotor skills such as running, hopping and jumping which have been found to be first mastered around the age of 6-7 (Gabbard, 2008); and, complex locomotor skills which are combinations of the above skills, such as galloping and leaping, and have been found to be mastered later in childhood.

The paragraph above illustrates why the two theoretical theories have led to confusion in our understanding of locomotive skills. The dynamical systems theory states if we put children in a situation such as running downhill a gallop technique will develop spontaneously (Davids et al., 2008), whilst Gabbard (2012) approaching this from an information processing approach, would categorise galloping as a complex skill that needs to be mastered. The truth is likely to be somewhere in the middle of these two theories, though what is more important is that less than 40% of children have mastered these skills by the time they leave primary school (Hardy, 2011). This is a huge problem, as locomotor skills are present in many of the more complex object control skills such as the kick (i.e. a child must be able to demonstrate a competent run and leap

to execute a masterful kick). As such, mastery of locomotor skills, and especially basic skills, has been found to precede object control skills and these are essential for children to demonstrate weight transfer and the correct kinematic chain of events (Stodden, Langendorfer, Fleisig, & Andrews, 2006).

Object control skills require controlling implements and objects such as balls, hoops, bats and ribbons, by hand, foot or with any other part of the body. Children have consistently been found to perform poorly at object control skills (Hardy, 2011; Okely & Booth, 2004). Children who demonstrate mastery over object control skills have been found to have timely coordination among body segments, whilst unskilled children do not possess the same kinematic sequencing or timing in their movement patterns (Stodden et al., 2006). According to Gallahue, Ozmun, and Goodway (2012) the expected age of mastery is between 7- 9 years, though research into the over-arm throw has found less than 32% of boys and 8% of girls showed competence by the age of 10 (Hardy et al., 2012). The over-arm throw is one of the most complex of the object control skills, and the components within them, require a great deal of sensory information; this includes transfer of weight, hip and shoulder rotation, object manipulation and timing the integration from multiple sources. Children will struggle to achieve this if the foundations have not been mastered. As such, the development of stability skills, which have been found to benefit the sensory system, may be advantageous in learning object control skills (Davids, Bennett, Kingsbury, Jolley, & Brain, 2000).

### 2.2.6 *General body coordination*

Coordination is the organisation of the different elements of a complex body or activity which enables them to work together effectively. General body coordination reflects the

ability to perform movement of various degrees of difficulty quickly, precisely and efficiently (Bompa, 1990). Specific movement coordination patterns (locomotor and object control skills) are important skills for a child to learn to enable them to engage in activities based within a school and sporting context. Barrow, McGee, and Tritschler, (1989) indicated a child's level of coordination is reflected in the ability of an individual to integrate all types of movement into specific patterns which are suited to overcome the task at hand. Researchers in Eastern European countries have not focused on FMS but have concentrated instead on a child's ability to demonstrate coordination in general non-sport specific tasks of general body coordination (Kiphard & Schilling, 1974, 2007; Vandorpe et al., 2011). These tests are commonly used to assess general coordination, and tend not to be based on any strict definition of coordination per se, but rather an implicit assumption that general coordination or general motor ability exists and can be measured (Wilson, 2005). Factor analyses do indicate that most of the variance in motor performance can be explained by a general 'ability' factor (e.g., Burton & Rogerson, 2001). This is reflected in the view that the coordination and control exhibited by skilled performers is due to their ability to modulate their behaviours to achieve consistent performance outcome goals in a dynamic environment. They are not locked into fixed rigidly stable movement skill solutions (Davids et al., 2008).

### 2.2.7 *Current model of movement skill competence*

Burton and Rogerson's (2001) taxonomy (see Figure 2-1) was developed in an effort to create a synergy between everyday practice in PE and a theoretical model of movement behaviour. They developed a new perspective based on four levels. At the highest level are movement skills. These are desirable skills for children to have mastered to enable them to engage in a wide variety of activities. The next level is movement skill sets.

These are movement constructs based upon the premise of identical elements theory (Thorndike, 1914) in that similar skills will cluster together due to similar skills sharing identical components or, according to the interpretation by Langendorfer et al. (2013), they share similar kinematic timing and optimal inter- and intra-coordination. Evidence for this has been found in the confirmatory factor analysis (CFA) on six locomotive and six object control skills that were found to cluster together in separate constructs. Movement skill foundations are placed at the third level. They are believed to possess the strongest genetic influence and are aspects of a person's physical, mental, and emotional make-up. They have been explained in dynamical systems terms in that they are marshalled together on a needs basis for an optimal solution to the task at hand. This soft assembly is dictated by the constraints of the person, task and environment with each foundation providing a unique contribution. The order/ priority given to each of these foundations will never be identical due to the ever-changing nature of constraints acting upon and within a child. This work is strongly aligned with Thelen's, (1995) work of rate limiters, in which she attempts to identify the component elements which may constrain the appearance of new movement patterns in infants. At the base of the taxonomy is general movement ability (GMA). The GMA hypothesis claims that many different motor abilities are highly related and can be characterised in terms of singular or global movement ability (Magill, 2011). To put this another way, GMA is a common factor that enables certain individuals to perform well, or to quickly acquire a high level of proficiency in any movement task (Burton & Rogerson, 2001).
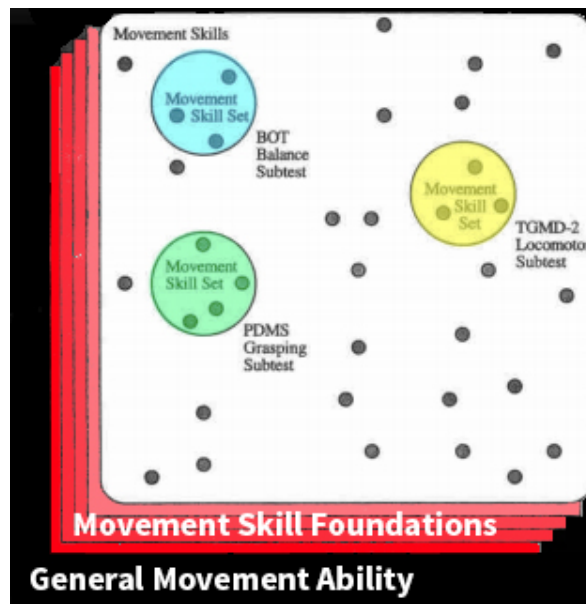
Figure 2-1: New assessment on movement skills and movement abilities (Burton & Rogerson, 2000)

A hierarchical taxonomy such as Burton and Rodgerson's, although nicely summarising the requirements of movement skill competence, has one important limitation: that it is impossible to test the model or provide evidence for causal relations and directions between the four levels. This significantly limits its effectiveness as a model to support the development of movement skill competence in children. Burton and Rodgerson's (2001) taxonomy does highlight and provide sufficient evidence to suggest that it is important to measure general body coordination alongside current FMS assessments.

## 2.3 Measurement of Children's Movement Skill Competence

There are many different assessment tools used to measure movement skill competence in children (Barnett & Peters, 2004; Cools et al., 2009; Wiart & Darrah, 2001). The choice of assessment battery depends on a number of criteria such as the purpose of measurement, age specificity and the suitability of the test for the cohort being tested (i.e. typical or a-typical development) (Cools et al., 2009). The popularity and

implementation of test instruments also vary depending on the geographical region. In Australia, assessment batteries such as the Test of Gross Motor Development, Second Edition (TGMD-2; Ulrich, 2000) are generally used to measure movement skill competence of children through a set of FMS (e.g. running, throwing, jumping, catching); whilst Belgium and other European countries have used the Körperkoordinationstest für Kinder (KTK; Kiphard & Schilling, 1974, 2007), a non-sport specific assessment of children's general body coordination.

Although movement tests purport to measure the same broad construct (i.e. movement skill competence), research on test comparisons generally reveals only moderate correlations. For instance, Fransen et al. (2014) compared the KTK and Bruininks-Oseretsky Test of Motor Proficiency, 2nd Ed (BOT-2; Bruininks & Bruininks, 2005) in primary school children and found a moderate association between the two tests performances. These findings are similar to other convergent validity studies (Logan, Robinson, & Getchell 2011; Smits-Engelsman, Henderson, & Michels, 1998; Van Waelvelde et al., 2007). A lack of homogeneity between assessment tools is the result of one of two scenarios, the first being that the instrument fails to capture the complexity of interrelated aspects of movement competence as outlined by Burton and Rodgerson's (2001) taxonomy. This scenario is discussed further in part 1 of the next section. The second scenario, discussed in part 2 of the next section, relates to the issue of validity and reliability of the assessment instrument. Where this has not been appropriately considered there is likely to be a high variation in the data collected and an increased likelihood of type 1 or type 2 errors. Both scenarios are framed in the discussion of three popular children's movement competence assessment tools: the Movement ABC (Henderson, Sugden, Barnett, & Smits-Engelsman, 1992); the Test of Gross Motor

Development- 2 (TGMD-2) (Ulrich, 2000); and, the Kooperkoordination test fur kinder (KTK) (Kiphard & Schilling, 2007). These tests were chosen for the following reasons: 1) all purport to measure a child's overall movement skill competence, 2) all are commonly used across an international context (Bös, 2003); 3) all are widely reported as measures of movement skill competence in academic literature (Cools et al., 2009) and, 4) all are often used in the PE setting (Burton, Miller, & Miller, 1998).

### 2.3.1 *Part 1: ability of current tests to capture the complexity of movement competence*

#### 2.3.1.1 *Movement assessment battery for children (Movement-ABC - Movement-ABC 2)*

The Movement-ABC (Henderson et al., 1992) assesses the developmental status of FMS, with a focus on detection of delay, or deficiency in a child's movement skill development (Cools et al., 2009). The test is suitable for children between 4 and 12 years of age and consists of 32 items, subdivided into four age bands. Each age band includes eight individual test items measuring movement skills in three categories: manual dexterity skills, ball skills and balance skills. Each item is rated on a 6-point rating scale, where 5 equates to the weakest performance and 0 to the best performance. A total impairment score expresses the child's test performance. Profile scores provide more specific information on the child's movement skill performance within each individual category (Henderson et al., 1992). The test is used as a screening instrument for problems in the development of motor skills (Law et al., 2004; Van Waelvelde, De Weerdt, De Cock, & Smits-Engelsman, 2004; Van Waelvelde et al., 2007). According to these authors, the tool is especially useful in exploring issues in the functional integration of motor control or problems that often appear for the first time in late

preschool and early primary school years. Burton et al. (1998) consider the test suitable for the assessment of motor abilities, early milestones, FMS and specialised movement skills. As such, this assessment tool does, on face value and content, seem to cover all the aspects of movement skill competence which were highlighted in the new assessment of movement skills and movement abilities (Burton & Rogerson, 2001).

### 2.3.1.2     *Körperkoordinationtest für kinder (KTK)*

The KTK (Kiphard & Schilling, 1974, 2007) is appropriate for children with typical developmental trajectories, as well as for children with brain damage, behavioural problems or learning difficulties. The KTK-test is a product-oriented test that refers to a norm but has the advantage that test items are not learned quickly, so the test can be used for evaluating therapies and interventions. The test can best be described as a non-sport specific assessment of a child's gross motor coordination, which requires the individual to modulate their behaviours to achieve consistent performance outcome goals in a dynamic environment. It does not measure movement skills, or movement skill sets, such as object control or locomotion. This assessment tool would seem to be a suitable measure of movement skill foundations and, due to the requirement of modulating the body to meet the demands of the environment, may also be an adequate measure of general movement coordination as defined by Burton and Rogerson (2001).

### 2.3.1.3     *Test of Gross Motor Development, second edition (TGMD-2)*

The TGMD-2 measures FMS performance based on qualitative aspects of movement skills. The test purports to identify children who are delayed in gross motor performance, so that practitioners are able to plan programmes to improve skills or for intervention. The age range (3 to 10 years) covers the period in which the most dramatic changes in a child's gross movement skill development occur (Ulrich, 2000). The test

includes locomotion and object control skills but not stability skills. The locomotor construct consists of six skills: run, gallop, hop, leap, horizontal jump, and slide. The object control construct also consists of six skills: two-hand strike, stationary dribble, catch, kick, overhand throw and underhand roll. A great advantage of the TGDM-2 is that each skill is broken up into separate components which are required for a masterful performance. This qualitative aspect of assessment allows the form of the movement rather than the outcome to be scored. As such the TGDM-2 is a process and product-oriented test that refers to a criterion and a norm. Burton and Miller (1998) concluded that the original TGMD assessment is suitable to assess movement skill sets and FMS. As the TGMD-2 is very similar to the original it is believed that this statement is still applicable.

Overall, all three test batteries have been shown to cover aspects of theory which underpin movement skill competence. The M-ABC has a wide variety of tests, and as such, it seems to be the most suitable to cover all aspects of Burton and Rogerson's taxonomy. However, the M-ABC has a number of important limitations. The tests are different across the age bands which limits its use for intervention or longitudinal data collection. The biggest issue, however, is its suitability for use in a typically developing population. The M-ABC is designed to detect delay or deficiency in a child's movement skill development and as such may present a ceiling effect for typically developing children. The KTK and TGMD-2 are both suitable for PE and sports settings of typically developing children (Cools et al., 2009). The tests are the same for all children within the age range of the TGMD-2 (5-11) and the KTK (5-15). The KTK is non-sport specific and, as such, theoretically measures a child's general movement coordination (Magill, 2011) or general movement ability (Burton & Rogerson, 2001); whilst the

TGMD-2 measures 12 FMS which are separated into two movement skill sets. To date, assessment tools have tended to either be, process measures similar to that of the TGMD-2 or, product oriented similar to the KTK.

The separation of product and process measurement of movement skill competence has been questioned (Stodden et al., 2008). The choice of a process or product test battery, in this respect, might be indicative of theoretical beliefs of how movement skill competence is formulated. For example, in general terms, an ecological dynamics theorist may favour a process-orientated approach, whereas a cognitive psychologist may adopt a product approach. The review of literature herein suggests that both assessment strategies provide a useful assessment of movement skill competence. By investigating the face and content validity of the three assessment tools, it can be considered whilst the M-ABC is deemed to cover all aspects of movement skill competence, the content may not be suitable for typically developing primary school children. On the other hand, whilst on the face of it the KTK and TGMD-2 separately do not cover all aspects of movement skill competence, their content is suitable for primary school children. By combining the two assessment measures this will, seemingly, cover all aspects of movement skill competence.

### 2.3.2 *Part 2: robustness of current tests of movement skill competence*

A second important consideration, when choosing an assessment tool is reliability and validity, since an assessment instrument that is not valid does not measure what it purports to measure and an assessment tool that is not reliable cannot be valid (Burton et al., 1998).

### *2.3.2.1       Validity of the three assessment tools*

A good assessment tool needs to demonstrate high reliability and validity. Validity is the quality of the assessment tool to measure reliably the movement behaviour being sought (Robertson, Burnett, & Cochrane, 2014). There are three main types of validity: content validity, criterion validity and construct validity (Cozby & Bates, 2012); all three assessment tools were investigated to see if each aspect of validity was tested in each of the three instruments.

Content validity refers to how well a specific test measures what it intends to measure. Out of the three tests, the TGMD-2 was the only one known to have undergone content validity (see Table 2.1) as part of the validation process. The next aspect of validity investigated was criterion validity which looks to understand if the test shows good agreement with an external measure or gold standard protocol. All three instruments provide criterion validity; interestingly the M-ABC uses the KTK as a gold standard measure which would attest to the robustness of the KTK instrument. The TGMD-2 shows moderate to strong correlations with the comprehensive scale of student abilities which is another test of gross motor skills and this is in line with other criterion validity findings (Logan, Robinson, & Getchell 2011; Smits-Engelsman, Henderson, & Michels, 1998; Van Waelvelde et al., 2007).

Construct validity is a very important aspect of validity for understanding movement skill competence, as it considers the ability of a test instrument to measure a theoretical construct of performance (Collins & Hodges, 2001). Put another way, it seeks to discover if the assessment tool measurement behaves in the way the theory suggests a measure of that construct should behave. Construct validity is mostly assessed through factor analysis; the M-ABC was not found to undertake any form of factor analysis. The

TGMD-2 and KTK employ two different types of factor analysis. The KTK uses exploratory factor analysis (EFA) and the TGMD-2 employs a confirmatory factor analysis (CFA). Both methods are used to understand the shared variance of the measured variables that attribute to a latent construct. A distinction between an EFA and CFA is that the CFA allows the researcher to test whether measures of a construct are consistent with a researcher's understanding of the nature of that construct, whilst the EFA is not required to have any specific hypotheses about how many factors will emerge and, as such, is exploratory in nature.

The EFA from the KTK demonstrated that the four tests load onto one factor. The TGMD-2 carried out the more complex analysis of the two. The CFA confirmed that six locomotor skills (run, gallop, leap, jump, slide and hop) load onto a single latent variable (named locomotor skills) and the six object control skills (throw, kick, strike, dribble, catch and underarm roll) load onto a single latent variable (named object control skills). For each of these models, a good model fit was discovered meaning that the skills had properly been assigned (Ulrich, 2000; Kiphard and Schilling 1974, 2007). A limitation of CFA is that it is not possible tell if these two sets of skills (locomotor and object control skills) load onto an overall FMS latent variable, and it is also not possible to compare if the KTK and TGMD-2 are measuring the same constructs of movement skill competence or different constructs within movement skill competence. This is an important line of inquiry for future research as advancements in statistical techniques have led to the development of structural equation modelling (SEM) that can look to answer the two questions posed above. SEM enables researchers to do this, first through carrying out CFA, by loading one or more observed variables on to a latent construct; and secondly, carrying out a structural regression model which allows them

to link latent constructs together or create a hierarchical model. This is an exciting development as it creates a direct conduit between our theoretical understanding of movement skill competence and what happens in the real world context. As such, SEM will be explored as a method of statistical analysis for understanding the constructs of movement skill competence throughout this thesis.

### 2.3.2.2 *Summary of the validity of the three assessment tools of movement competence*

The TGMD-2 is the only instrument for which all validity tests have been conducted. There is a distinct possibility that the KTK might include a content validity phase but this could not be substantiated. The M-ABC scored poorly compared to the other two assessment tools as it had only undergone one validity check - criterion validity and interestingly this was performed using the KTK as the gold standard measure (see Table 2-1).

Table 2-1: Validity of the TGMD-2, KTK and M-ABC

| Validity | Content Validity | Criterion Validity | Construct Validity |
|---|---|---|---|
| TGMD-2 | Three experts independently deemed the 12 skills as being important skills a child needs to develop | Moderate to strong correlations were found between the TGMD-2 and the comprehensive scale of student abilities locomotor 0.63 and object control 0.41 | EFA showed that the skills loaded on to two factors. CFA showed a good model fit with both locomotor and object control skills fitting on a FMS construct. |
| KTK | Not determined | Differentiation between typical and atypical developing children | Factor analysis showed that the test evaluated dynamic body coordination and body control |
| M-ABC | Not determined | Concurrent validity with BOTMP r= -0.53 and with KTK r = 0.62 | Not determined |

### 2.3.2.3 *Reliability of the three assessment tools*

After validity has been established the next step is to ensure an assessment tool is reliable. Again, there are three types of reliability which are commonly evaluated in assessment tool development (Cozby & Bates, 2012). The first type of reliability is intra-rater reliability; this is the degree of agreement among repeated administrations of the assessment tool performed by a single rater. The second is inter-rater reliability, this is the degree of agreement among raters. It gives a score of how much homogeneity there is in the ratings given by the different trained assessors. Finally, test–retest reliability is normally investigated, this is the variation in measurements taken by a single person using the same assessment tool, under the same conditions, with a relatively short period of time between test points.

### 2.3.2.4 *Measuring reliability*

These three types of reliability are usually assessed through intra-class correlation, also known as the intra-class correlation coefficient (ICC). The ICC describes how strongly units in the same group resemble each other. While it is viewed as a type of correlation, unlike most other correlation measures it operates on data structured as groups, rather than data structured as paired observations. The key difference between the two statistics is that in the ICC, the data are centred and scaled using a pooled mean and standard deviation, whereas in the Pearson correlation, each variable is centred and scaled by its own mean and standard deviation. This pooled scaling for the ICC is logical considering all measurements are of the same quantity (albeit on units in different groups).

The KTK was found to be the most reliable assessment tool, scoring highly on intra, inter and retest reliability (see Table 2-2). The TGMD-2 also demonstrated excellent reliability on inter and retest reliability. Whilst the inter reliability was lower than the KTK, it should still be considered excellent because it would be a lot harder to establish reliability using a process based assessment tool. In the case of the TGMD-2 the assessor has to observe the process of the movement and score multiple body segments at the same time, which is a lot more taxing and subject to error than the KTK which is a product oriented test and counts the total number of steps, hops or jumps. The M-ABC was found to be the least reliable although the inter and retest reliability were still adequate reliability testing.

Table 2-2: Reliability of the TGMD-2, KTK and M-ABC

| Reliability | Intra Reliability | Inter- rater reliability | Retest- reliability |
|---|---|---|---|
| TGMD-2 (Ulrich, 2000) | Not determined | Correlation for subtests and composites ranging from 0.97 - 0.99, r= 0.84 - 0.96,  2 examiners scoring completed protocols | Locomotion r = 0.85, Object Control: r = 0.88, Gross Motor Composite: r = 0.91 |
| KTK Kiphard and Schilling (2007) | ICC = 0.97 MQ total ICC = 0.80 backward balance ICC = 0.95 sideward jump ICC = 0.94 displacing boxes ICC = 0.96 one leg jumping | ICC > 0.85 | r > 0.85. Comparison of averages between test and retest (all non-significant) |
| M-ABC | Not determined | ICC = 0.70 | 3 raters: ICC = 0.75; 0.64 (4-6 years), 0.43 (6-8 years?), 0.96 (9-10 years?), 0.97 (11-12 years) |

### 2.3.3 *Summary of the measurement of movement skill competence*

These three tests were chosen as they are often used, or referred to, in an international

context (Bös, 2003; Burton et al., 1998; Simons, 2014). All three instruments are in

their second editions and as such are seen as providing the gold standard of movement

competence assessment in children. It can however be concluded that whilst each

measure has its strengths, individually they are not robust enough, or broad enough, to

cover all aspects of movement skill competence in children. The two instruments that

show the most potential for mainstream children are the KTK and TGMD-2. On the

face of it, these two assessment tools provide a holistic model of children's movement skill competence, though further construct analysis and data modelling is needed to substantiate or discredit this.

### 2.3.4 *Stability skills - a insufficiently understood construct*

The only construct that these two instruments do not contain, which the M-ABC does, is dynamic and static balance (Cools et al., 2009). To date, FMS research investigating either dynamic or static balance has focused on how it effects the development of locomotor and object control skills, and this has led to limited understanding (Espenschade & Eckert, 1967; Keogh, DeOreo, & Keogh, 1980; Wickstrom, 1977). A good example of this is the work carried out by Ulrich and Ulrich, (1985) who found that the composite balance test from the Bruiniks-Osertsky test of motor proficiency in 3-5 year olds significantly predicted a qualitative rating of hopping, jumping and striking proficiency, but not of other key FMS. Ulrich and Ulrich speculated that the composite score for balance may be too insensitive to assess the specific types of balance control required in other FMS. Chew-Bullock et al., (2012) in their study, did find a significant correlation between single leg balance and kicking accuracy, but not kicking velocity.

These findings are consistent with the notion that when kicking for velocity, the centre of gravity will be outside of the body, to utilise momentum so as to increase power, making it unlikely that maintaining static balance would be of importance (see Butterfield & Loovis, 1994 for similar results). These studies highlight that balance is task specific and dynamic and that one specific type of (static) balance test is potentially an unreliable measure for stability skills which are underpinned by a child's postural control system. As discussed earlier, postural control is similar to the definition of

stability skills put forward as the third construct of FMS. The absence of a suitable test to measure a child's stability skills could be a crucial missing piece of the current FMS and overall movement skill competence literature. This link may be vitally important when considering the link stability skills have, as already noted, with our sensory system. Further research is therefore needed to investigate the construct of stability skills as defined by Gallahue et al., (2012), and to see how this construct fits into the more prominent constructs within FMS and then the overall MC model.

## 2.4 Psychological Aspects Associated with Movement Skill Competence

### 2.4.1 *Physical self-concept*

Self-concept is used as an umbrella term as an evaluative indicator of self. Self-concept is referred to as one's assessment of one's own competence, attributes and characteristics that are viewed in comparisons with others (Gallahue et al., 2012). This self-assessment happens regularly during PE lessons where children are provided with opportunities to try new skills. Hence, their physical abilities are constantly on display to their peers, an experience which can lead to feelings of both success and failure. PE is therefore an educational environment that impacts upon children's physical self-concept development (Gehris, Kress, & Swalm, 2010; Goodwin, 1999). In PE, a positive physical self-concept is associated with higher engagement levels, skill development, and motor learning (Peart, Marsh, & Richards, 2005). Past research has demonstrated that if PE undermines physical self-concept, both long and short term gains in skill development can be constrained (Marsh & Peart, 1988).

Hierarchical models of self-concept have assisted in the understanding of self-concept and viewed it as a multidimensional construct that consists of academic self-concept,

social self-concept, emotional self-concept, and physical self-concept. When examining self-concept in children there are a number of issues to consider according to Rudisill, Mahar, and Meaney, (1993). Young children who are unaware of their actual competence may over or underestimate their perception of competence. According to Stein, Riddell, and Fowler, (1988) children between the ages of 5 and 8 years are also developing the formation of self-concept. Physical self-concept (physical ability and physical appearance), social self-concept (peer relationships and parental relationships), and the general self-concept subscales have been found to be important areas to develop to assist in the development of movement skills (Harter, 1999).

### 2.4.2 *Measurement of self-concept*

The widely held view of self-concept as a multi-dimensional construct has necessitated appropriate measures in the assessment of the (physical) self that reflect this structure. The Physical Self-Perception Profile (PSPP) (Fox, 1990) incorporates five domains including sport competence, physical strength, physical conditioning, body attractiveness and physical self-worth which present a multidimensional model of the physical self. The PSPP has proven to be a useful tool in the measurement of physical self-perception among older children and adults but is limited in its delivery to young children (Eklund, Whitehead, Margaret, & Welk, 1997). Harter and Pike, (1984) developed the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children which evaluates judgments in five domains of self-concept. These scales measure perceptions of cognitive competence, physical competence, physical appearance, social appearance, and behavioural conduct. In addition, there is a measure of general self-worth.

The Physical Self-Description Questionnaire-short form (PSDQ-s) (Marsh, 1997) incorporates the required multidimensional constructs for the assessment of children's self-concepts and has been used for children as young as seven years old. The PSDQ-s is comprised of nine factors or scales specific to physical self-concept: activity, appearance, body fat, coordination, endurance, flexibility, health, sport, strength, and two global scales – global physical and global esteem. The PSDQ-s has been shown to have good validity and reliability; for example, Marsh et al. (2005) reported Cronbach alphas between .57 and .90.

### 2.4.3 *Perceived movement skill competence a sub theme of physical self-concept*

Competence Motivation Theory (Harter, 1982) predicts that individuals perceiving high competence in a domain (e.g. physical activity) are more likely to engage in those domain activities than individuals who perceive low perceptions of competence. Such individuals are motivated to make a change in their own environment and engage in mastery attempts. If the attempt is successful an individual can experience intrinsic motivation leading them to further enhance their competence. However, if the attempt fails then the motivation for further attempts are decreased thus increasing negative self-perceptions. As such, it is important for children to have mastery experiences (Shapiro, Yun, & Ulrich, 2002).

Barnett et al. (2009) found perceived movement skill competence mediated actual object control competence and self-report physical activity in adolescence. This relationship has also been found to work in the reverse direction (when physical activity was the predictor) (Morgan, Van Beurden, Ball, & Lubans, 2011). This supports the idea that there is a dynamic reciprocal pathway between perceived movement skill

competence and actual movement skill competence. Babic et al. (2014) in a systematic review and meta-analysis of 59 studies examined physical activity and physical self-concept in youth. They found that perceived sport competence had the strongest relationship to physical activity compared with other aspects of self-concept. It can be argued that perceived movement competence is a precursor for actual movement competence when viewing from the reciprocal relationship of Stodden et al., (2008) model. Stodden et al. (2008) conceptualised a comprehensive dynamic model of the relationship between movement skill competence, perceived movement skill competence, health related fitness and physical activity (see Figure 2-2). This model suggests that children who have low skill levels may be drawn into a "negative spiral of disengagement" where low skill level contributes to low perceived physical competence and low physical activity levels, raising the risk of obesity. They suggested that as children mature these relationships will become stronger.
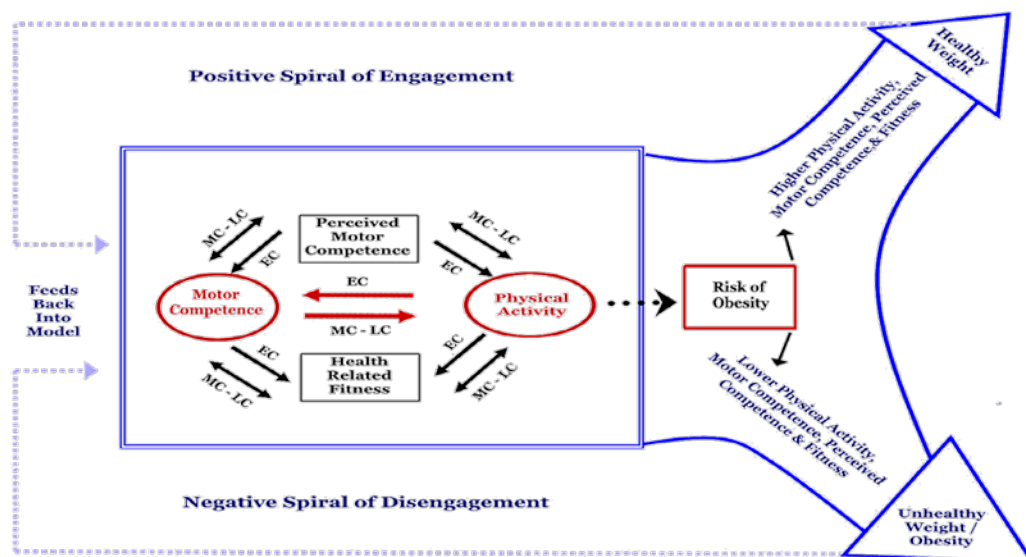


Figure 2-2: A Developmental perspective on the role of motor skill competence in physical activity (Stodden et al., 2008)

An alternative measure to the PSDQ-s is the Pictorial Scale of Perceived Movement Skill Competence (PMSC). The PMSC was developed for the purpose of assessing FMS competence perceptions among children (Barnett, Ridgers, Zask, & Salmon, 2015). It is the first tool for young children that assesses perceptions in the same FMS skills as those commonly used to test actual FMS ability. It uses the format and item structure from a well-known and well-utilised instrument that assesses physical competence self-perception (Harter & Pike, 1984). The PMSC assesses 12 perceived FMS based on the TGMD-2 (Ulrich, 2000). This instrument has shown that children's perceived FMS and actual FMS competence is associated in young children. It was also able to distinguish performance based upon gender, with girls having lower perceived object control competence (Slykerman, Ridgers, Stevenson, & Barnett, 2015), a finding which is reflected in data on actual object control skill performance (Hardy, 2011).

## 2.5    Epidemiology of Movement Skill Competence

### 2.5.1 *Current levels of movement skill competence in Australian children*

Currently, in Australia many children are not progressing from a rudimentary form to mastery in many locomotor and object control skills (Barnett et al., 2013). For instance, in New South Wales (NSW) children have continuously been found to score below 40% in five out of six FMS (run, vertical jump, side gallop, leap, kick, over-arm throw and catch) and are entering adolescence without having mastered these skills (Hardy et al., 2011). In Western Australia over the past 30 years, 27,000 primary school-aged children have been assessed, both in terms of their skilfulness and fitness. The findings have demonstrated a marked decline in six to 12-year-old children's general physical fitness and skilfulness. The biggest decline was observed in six-year-olds, who now perform markedly worse than those assessed in the 1980s in simple tasks such as underarm

throws, catching and bouncing balls (Tester et al., 2014). Similar poor levels of movement skill competence have been found in England (Foweather, 2010; Morley, Till, Ogilvie, & Turner, 2015) and western mainland Europe (Bös, 2003; Vandorpe et al., 2011).

### 2.5.2 *Importance of movement skill competence in children's health and wellbeing*

Low movement skill competence has been found to be associated with several poor health outcomes including low physical activity, poor physical fitness, low perceived movement skill competence and an inverse relationship with weight status (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009; Stodden, Gao, Goodway, & Langendorfer, 2014; Vlahov, Baghurst, & Mwavita, 2014). In addition, FMS has been found to predict levels of physical activity and physical fitness in later life (Jaakkola et al., 2015; Lubans et al., 2010; Robinson et al., 2015). Barnett et al. (2008) found that mastery of object control skills in childhood accounted for 3.6% and 18.2 % of participation in moderate-to-vigorous physical activity and organized physical activity, respectively, during adolescence. This supports the premise that FMS skills, especially object control skills, are important skills for a child to learn and will put them in good stead for an active lifestyle across the lifespan (Ahnert, Schneider, & Bös, 2009; Stodden et al., 2008).

### 2.5.3 *Chronological age of FMS mastery*

Research showing when a child should move from a rudimentary form to mastery in any FMS is scant. Despite this lack of evidence there are guidelines which state that if children are exposed to practice and guidance it should take anywhere between four and ten hours to master FMS (Walkley et al., 1993). However, according to the New South

Wales Department of Health's (2010) Schools Physical Activity and Nutrition Survey (SPANS) (Hardy, 2011), ten hours of purposeful practice is needed for the majority of children to master each FMS. SPANS also predicts that by the age of nine, 80% of children should have mastered the key FMS. These guidelines lack empirical evidence. In a highly controlled series of studies on pilots in the Second World War it was stated that for a pilot to move from the motor phase to the autonomous phase it took approximately 100 hours of practice (Fitts, 1964). Although FMS skills are a lot simpler it might still be expected that it would take more than ten hours for children to master a new skill.

### 2.5.4 *Lack of empirical evidence in policy recommendations*

The lack of empirical research underpinning recommendations are epitomised by the United States of America Physical Literacy Plan for the USA and the rest of the world (Project Play, 2015). Project Play is the latest in a long line of policy recommendations to improve movement skill competence through the development of FMS as a driver for improving physical activity and healthy behaviours. The FMS contribution to this report is based upon research carried out in 1982 by Seefeldt and Haubenstricker (1982). The reliance on historical data collected more than three decades earlier is symptomatic of the lack of progression in our collective understanding of FMS trajectories in children. Project Play (2015) disregards recent research outlining the importance of object control skills, and the opening infographic (see Figure 2-3) states that 'the three constructs of FMS which children must develop to be physically active are locomotive skills, balance skills and swimming'.

Figure 2-3: Project Play importance of FMS (Retrieved from http://plreport.projectplay.us/ )

The exclusion of object control skills in this infographic is nonsensical in view of the fact that a large body of concurrent literature has found object control skills essential to improved participation in physical activity and sport (Vlahov, Baghurst & Mwavita., 2014; Barnett et al., 2008). Furthermore, the second infographic (See Figure 2-4) which is revised from Seefeldt and Haubenstricker (1982), suggests that between the ages of 5 - 7, 60% of children should be able to demonstrate proficiency in several basic FMS, with half these skills being object control skills.
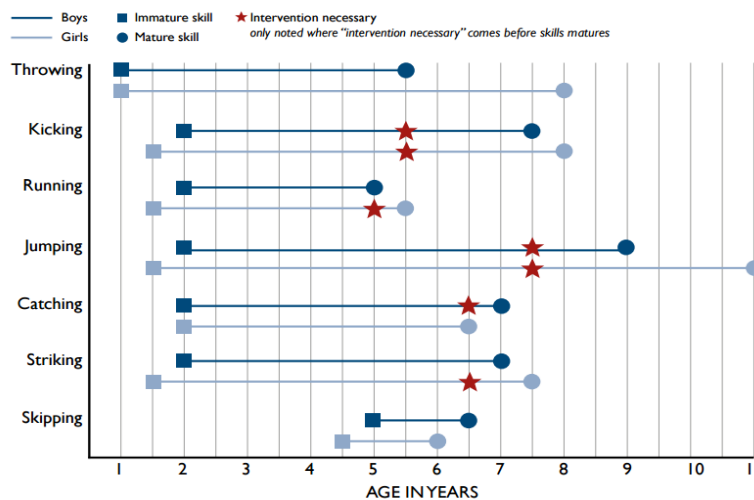


Figure 2-4: FMS developmental trajectories in children (Retrieved from http://plreport.projectplay.us/ )

On examination, the original paper by Seefeldt and Haubenstricker (1982) largely focuses on the observational stages of the development of the overarm throw, and does not include intervention points. Instead, Seefeldt and Haubenstricker (1982) state that in the process of developing a masterful throwing, striking and or kicking action a high level of foundational postural control and movement demands are needed; and if children are not sufficiently mature at this stage, more time will be needed in order to master the development of the step with the collateral leg and trunk rotation. At no point in the Project Play report is this mentioned, instead it states that the star indicates '*the age at which experts say children require an "intervention," or "teaching effort, to help them develop a skill'* (Project Play, 2015; p. 6). The report fails to state what kind of intervention is required, or indeed why the age designated by the star has been chosen. A reference is provided for another report for parents setting out guidelines for the development of 'physical literacy' (Higgs et al., 2014) but neither report supplies a reference for the source of this expert opinion. Given the term physical literacy has gained currency across the globe, it is unfortunate that the current definition lacks detail leading to vague guidelines such as those found in the Project Play report.

Australia has attempted to operationalise the development of movement skill competency through introducing the Foundations, Talent, Elite, Mastery (FTEM) framework, this is an athlete development framework created by multidisciplinary sport practitioners (Gulbin, Croser, Morley & Weissensteiner., 2014). FTEM is unique in comparison with alternative models and frameworks, because it integrates general and specialised phases of development for participants within the active lifestyle, sport participation and sport excellence pathways (see Figure 2-5).
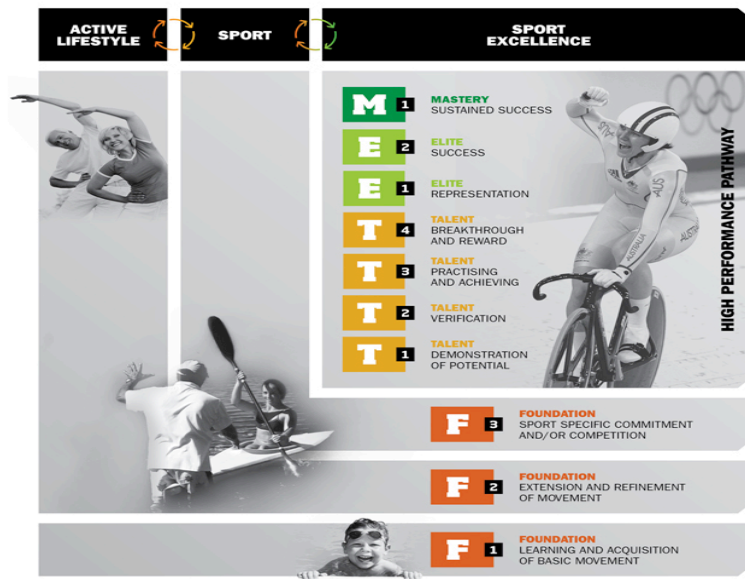
Figure 2-5: The integrated FTEM (Foundations, Talent, Elite, Mastery) framework for the optimisation of sport and athlete development. (Retrieved from www.clearinghouseforsport.gov.au)

The relevant area of focus for this thesis is the foundation phase (F 1-3) and the framework highlights that those who do not progress out of F1 the FMS stage will lead inactive lifestyles moving forward. Children who do progress beyond F1 will refine these skills in F2 through participating in informal and formal small sided games. The transition out of F2 and into F3 is characterised by an increase in commitment to training, sport specific skill development, and/or formal engagement in competition. This framework, whilst appealing, fails to provide a model showing how children progress through these vital phases and graduate to physical activity participation and elite sport.

2.6　　　**Developing Movement Skill Competence through PE**

2.6.1　*Movement skill competence - learned through doing, or needs to be taught?*

The third contentious issue with regards to FMS is whether these skills develop through maturation and opportunity to participate in informal play or need to be developed through instruction and teaching. Literature shows that FMS are best developed through exploration, with children having opportunities to practice specific skills within an appropriate environment with the required space, equipment and instructor led positive reinforcement (Barnett, Hinkley, Okely, & Salmon, 2013). A number of early childhood intervention programmes (Goodway & Branta, 2003; Robinson & Goodway, 2009a; Robinson, Rudisill, & Goodway, 2009b) have shown that when young children are provided with well-equipped free play time, they do not significantly improve their FMS, and that instruction and extrinsic guidance are essential for improvements. Three recent systematic reviews confirm that interventions improve children's movement skills beyond what can occur in free-play (Logan, Robinson, Wilson, & Lucas, 2012) or ecological control groups (Iivonen et al., 2013; Morgan et al., 2013).

Newell, (1986) created a model to explain how the information from the environment and tasks we carry out in our everyday lives directly constrains our actions. Newell's model dictates that coordination of all movement patterns is shaped by interactions among three categories of constraint: organismic, environment, and task (see Figure 2-6). Conceptually, each category is represented on one point of a triangle and coordination emerges as a product of contributions from the three elements or constraints. As such, the human body does not prescribe any coordination patterns (skills) to be more fundamental than any other, but it is the interaction between the three

constraints that dictates whether a movement pattern is fundamental for a child's everyday life.
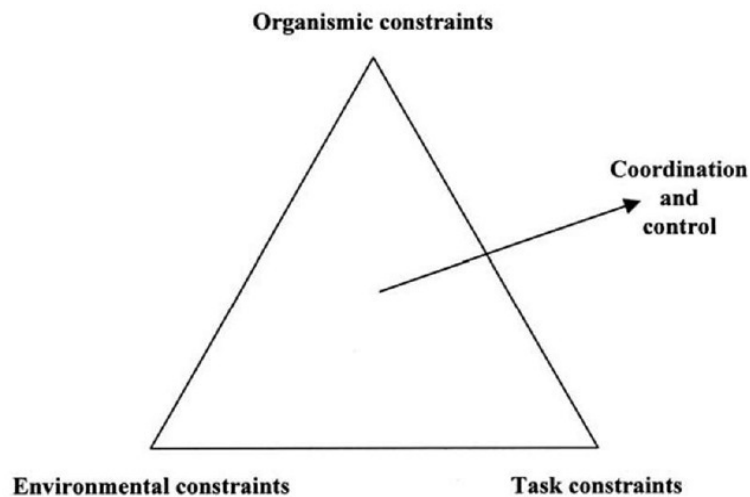


Figure 2-6: Diagrammatical representation of constraints based model (adapted from Newell, 1986)

Newell's constraints based model is commonly used to understand the factors which affect movement skill development and learning and should therefore be considered when planning any intervention to develop movement skill competence. For example, one needs to consider organismic constraints such as body shape, height and weight, and, at a microscopic level, functional constraints such as the sensory system and postural control. Environmental constraints are external to the organism and can include general constraints, such as surface or weather, or task-specific constraints (which are not necessarily mutually exclusive) such as a playing surface.

Task-specific constraints are linked to the goal of the activity and are influenced by the goal itself, rules affecting goal achievement, equipment and other participants involved. Previous research using this approach has neglected the role of the instructor and has

instead focused on the environment and equipment to improve movement skill competence, although Newell (2002) himself advocates the importance of instruction in the development of movement skill competence. In summary, children developing movement skill competence will benefit from integration of instruction and modelling when learning these skills for the first time: this is similar to Fitts and Posner's (1967) cognitive stage.

### 2.6.2 *Improving movement skill competence within the education system*

The Australian government recognizes that PE and sporting programmes in schools have the potential to make children active for the rest of their lives (Australian Curriculum & Authority, 2012; Ellis, 2010). PE in schools has the potential to enable children to be healthy and engaged learners at school (Sallis et al., 2012). A key outcome of PE is to develop children's movement skill competence so they can engage in an active lifestyle during and beyond school years (Barnett et al., 2013). As such, PE has been the area of focus for many Australian researchers over the last two decades (Booth et al., 1999; Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2015; Hardy et al., 2013; Lai et al., 2014; Morgan et al., 2008; Okely & Booth, 2004).

### 2.6.3 *The role of current PE in improving movement skill competence*

Several systematic reviews of school based interventions have been conducted in recent years and these have provided a positive step forward in highlighting the key features of effective interventions to enhance movement skill competence. Morgan et al. (2013) conducted a systematic review and meta-analysis of 22 intervention studies to improve FMS and evaluated the evidence for the benefits of these FMS interventions in school settings. Logan and colleagues carried out a similar systematic review of 21 studies although this also included typically and a-typically developing children. Dudley,

Okely, Pearson and Cotton (2011) carried out a systematic review of published literature on the effectiveness of PE in promoting participation of physical activity, enjoyment of physical activity and movement skill proficiency in children and adolescents; a total of 23 articles met the inclusion criteria and were included in the review. These systematic reviews will be discussed in the next section, specifically information pertaining to outcome measures, the methodological design and theoretical framework will be highlighted.

Morgan et al. (2013) reported findings from a meta-analysis and systematic review that examined a total of 22 studies aimed at developing FMS in children and adolescents. Studies were only included in the review if they measured children enrolled in primary or secondary school, studies targeting overweight/obese children or children from schools in disadvantaged areas were included, but those where participants had developmental coordination delays were excluded. Results indicated that the pooled analysis across all studies showed statistically significant intervention effects for overall gross motor development, locomotor skills and object control skills. Morgan and colleagues revealed large effect sizes for overall gross movement competence (SMD = 1.42) and locomotor skill (SMD =1.42) competency and a medium effect size for object control skill (SMD= 0.63) competency. The authors suggested that whilst these findings are positive for FMS improvements following the interventions, the results should be interpreted with caution because of the high risk of bias found in analysis. This was due to a lack of adequate detail in the published studies which meant there were no obvious factors which had led to superior FMS development, different studies provided contrasting dose responses, pedagogical styles and settings that had led to enhanced movement skill competence.

A large proportion of studies cited in this review were a-theoretical, in that they lacked a framework to guide and consider the important factors which may significantly influence movement skill competence. Two studies from the review did include an underpinning theory. Karaboutniotis, Evaggelinou, Tzetzis (2002) and Martin, Rudisill, and Hastie, (2009) utilised self-determination theory (STD) for creating a mastery oriented pedagogical approach and found that when the learner experienced autonomy, was given developmentally appropriate tasks, and received individualised feedback this led to the greatest improvement. These outcomes support the view that basing research in a theoretical framework is advantageous for the development of movement skill competence. That said, the results of these two studies were not the same. Martin et al. (2009) found large significant improvements in FMS after 900 minutes intervention time whilst the study by Karaboutniotis et al. (2002) showed a significant, but smaller effect on FMS development after a 960 minute intervention. SDT theory is an excellent theory for developing pedagogical design, but it does not account for other important factors which underpin the development of movement skill competence such as biological maturational, gender and socio economic background which have all been found to influence movement skill competence (Hardy et al., 2013; Okely & Booth, 2004). To account for these factors a theoretical framework is needed that accounts for, or considers how, children's movement skill competence is developed. For example, one limitation of this systematic review by (Morgan et al., 2013) is that, even though it included a combination of process and product measures, it only focused on the assessment of locomotive and object control skills. It did not evaluate studies which limit the assessment of stability skills to a static balance and did not include general body coordination which are both highlighted as important areas of movement skill

competence in children according to dominant theories and frameworks of movement skill competence.

Dudley et al. (2011) reported that four out of the 23 studies showed statistically significant intervention effects on movement skill development. Overall, evidence suggested that the most effective strategy to increase children's levels of physical activity and improve movement skill proficiency in primary schools was direct instruction, a prescribed curriculum, adopting a whole-school approach to physical activity and providing teachers with sufficient, ongoing professional development in using PE instruction methods and curriculum. This finding is consistent with a recent meta-analysis which suggests that direct-instruction teaching strategies have medium effect sizes on targeted intervention groups in educational settings (Hattie, 2009). Dudley et al. (2011) highlight that a lack of high quality evaluations and adequate statistical power hampered their conclusions.

The reviews by Morgan (2013) and Dudley (2011) highlighted that the quality of instruction by highly trained, competent and confident individuals is of utmost importance in improving FMS competence. Evidence from the United Kingdom suggests, however that investing large amounts of money to achieve competent and confident delivery of PE is not solely the answer. The United Kingdom invested in excess of £2.5 billion ($5.5 billion dollars) into PE and school sports between 2002 and 2010. Its overall objective was to reduce sedentary activity and levels of obesity in children (5–16 year-olds) through enhancing the take-up of sporting opportunities (Foster 2015) . It set an ambitious target to engage children in two hours of high quality PE and sport at school each week and gave the schools the resources to carry this out. The number of non-teaching adults in primary schools increased dramatically (Lavin,

Swindlehurst, & Foster, 2008). In 2004, there were as many as 138,000 individuals delivering 'sports sessions' within primary schools who were not qualified teachers (Sports Coach UK 2004). Increasingly, coaches were found to be delivering curricular PE lessons (Blair, Capel, Breckon, & O'Neill, 2006). Concerns were raised by Griggs (2007) that this approach would do 'more harm than good by embracing the sporting community within a system that they do not understand' (p. 66), he cited a lack of knowledge and understanding of the National Curriculum for PE, classroom management skills and personal knowledge of the children and their individual needs and abilities (Griggs 2007, p36). Findings from the Health Survey for England add weight to this argument as the proportion of both boys and girls aged 5-15 meeting the recommended physical activity guidelines fell between 2008 and 2012. The largest declines were at ages 13 to 15 for both genders. This evidence from the UK highlights the importance of having a deep understanding of the broader educational climate and how PE is delivered within this context.

### 2.6.4 *Current context of PE in Australian schools*

The majority of PE lessons in Australian primary schools are delivered by classroom teachers. There is little data establishing the current day-to-day duration, frequency and content of primary school PE lessons in Australia, because many existing data may not capture typical practice. A recent study by Keagan and Telford (2015) aimed to capture the practice of classroom primary teachers in delivering regular PE lessons. This is an important area of study as classroom teachers are responsible for 80% of the target allocation of 150 min/week of PE, even where the school does have a specialist PE teacher. A strength of this study is that it is focused on state primary schools. It did not rely on pre-arranged appointments to conduct observations and, as such, had ethical

approval to carry out on the spot checks. A total of 91 random, unannounced one-hour visits were conducted from which 27 PE lessons were observed. The results make bleak viewing, as on average, children received 13.5% of the mandated 150 minutes per week of PE from the classroom teachers. PE lessons were an average of 30.4 minutes (SD = 11.3 min), of which 38% (M = 11.02 min) was coded as moderate to vigorous physical activity (MVPA). A total of 62 per cent of time was spent with the children being sedentary. Regarding teacher interactions, 47% of class time was spent observing, 35% giving instructions, and 15% managing behaviour, with little or no 'promotion of fitness' or 'demonstration'. Thirty two per cent of class activity was devoted to management, with 26% game-play, 22% skill practice, and 11% coded as fitness activity. The study concluded that PE delivered by classroom teachers in state-run primary schools did not meet the mandated 150 minutes per week of PE, nor did it contribute meaningfully to the recommended 300 minutes per week of MVPA. The overall pattern of instruction could be described as "tell-and-do", focusing on instruction and observation/monitoring and certainly not mastery oriented climates which are regarded as being important for children's motor skill development and enjoyment of PE.

In the next section there is a discussion of whether PE specialists, classroom teachers or sports coaches are best equipped to teach PE in primary schools, with a view to understanding who might best be placed to deliver the Australian Gymnastics Program, Launchpad.

### 2.6.5 *Who should be responsible for teaching PE in Australian schools?*

#### *2.6.5.1 The Physical education teacher*

PE delivered by specialist PE teachers has been found to have a number of positive benefits in primary school aged children. The S.P.A.R.K study investigated the effect of trained physical education specialist teaching PE compared to trained classroom teachers over a two year period. The study found physical education specialists were superior to trained classroom teachers in most outcomes i.e. specialists spent more time in physical education classes, provided students with more physical activity, and enhanced female students' fitness. Another study which investigated the delivery of PE by specialist PE teachers found both health and academic benefits, including reduced incidence of elevated low density lipoprotein cholesterol, insulin resistance, percentage of body fat and improved numeracy and literacy compared to classes taught by the class teacher (Telford et al., 2012). These findings offer strong support for the position of the PE teacher in Australian primary schools and a good argument that PE teachers should deliver PE in schools. Unfortunately, across Australia PE is mainly taught by the classroom teacher. The LOOK study (Telford et al., 2013) situated in Canberra found that in 30 randomly selected primary schools there were only two specialists PE teachers. Similar findings have been reported in NSW where PE is generally taught by classroom teachers (Hardy et al., 2011).

#### *2.6.5.2 Classroom teacher*

Talbot (2008) observed that the best quality PE she has seen in primary schools has been 'delivered by primary teachers who were not PE specialists, but specialists in children's development… who know the children they teach well' (p. 7). For Talbot, the answer is to develop the confidence and competence of primary school teachers to

deliver high quality PE. However, many classroom teachers lack the confidence and competence to teach PE in schools. Classroom teachers perceive PE as one of the most challenging subjects in the curriculum to deliver (Katene & Edmondson, 2004; Chappell, 2006). This is largely due to the fact that classroom teachers only have a very small percentage of their pre-service training dedicated to PE (Morgan & Bourke, 2005). One study found that the quality of a teacher's own school PE experience directly predicts his or her confidence to teach PE (explaining 30% of the variance; (Morgan & Bourke, 2008). Another factor is that PE has been marginalised in primary schools and is no longer seen as a curriculum priority (Hardy, 2011; Moneghetti, 1993). This decline in priority has been found to have had an impact upon the quality and quantity of gymnastics in primary schools (Smith,. 1989).

### 2.6.5.3 *Sport coach*

An alternative mode of delivery is to use specialised sport coaches. This is an attractive proposition for the national governing bodies as it offers them a direct presence within schools and has the potential to boost participation levels at local clubs from children who enjoy sport in their curriculum time. This arrangement might also be viewed positively by the school senior leadership team. The strong focus on academic achievement, through NAPLAN, which the government uses to judge schools' success, means that school principals are mindful of timetabling constraints and the need to consider teachers' planning time. In South Australia, for example teachers need to have 16% non-instruction time and account must be taken of teachers' requests regarding the lessons they wish to be covered. These timetabling constraints, coupled with the reported reluctance of class teachers to teach PE (Morgan & Hansen, 2008), mean that employing coaches might well appear to be an attractive option for organising cover,

particularly as employing a PE teacher is a hefty cost on a school's budget compared to bringing in a local coach to cover PE lessons for a minimum hourly rate of pay (Griggs, 2010). However, concerns have been raised that placing coaches in schools to teach PE can do 'more harm than good by embracing the sporting community within a system that they do not understand'. This view was borne out by research identifying that coaches working in primary schools lacked a significant amount of information and training possessed by the regular classroom teacher which was fundamental to effective teaching and learning (Griggs, 2007).

### 2.6.6 *A new delivery model to improve PE in Australian primary schools*

In the light of these findings, it would seem that the best vehicle for delivering a PE intervention in the primary school context could be one which involves PE teachers, classroom teachers and coaches coexisting in a professional capacity. This premise would see them working in unison with a common goal of providing a quality PE experience that develops children's movement skill competence, confidence and laying the foundations for an active life. Theoretically, working with coaches who have an in-depth knowledge about a sport could build the confidence of primary classroom teachers to deliver PE. The model would provide a complementary synergy of content and pedagogical knowledge with all working together to provide a high quality PE experience for all children. It would further support the theoretical position that encourages teachers and coaches to engage in the social construction of knowledge and understanding (Lave & Wenger, 1991; Wenger, McDermott, & Snyder, 2002). Having considered a delivery model the next is to review an effective design for the curriculum intervention.

2.7 **Importance of a Strong Study Design**

Morgan et al. (2013) and Dudley et al. (2011) highlighted the importance of a strong study design and recommended the use of Consolidated Standards of Reporting Trials and Transparent Reporting of Evaluations with Non-Randomised Design Statement (CONSORT). Reithmuller et al. (2009) conducted a systematic review of controlled trials on the efficacy of motor development interventions in young children. This was focussed on the process of the study rather than the FMS outcome. It looked at the design, methodological quality, intervention components, and application of the CONSORT and Transparent Reporting of Evaluation with Nonrandomised Designs (TREND) statements. In total, 17 studies met the inclusion criteria of being a control or randomised control trial, and on average the interventions lasted 12 weeks with a mean duration of one hour per week. The interventions themselves were either delivered by teachers, researchers, or students and nearly 60% of the studies reported statistically significant improvements following completion of the intervention.

Reithmuller et al. (2009) deemed 20% of the studies to be of high methodological quality, despite the fact that to qualify, studies were only required to meet five out of the ten items on the risk of bias checklist for the control trials; and six out of ten for the randomised control trials. The majority of these studies did cover the basics such as assessment using a validated measure (80%) and assessment of control and intervention groups at comparable times (70%). Only one study used 'intention to treat analysis' for missing data and had a follow-up after pre-test, although in actual fact, mixed linear modelling would have been a better way to handle missing data, since when using 'intention to treat' it assumes no changes, and this is unlikely to be the case in interventions with young children. Just under one third (30%) of the studies compared

baseline characteristics between groups and accounted for potential confounders in analyses.

The need for clear transparent reporting is an essential aspect of delivering high quality research aimed at improving movement skill competence, for if this is not carried out the chance of type one error is increased. Ideally, whole year groups and classes of children should be recruited to maximize sample size. If a whole year group is recruited, then a cluster randomized, controlled trial would be desirable. Interventions that focus on movement skill competence outcomes should be methodologically sound and follow guidelines detailed in the TREND statement, ensuring transparent reporting. Attention should be given to longer interventions; using assessors who are blind to group allocation and adopting validated measures of motor development. Comparing baseline characteristics is also essential for a successful movement skill intervention study. However, affordability is also of paramount importance. The cost associated with running RCTs, if applying all of the above guidelines, could be prohibitively expensive. For example, clustered randomised controlled trials should take into consideration the SES of schools/pupils, which could lead to very large sample sizes and the number of researchers necessary to do assessments would simply be unaffordable. There appears therefore to be a real disconnect between the advice for researchers, and what is practically feasible.

### 2.7.1 *School based interventions to improve movement skill competence*

To date, Australian interventions to improve movement skill competence, and especially FMS, have focused primarily on improving the specific skills examined by assessment tools such as the Test of Gross Motor Development (Ignico, 1991; Karaboutniotis et al., 2002), TGMD-2 (Cliff et al., 2011; Cohen, Morgan, Plotnikoff,

Callister, et al., 2015) or 'Get Skilled, Get Active' (Salmon et al., 2005; van Beurden, Zask, Barnett, & Dietrich, 2002). A common theme in these interventions has been that children are provided with a learning environment in which, explicitly or implicitly, they practice the object control and locomotor aspects of FMS. For example, Martin et al. (2009) used a mastery motivational climate that allowed students to move freely through FMS stations. The finding that the practice of specific skills leads to significant enhanced performance of these skills at the post-test assessment is not of great surprise. Furthermore this type of skill practice is not sufficient to develop the all round movement skill competence which is required to participate in many different sporting and physical activity settings (Balyi & Hamilton, 2004). Retrospective research of elite athletes has shown the importance of the sampling years for trying out different sports and learning a broad range of movement skills and not specialising in a few skills (Hornig, Aust, & Gullich, 2014). In view of this, it would seem that assessments and interventions are needed which can support 'all round' movement skill competence and equip children with a broad range of skills to enable them to participate in a variety of sports.

Recent research tends to see perceived movement skill competence as being the principle determinant for physical activity participation (Barnett et al., 2011; Cohen, Morgan, Plotnikoff, Barnett, & Lubans, 2015; Robinson et al., 2015). Ntoumanis and Biddle (1999) have shown that skill mastery (task oriented) sport programmes and "task-based" motivational climates as used in Martin et al (2009) study, are key to high participation rates and long-term engagement in physical activity and sport. Many sport activities are inherently competitive and ego-oriented in that they are focused on winning or losing. Primary school gymnastics, on the other hand, is by its very nature

task-oriented and focused around the development of skills in a fun, non-pressured environment (Halliburton & Weiss, 2002). Halliburton and Weiss (2002) found task mastery orientations advantageous to the gymnast's motivation and adherence; this was especially true in younger, less skilled female gymnasts. This suggests that gymnastics could be an appropriate vehicle for developing movement skill competence.

### 2.7.2 *History of gymnastics in the Australian PE*

Australian PE was originally based around corporeal education, this was influenced by interpretations of Swedish and German gymnastics introduced by educators and practitioners from Europe and Britain who migrated to Australia (Wright 2011). Gymnastics activities were, for a long period, the only form of PE taught in Australian government schools and were used as a guise for military preparation and conditioning (Kirk & Macdonald, 1998). Though well intentioned (i.e. to provide Australia with a fit and strong fighting population), it was regarded by teachers and students alike as dreary and repetitive (Kirk & Macdonald, 1998). Techow, like other physical educators of his time was influenced by Ling's Swedish gymnastics model. Gustave Techow (1866) was in a constant battle with the Victoria Education Department to provide 'a more liberal and meaningful' interpretation of PE in the elementary school system. Physical educators led by Techow espoused a philosophy of PE that emphasised health and individual development/achievement and the idea that physical activity, particularly for children, should be pleasurable.

*"The subject of physical education, long consigned to neglect, is beginning at last to obtain a share of that attention which its importance demands. It has become a recognised fact, that the body can be educated as well as the mind; that the one is*

*capable of improvement by culture as the other." Gustave Techow, Melbourne, 1866*

*(quoted in Crawford, 1992: pp170)*

By the 1930's PE teachers were predominately female, and had moved away from the Ling system as they felt it was too regimented for children. As a result, they began to practice a more creative form of gymnastics, though since the 1950's gymnastics in Australia has been in decline, both in terms of the quality of gymnastics being taught and the time given to it within the curriculum (Smith, 1989). Wright, (2006) argues that a reason for this is that Australian PE has seen an increased presence of sport education and sport pedagogy at the cost of perceived feminist sports such as gymnastics.

### 2.7.3 *Gymnastics Australia's proposal to improve movement skill competence in PE*

In July 2010, Gymnastics Australia (GA) received funding from the Australian Sports Commission to fund a 'Fundamentals for Life' initiative to increase movement skill competence in Australian children. GA sees gymnastics as being synonymous with movement: moving in gravity defying ways with coordination, fluency and timing. GA considers gymnastics has the potential to become the 'Nursery of Australian Sport' and believes that the introduction of a gymnastics based curriculum with better training and support for primary school teachers can improve Australian children's movement skill competence. To achieve this, GA designed a LaunchPad program aimed at children under the age of 12 years. Its resources are divided into three levels: KinderGym aimed at 2-5 years; GymFun for children aged 5-8 years; and GymSkills for children aged 9-12 years. While these resources are broadly age related they are not age dependent. This means that deliverers should use age as a guide to the selection of resources but the deciding factor should be a child's actual competence level. Each set of resources

contains a set of chronological lesson plans, with each lesson building upon the previous one, and skill cards to complement the lesson plans. There are several possible delivery options available to GA to implement their programme, such as gymnastics qualified coaches, classroom teachers and primary PE teachers.

## 2.8    **Gymnastics and Movement Skill Competence**

Gymnastics requires a great diversity of movements in different directions (forward, sideways and backward), on different levels (head level, hip level and horizontal level) and around different axes (frontal, sagittal and vertical) in a controlled manner (Novak et al., 2008). Children are challenged to move with poise, efficiency from dynamic balances to static balances, as well as moving in gravity defying ways on and off equipment (Culjak, Miletic, Kalinski, Kezic, & Zuvela. 2003).

A number of cross–sectional studies have found gymnastics to have positive benefits on general coordination and postural control. Bencke, Damsgaard, Sækmose, Jørgensen, Jørgensen, and Klausen (2002) investigated the effects of specific sports training on motor coordination and anaerobic power in 184 children from different sports (swimming, tennis, team handball and gymnastics). Whilst no difference was found for anaerobic power, the gymnast specific training resulted in better motor coordination in the jumping tasks compared to the other sports.

Calavalle, Sisti, Rocchi, Panebianco, Del Sal, and  Stocchi (2008) compared the postural performance of female rhythmic gymnasts to a group of female university students. The findings suggested that gymnastics training enabled gymnasts to have a broader lateral direction (side to side) postural control. The authors suggested that gymnastics training seemed to have a direct effect on the ability to maintain bipedal

posture, which may confirm the "transfer" hypothesis of gymnastics expertise to bipedal postural sway (Calavalle et al., 2008). Similar findings have been found in children. Garcia et al. (2011) found significant improvements in bipedal (static upright two foot stance) postural control in 5-7 year old gymnasts compared to non-gymnasts. Despite these positive results, there has been a dearth of research investigating the effects of a gymnastics intervention on children's development. Only two studies were found to have investigated the effects of longitudinal gymnastics training on primary school children. Culjak, Miletic, Kalinski, Kezic, and Zuvela, (2014) carried out an 18 week gymnastics intervention on FMS development and Alpkaya, (2013) investigated a 10 week gymnastics programme on aspects of children's physical fitness; these studies are discussed in depth below.

Culjak et al. (2014) examined whether an 18 week gymnastics curriculum (135 minutes per week) with 75 grade one children (seven years old) improved FMS development. Children were assessed on their FMS skills using an FMS obstacle course, and were also assessed on specific gymnastics skills (forward roll, descended backward roll, handstand against wall, cartwheel, springboard jump with running start, switching positions on the rings, front of the foot walking on a small beam, forward jump-off a small beam). Overall findings showed children improved their scores on both the FMS obstacle course and all eight gymnastics skills. They concluded that learning gymnastics at a young age will not only improve gymnastics skills but will also, through the mastery of basic gymnastics skills, provoke improvement in FMS. However, the study had a number of important limitations. Firstly, there was no control group and consequently it is difficult to know whether the gymnastics lessons were the catalyst for FMS improvement. Another issue was the choice of assessment tool, as neither the FMS

or gymnastics test have undergone previous validation and reliability testing. Culjak et al. (2014) stated that a high correlation between the FMS test protocol and the TGMD-2 ($r = .82$) had been reported in a study with 8 year old children. However, it is clear more work needs to be done to validate this FMS test for children across the primary school age range as well as to undertake other validity and reliability measures which were covered earlier in this review. In addition, no validation was conducted for the gymnastics test battery. Considering the nature of the intervention, it is not surprising that the children showed improvements on these tests. The statistical procedures used are also problematic. The authors of this study conducted multiple t-tests without appropriate corrections for a number of comparisons increasing the chance of type-1 error (Duncan, 1955). The lack of validity of the assessment tool and insufficient reporting of standard deviations for mean scores could indicate that reported correlations between the gymnastic tests and polygon test could be due to large variance in the mean data points.

Alpkaya (2013) investigated the effect of gymnastics in addition to the standard PE curriculum in 7- 8 year olds. This study benefitted from the addition of a control group which meant direct comparisons could be made between a gymnastics group and a standard PE group on their performance on various children's motor skills and strength tests (dynamic balance, standing long jump, leg curl up test, trunk lift, bent arm hang and push up). Both the control and the gymnastics group undertook two hours of standard PE; however they did not outline what was included in this curriculum. In addition to this the gymnastics group undertook an additional two hours of gymnastics per week. Paired sample t-test showed significant improvements in all motor and strength tests in favour of the gymnastics groups. The authors concluded that PE classes

alone did not affect children's motor performances and that the improvements were due to the additional gymnastics sessions. The overall design was better than Culjak et al (2014) study due to the inclusion of a control group, however there are still a number of limitations which should be addressed. Firstly, the study was underpowered; 15 children in the gymnastics group and 15 in the control group coupled with using paired sample t-tests on the six tests increases the likelihood of type 1 error (Duncan, 1955). Secondly, although the assessment tools are widely established, the methods section of this study does not mention any reliability assessment for research assistants or any training they may have undertaken. Finally, the changes observed in motor skills may be the result of dose response rather than the gymnastics activities themselves. The two additional hours of any physical activity programme which incorporates instruction is likely to observe a significant improvement in motor skill performance (Logan et al., 2012; Morgan et al., 2013).

In summary, whilst both of these studies investigated the effects of gymnastics over a substantial period of time the findings are of limited significance due to the lack of rigour in the studies' methodology. Due to poor design, the study by Culjak et al. (2014) lacked a control group, and whilst the Alpkaya (2014) study included a control group, the disaprity in the doses of activity makes it impossible to substantiate whether improvement seen in Movement skill competence was due to the effect of gymnastics teaching or merely the time engaged in instruction. Furthermore, the type of analysis used in both studies was inappropriate due to the increased chance of Type 1 error. In conclusion, these studies have significant flaws and greater rigour is needed in future research studies that aim to evaluate the effect of gymnastics in developing children's movement skill competence.

### 2.8.1 *Potential of gymnastics as a vehicle for developing movement skill competence in primary school age children*

Cross–sectional studies have shown that gymnastics can have a positive benefit on movement skill competence. A possible explanation for this is that gymnastics training, as noted above, enhances the development of the efficiency of a person's postural control system (Calavalle et al., 2008; Garcia et al., 2011). Postural control is no longer considered simply a summation of static reflexes but, rather, a complex skill based on the interaction of dynamic sensorimotor processes (Horak, 2006). As described by Horak, (2006) the two main functional goals of postural behaviour are postural orientation and postural equilibrium. Postural orientation involves the active alignment of the trunk and head with respect to gravity, support surfaces, the visual surround and internal references. Sensory information from somatosensory, vestibular and visual systems is integrated, and the relative weights placed on each of these inputs are dependent on the goals of the movement task and the environmental context. Postural equilibrium involves the coordination of movement strategies to stabilise the centre of body mass during both self-initiated and externally triggered disturbances of stability. The specific response strategy selected depends not only on the characteristics of the external postural displacement but also on the individual's expectations, goals and prior experience. Anticipatory postural adjustments, prior to voluntary limb movement, serve to maintain postural stability by compensating for destabilising forces associated with moving a limb. The amount of cognitive processing required for postural control depends both on the complexity of the postural task and on the capability of the subject's postural control system.

The finding that gymnastics enhances the postural control system in children is exciting and has potential effects beyond children's stability skills. It is possible that the development of postural control could help reverse the current low levels of object control skills seen in primary school children. In support of this argument, it has been found that object control skills are harder to improve than locomotive skills due to their greater skill component complexity and perceptual demands (Morgan et al., 2013). Superior postural control may contribute to greater perceptual capacity. In particular, improved integration of feedforward mechanisms lead to greater stabilisation and orientation of the body in space, especially during the more complex components which require rotation of multiple body segments and weight transfer during the kinematic chain of skills (e.g., throw, strike, and kick). This line of thinking is supported by the findings of Davids, Bennett, Kingsbury, Jolley, and Brain, (2000) and their suggestion that underdeveloped postural control in children can act as a limiter on learning to catch. They observed improved catching performance in novice performers when in a seated stable position compared to when standing. They go on to suggest that whilst in a seated position, errors in the postural control sub-system were not amplified through the system to perturb the sensitive fine orientation and grasp phase of the catch.

This raises exciting possibilities, though to date, due to the low quality of intervention studies in the school setting, our understanding of the power of postural control to develop children's movement skill competence is limited. This issue will be further examined in this thesis.

## 2.9 Conclusion and Summary

There is general agreement that the development of movement skill competence is important for long-term engagement in physical activity and is associated with a variety

of other health benefits. This consensus has not however led to effective action in schools as current levels of movement skill competence are poor and have been so for at least a decade. Research has in the past suffered from a lack of theoretical agreement and understanding of how to assess and develop children's movement skill competence.

There is agreement that movement skill competence is multi-dimensional and hierarchical in nature, however there is a clear gap between our hypothetical understanding of the constructs of movement skill competence and what we measure on the ground. Construct validation of the existing assessment tools has not yet succeeded in joining the theory with practice. The development of our understanding of movement skill competence in children has also been hindered by poor intervention design. Previous studies have lacked experimental rigour thus increasing the chances of Type 1 or Type 2 errors. All research undertaken in the field should in future follow CONSORT and TREND guidelines where at all possible to ensure the data collected is of high quality and extends our understanding of the area. This literature review supports the development of a gymnastics based intervention delivered collaboratively by class teachers, PE teachers and PE coaches to improve primary school children's movement skill competence.

### 2.10     Two Major Aims of this Thesis

This thesis sought to address two aims. The primary aim was to evaluate the effectiveness of a gymnastics intervention for improving movement skill competence relative to the standard PE curriculum being delivered in schools. In order to achieve the primary aim, it is important to gain a greater understanding of the constructs which underpin movement skill competence in children. Consequently, the secondary aim is to

evaluate the contributing role general coordination, locomotive, object and stability

skills play in the development of movement skill competence.

# CHAPTER - 3  A MEASUREMENT MODEL

# OF MOVEMENT SKILL COMPETENCE IN

# CHILDREN

(Published Paper)

*"I have learned over the years that when one's mind is made up, this*

*diminishes fear; knowing what must be done does away with fear."*

*Rosa Parks*

3.1      **Introduction**

Movement skill competence is an integral component of physical literacy, which has been defined as having the movement skill competence, knowledge, skills and attitudes to live a healthy life and to be an advocate for others to do the same (Whitehead, 2007).

Physical literacy has become an important focus of PE curricula (Mandigo, Francis, Lodewyk, & Lopez, 2009) and in the promotion of physical activity (Whitehead, 2001). For example, the PE curricula in England (Department of Education, 2013) and the United States of America (SHAPE, 2014) aim to promote lifelong participation in physical activity through the development of physical literacy, with a focus on developing movement skill competence in children, and through the development of self and social awareness, self-regulation and responsible decision making, to foster overall personal well-being. The result being a physically educated person with the ability to use these skills in everyday life and developing a disposition towards purposeful physical activity being an integral part of daily living (Castelli, Centeio, Beighle, Carson, & Nicksic, 2014). Though not explicitly included in the Australian Curriculum and Authority (2012) curriculum, the lead author of this curriculum has stated that in future iterations of the curriculum there are possibilities for physical literacy to be included as a general capability (Macdonald & Enright 2013). In the effort to create physically literate children it is important that the concept of movement skill competence is better understood and defined.

According to Whitehead, movement competence is multi-dimensional in nature, containing three interrelated constructs: simple movement capacities, combined movement capacities and complex movement capacities (Whitehead, 2010). Such a multi-dimensional conceptualisation of is common in the human movement literature

and overall, there is still a lack of consensus about what movement skill competence encompasses. An important reason for this disagreement is the variation in measurement methods (Giblin, Collins, & Button, 2014). For example, in North America the TGMD-2 (Ulrich, 2000) has been a test battery of choice to examine children's movement skill competence. The TGMD-2 is a process oriented test battery that measures competence in a set of motor skills deemed essential for predicting participation in physical activity and sport. The motor skills are known as FMS and have been subdivided into two categories called locomotor and object control skills. Confirmatory factor analysis on an American sample has provided evidence for the proposed hierarchical structure of the TGMD-2, suggesting that the TGMD-2 provides a good evaluation of children's gross motor competency (Ulrich, 2000).

The KTK has been developed in Germany to examine non-sport specific gross body coordination in children. The KTK has been shown to have good reliability (test-retest reliability between .80 and .96) and factorial structure, where adequate predictive validity has been shown by its ability to distinguish between brain damaged and normal children (Kiphard & Schilling, 1974, 2007).

There is a growing body of evidence that assessment tools should not be used interchangeably. Fransen et al., (2014) compared the KTK and Bruininks-Oseretsky Test of Motor Proficiency (BOT-2; Bruininks & Bruininks, 2005) in primary school children and found only a moderate association between the two tests. These findings are similar to other convergent validity studies (Logan et al., 2012; Smits-Engelsman et al., 1998). It is currently unclear whether the TGMD-2 and KTK are measuring the same or different aspects of children's movement skill competence. If the two test batteries measure different aspects of movement skill competence, this would suggest

key information could be missed if only one test battery is used. In view of this uncertainty, the first aim of this study was to explore whether the two test batteries measure different aspects of movement skill competence. It is hypothesised that movement skill competence includes both locomotor and object control competence and that this is distinct from body coordination. To date, no Australian studies have examined the factorial structure of the TGMD-2. Similarly, no studies examining the KTK, outside of Europe, have reported whether their proposed factorial structure is invariant across samples of different cultural backgrounds. A secondary aim of the present research was therefore to examine the factorial structure of both the TGMD-2 and KTK in a sample of Australian children.

## 3.2 **Method**

### 3.2.1 *Participants*

In total, 158 children aged 6-12 participated in the study ($M$ age = 9.5 SD 2.2), 86 (54%) were boys and 72 (46%) were girls. The study was approved by the University Ethics Committee and Victoria Department of Education and Early Childhood Development, and parental consent was obtained for all participants (Appendix A and B).

### 3.2.2 *Test Battery*

The TGMD-2 (Ulrich, 2000) assesses proficiency in six locomotor skills (run, hop, slide, gallop, leap, horizontal jump) and six object control skills (striking a stationary ball, stationary dribble, catch, kick, overhand throw, underhand roll). Each participant completes all 12 skills of the TGMD-2 and is given one practice attempt and two

assessment trials for each skill. For each skill, skill components are marked as 'present' or 'absent' (Appendix H).

The KTK (Kiphard & Schilling, 2007) is an outcome based assessment that consists of four non-sport specific sub-tests that measure gross motor coordination. Reverse balancing requires participants to walk backwards along three different balance beams, with increasing levels of difficulty due to the width of the beams decreasing from 6cm to 4.5cm to 3cm respectively. Moving platforms requires participants to move laterally for 20 seconds across the floor using two wooden platforms. Participants step from one platform to the next platform, and then move the first platform to their side in the direction they are travelling and step on to it. Hopping for height requires participants to hop on one leg over an increasing number of 5cm foam blocks to a maximum of 12 blocks. Participants have to begin hopping 1.5m away from the foam blocks, hop up to and over the foam block and complete a further two hops for the trial to be deemed successful. The final task is continuous lateral jumping in which participants are required to complete as many sideways jumps as they can, with feet together, over a wooden slat in 15 seconds (Appendix I).

### 3.2.3 *Training and reliability*

A total of 10 Research Assistants (RAs) each received six hours training in the administration of the TGMD-2 and KTK. At the end of this training period the RAs administering the KTK assessment tool scores were compared and achieved 94% agreement  reliability. Two of the RAs received an additional three hours training on coding each of the 12 TGMD-2 skills.

These two RAs independently coded videos of 15 children who completed the 12 TGMD-2 skills. To determine the level agreement between the two RAs, total scores for

each subset (locomotive and object control) were first z-transformed. Next, limits of agreement for each subset were calculated based on the mean difference between the two assessors' scores and the respective standard deviation of these differences (Bland & Altman, 1986; Nevill, 1996). The 95% limit above and below the mean for locomotor skills were - 0.7 to 0.7 and for object control skills 95% limit agreements were -0.6 to 0.6. The RA's 95% confidence intervals are within one standard deviation (1.96) and contain zero, demonstrating that the two RAs have excellent inter rater reliability.

### 3.2.4 *Procedure*

The assessments of TGMD-2 and KTK were carried out in a large sports hall. Groups of four participants rotated around five stations, each manned by two trained RAs, and the TGMD-2 stations were video recorded for subsequent coding. The four KTK assessments were divided into two stations whereas the TGMD-2 was split into object control and locomotive skills.

### 3.2.5 *Statistical analysis*

Raw scores for each TGMD-2 skill and the four KTK tests were transformed onto the same scale through z-transformation. Following this, data was assessed for violation of the assumptions of normality and for outliers.

Confirmatory factor analysis was used to examine the factorial structure of the KTK and TGMD-2 using AMOS 22. First, a confirmatory factor analysis was conducted to examine whether the individual tests of the KTK served as a good indicator for the latent factor Body Coordination. Following this, two confirmatory factor analyses were conducted to assess the fit of the TGMD-2 skills into locomotor and object control latent factors respectively. In the instance of an adequate fit, a fourth confirmatory

factor analysis was conducted to examine the hierarchical nature of the TGMD-2 by testing whether locomotor and object control loaded on the higher order variable, FMS. If the fit was found to be inadequate, the model was respecified. Finally, if the fit was adequate, it was examined whether the empirical data fitted the hypothesised model in which both FMS and body coordination loaded on the latent variable movement competence.

### 3.2.5.1 *Goodness of fit*

Confirmatory factor analysis was conducted with the maximum likelihood method of estimation. In order to specify a model containing latent variables for all factors, error variance was set at zero. Residuals from the observed variables were allowed to co-vary within each specified factor, as indicated by corresponding arrows in path diagrams. Several goodness of fit measures were used to describe the models. In addition to the Chi square ($\chi$2) statistic, which is influenced by sample size (Ullman, 2006), the following fit indices were considered: Chi square/DF ($\chi^2$/DF); Comparative fit index (CFI) (Bentler, 1990); Root mean square error of approximation (RMSEA) (Browne, Cudeck, & Bollen, 1993); Standardised root mean residual (SRMR) (Bollen, 1989); and the P of close fit PCLOSE (Hu & Bentler, 1999).

The $\chi^2$ statistic is a measure of overall fit of the model to the data, with a non-significant P-value ($p > .05$) indicating a good fit. Also, $\chi^2$ divided by the degrees of freedom ($\chi^2$/df) provides an indicator of fit with values of $< 2$ considered adequate fit. Comparative fit index values of .90 or above indicate an adequate fit. Root mean square error of approximation values of .06 or lower and standardised root mean residuals values of .08 or lower indicate a close fit when these statistics are taken together (Kline, 2011). However, it should be noted that Vandenberg and Lance, (2000) have suggested

that cut-off values of .08 for root mean square error of approximation and .10 for standardised  root mean residuals are acceptable lower bounds of good model fit. Finally, the PCLOSE should be non-significant (p > .05) (Browne et al., 1993).

### 3.3 Results

The Mardia, (1970) test for multivariate kurtosis was undertaken, following (Kline, 2011) suggestion that critical ratio of > 3 are of a concern. None of the models showed problematic levels of skewness or kurtosis. Mean scores and standard deviations are reported below for all children on both test batteries (see Table 3-1).

Table 3-1: Mean and standard deviations for Anthropometric, TGMD-2 and KTK.

| Age group | Variables | Boys | | | Girls | | |
|---|---|---|---|---|---|---|---|
| 6- 8 years | N | | 24 | | | 21 | |
| | Locomotive | 32.9 | ± | 5.3 | 35.9 | ± | 4.7 |
| | Object Control | 34.2 | ± | 5.9 | 30.3 | ± | 4.7 |
| | Body Coordination | 128.9 | ± | 38.4 | 142.2 | ± | 35.7 |
| 8-10 years | N | | 31 | | | 26 | |
| | Locomotive | 35.8 | ± | 3.8 | 34.1 | ± | 4.2 |
| | Object Control | 37.3 | ± | 4.6 | 35 | ± | 3.9 |
| | Body Coordination | 173.5 | ± | 43.9 | 176.2 | ± | 46.7 |
| 10-12 years | N | | 31 | | | 25 | |
| | Locomotive | 36.4 | ± | 5.3 | 35.4 | ± | 4.3 |
| | Object Control | 41.3 | ± | 4.3 | 35.2 | ± | 4.7 |
| | Body Coordination | 209 | ± | 49.5 | 202.2 | ± | 42.5 |
| Total | N | | 86 | | | 72 | |
| | Locomotive | 35.2 | ± | 5 | 35.1 | ± | 4.4 |
| | Object Control | 37.9 | ± | 5.6 | 33.7 | ± | 4.9 |
| | Body Coordination | 173.8 | ± | 54.4 | 175.3 | ± | 48.1 |

Note: The means are reported as raw score values

### 3.3.1 *Confirmatory factor analysis for the KTK*

The confirmatory factor analysis for the KTK provided an adequate model fit ($\chi^2$ (2df) = 1.49; p = .47; $\chi^2$/df = 0.75; CFI = 1.00; SRMR= .01; RMSEA = .01; PCLOSE = .60).

All four observed measures had a strong effect on the latent variable Body Coordination (see Figure 3-1).
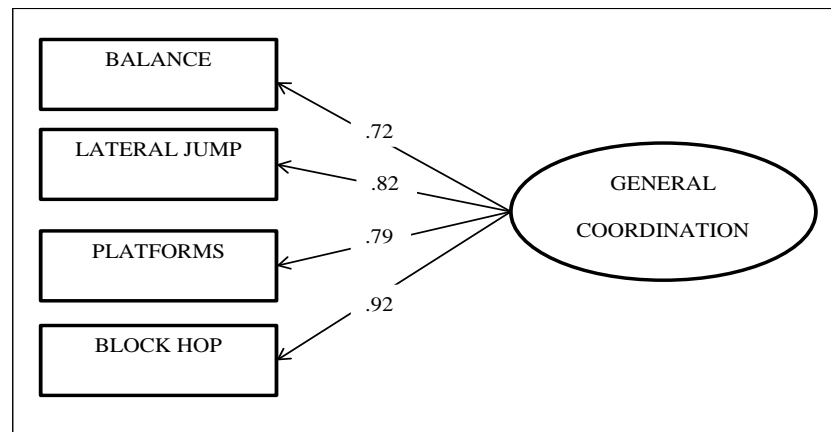


Figure 3-1: Confirmatory Factor Analysis for the KTK

### 3.3.2 *Confirmatory factor analysis of the TGMD-2*

The Confirmatory factor analysis for locomotive skills showed an adequate fit for the overall model ($\chi^2$ (9df) = 9.21; p = .42; $\chi^2$/df = 1.02; CFI = .99; SRMR = .05; RMSEA = .01; PCLOSE = .69). The initial confirmatory factor analysis for object control provided an inadequate fit ($\chi^2$ (9) = 27.54; $\chi^2$/df = 1.34; p = .001; CFI = .80; SRMR = .07; RMSEA = .11; PCLOSE = .02). The modification indices indicated that the error term for the observed variable throw was related to the error term of the observed variable strike. As such, the error terms for these variables were co-varied. The revised model for object control provided an adequate fit ($\chi^2$ (8) = 10.13, p = .26; $\chi^2$/df = 1.26; CFI = .98; SRMR = .04; RMSEA = .04; PCLOSE = .52).

FMS hierarchical model for the TGMD-2 (see Figure 3-2) showed an adequate fit ($\chi^2$ (52) = 71.07; p = .04; $\chi^2$/df = 1.36; CFI = .86; SRMR= .07; RMSEA = .05; PCLOSE = .52). In this model object control had more effect (r = .67) than locomotor (r = .39) on

overall fundamental movement skill. The catch was found to load very weakly onto object control (r = .08) though it did still contribute to the overall model fit (see Figure 3-2).
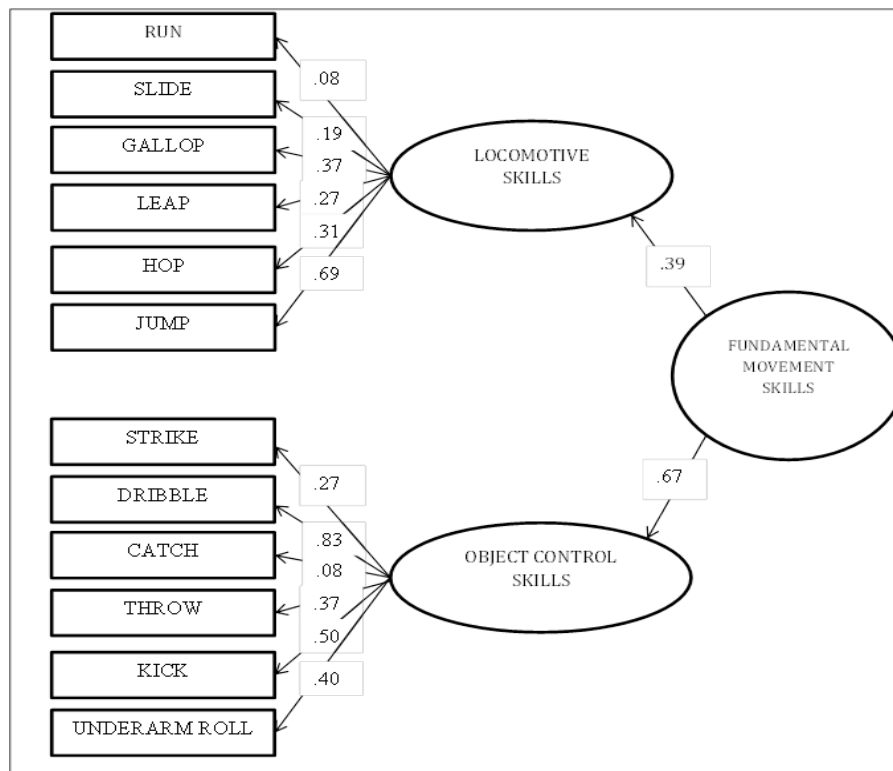


Figure 3-2: Fundamental movement skills hierarchical model for the TGMD-2

### 3.3.3 *Movement competence structural model*

The initial confirmatory factor analysis for the hypothesised movement competence model (see Figure 3-3) showed an improper solution caused by over specification of the TGMD-2 skills with two second order factors (locomotor and object control) and the higher order factor FMS both explaining the TGMD-2 skills, therefore creating an unstable fit. A second confirmatory factor analysis for movement skill competence was carried out (see Figure 3-4).
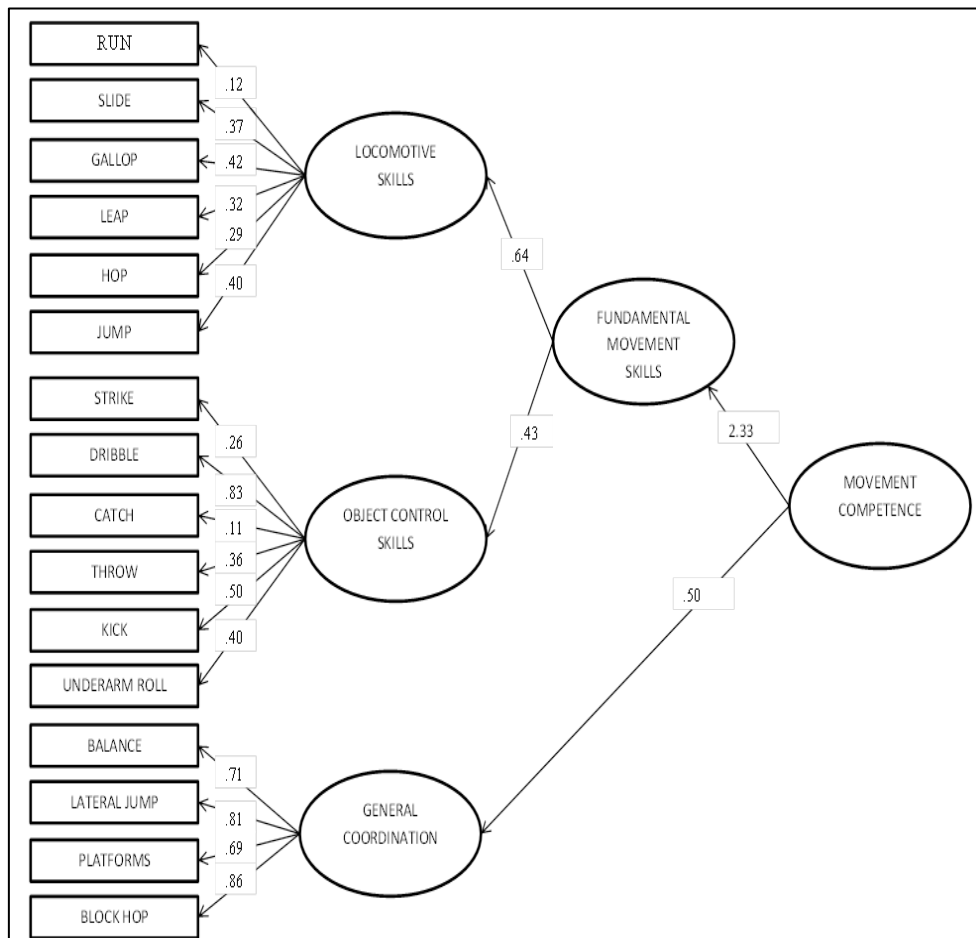
Figure 3-3: Initial hypothesised CFA for movement skill competence.

The FMS latent variable was dropped from the movement competence model to avoid over specification of the TGMD-2 skills. The three second order latent variables: coordination, object control and locomotor now loaded directly into movement competence. An adequate fit was achieved ($\chi^2$ (102) = 155.40; p = .001; $\chi^2$/df = 1.52; CFI = .89; SRMR= .09; RMSEA = .06; PCLOSE = .24). In this model locomotor (r = .86), object control (r = .71) and body coordination (r =.52) loaded on movement competence. The catch also now provided a higher loading on object control.
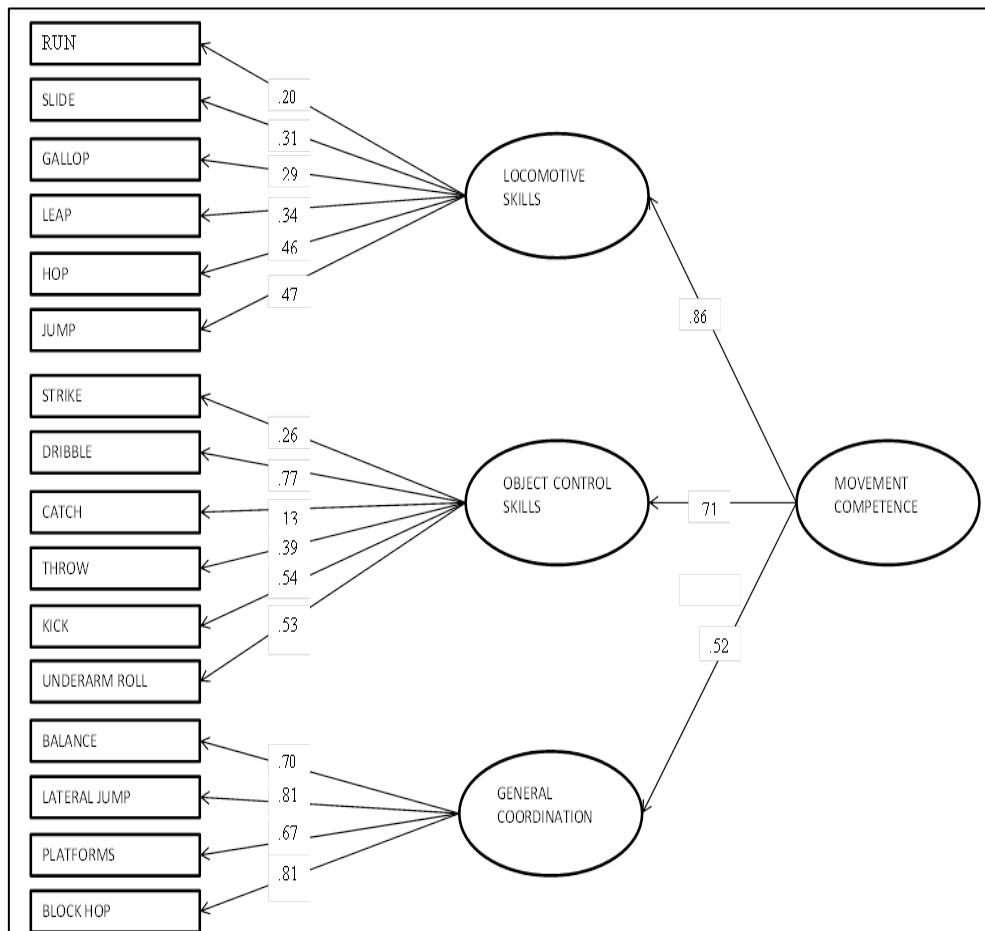
Figure 3-4: Revised CFA model of movement skill competence

### 3.4 Discussion

This study examined the relationship between the TGMD-2 and the KTK and tested its factorial structure in a sample of Australian children. Both the TGMD-2 and KTK, when examined independently, showed good model fit in our sample. In addition, findings support the hypothesis that the TGMD-2 and KTK measure discrete aspects of the movement competence construct.

In this study the proposed model of movement competence model suggests that both object control and locomotor skills of the TGMD-2 and the body coordination skills of the KTK are related to the overall concept of movement competence. The final model

provided an adequate fit and there did not appear to be any redundancies. An important implication of this finding is that, if used individually, these commonly used assessment batteries provide only a limited view of the overall movement skill competence of children. To obtain a more holistic picture future research should examine both FMS and body coordination skills. The catch was found to load very weakly onto the object control construct. A high percentage of children demonstrated mastery over the catch, however this was not the case for the other object control skills. This could explain why catch demonstrated a low loading on the object control skill construct. Future studies should look to make the catching activity more challenging as it is currently very easy compared to the other object control skills.

The KTK is a product assessment test battery with each skill outcome being assessed quantitatively (i.e. number of jumps completed in a specific time). In contrast the TGMD-2 provides a qualitative assessment of skill execution (i.e., whether a child does or does not demonstrate specific component). Although the TGMD-2 does not measure the outcome of a given movement sequence, it is implicitly assumed that the underlying process is associated with successful outcomes. Indeed, empirical evidence suggests associations between skill process and skill outcomes. Miller (2007) investigated the correlation between process and product scores of a two-handed sidearm strike in children. A significant relationship was found between the product and process scores for each trial (correlations ranging from r = .51 to .66) demonstrating a consistent association between technique and outcome (Miller, Vine, & Larkin, 2007). Roberton and Konczak, (2001) compared the product and process of the overarm throw and reported a significant correlation between quantitative (ball velocity) and quality of

performance in primary school children. Both these studies provide evidence for a positive relationship between process and product FMS measures.

The separation of product and process measurement of movement skill competence has been questioned (Stodden et al., 2008). The choice of a process or product test battery, in this respect, might be indicative of theoretical beliefs on how movement skill competence is formulated. For example, in general terms, ecological dynamics theorists may favour a process orientated approach whereas a cognitive psychologist may adopt a product approach. This analysis suggests that both assessment strategies provide a useful assessment of movement skill competence and that both strategies should be used concurrently to obtain a more holistic assessment of the movement skill competence of children.

Two recent systematic reviews and meta-analyses have provided evidence that FMS interventions can be successful in motor skill development in children (Logan et al., 2012; Morgan et al., 2013). These interventions only focused on aspects of FMS development rather than development of FMS and body coordination. The results of the present study and work by Ericsson, (2008) suggest that children's movement skill competence encompasses a number of additional components besides FMS and that interventions based solely on the development of FMS might not provide adequate development of body coordination resulting in a lack overall movement skill competence in the long-term.

The proposed movement skill competence model suggests that for children to be truly competent they should participate in a wide range of activities. This is supported by evidence demonstrating that elite athletes do not specialise in their specific sport from

an early age but participate in a wide range of activities throughout childhood and specialise when they are older (Berry, Abernethy, & Côté, 2008; Côté & Fraser-Thomas, 2007). To this extent, children should be encouraged and given the opportunity by parents, schools and clubs to take part in task oriented body coordination movement activities which focus on moving and controlling the body in gravity defying ways to encourage the development of movement fluency, rhythm, timing and body strength. Suitable examples of such activities would be gymnastics, dance and martial arts. Activities such as these should be experienced alongside learning key object control and locomotive skills, learnt through deliberate play (Côté & Fraser-Thomas, 2008) and traditional sports. Together they will promote a strong foundation in overall movement skill competence.

These results highlight that movement skill competence is a multi-dimensional concept and may not be recorded adequately by one test battery. As such, this model may still fail to capture all aspects of children's movement skill competence. In turn this results in current interventions typically only being designed to address select aspects of movement skill competence. In addition, the movement skill competence model presented in the present study needs to be tested in larger samples of children across different countries to demonstrate its generalisability.

In conclusion, the results of the present study provide support for the factorial structure of the TGMD-2 and KTK in a sample of Australian children. In addition, movement skill competence consists of both FMS (process) and body coordination (product) activities. As such, this study suggests that the pilot intervention should consider using testing batteries which provide a more holistic way of assessing movement competence in children.

# CHAPTER - 4  PILOT STUDY

# "EFFECTIVENESS OF AN EIGHT WEEK GYMNASTICS CURRICULUM IN DEVELOPING MOVEMENT SKILL COMPETENCE AND PHYSICAL SELF-CONCEPT"

"""""(Paper in Review)

*"You miss 100% of the shots you don't take."*

*Michael Jordan*

### 4.1 **Introduction**

Gymnastics was once a cornerstone of the PE curriculum in schools but concerns of its decline have been reported in both the United Kingdom and Australia (Smith, 1989a; Wright, 2011). This includes both a reduction in the volume of gymnastics taught in PE as well as the quality of instruction (Smith, 1989b). The demise of gymnastics in the PE curriculum has coincided with research findings indicating a decline in children's movement skill competence in Australia and other western countries (Bös, 2003; Hardy, 2011; Tester, Ackland, Houghton, et al., 2014). Gymnastics Australia purports that the introduction of a gymnastics based curriculum with better training and support for primary school teachers can improve not only children's FMS but also other aspects of movement skill competence (Gymnastics Australia, 2011). Burton et al., (1998) have argued that the PE curriculum should be consistent with a theoretical model of movement skill competence. The previous chapter provides a model of movement skill competence which included FMS in the form of locomotor and object control skills as well as children's general body coordination. This model of movement skill competence, together with the suggestions by Gymnastics Australia, provides a strong basis for a PE curriculum which has a robust skill development aspect embedded (Gymnastics Australia, 2011). During PE lessons, children are provided with opportunities to try new skills, and their physical abilities are constantly on display to their peers, an experience which can lead to feelings of both success and failure. PE is therefore an educational environment that impacts upon children's physical self-concept development (Gehris et al., 2010; Goodwin, 1999). In PE, a positive physical self-concept is associated with higher engagement levels, skill development, and motor learning (Peart et al., 2005).

Many of the sporting activities in which children engage during PE are inherently competitive and ego-oriented, in that they are focused on winning or losing. Gymnastics, on the other hand, is task-oriented and focused around the development of skills in a non-pressured environment (Halliburton & Weiss, 2002). Development of skills in this environment is likely to have a greater influence on children's FMS development (Martin et al., 2009), as well as having a positive influence on their physical self-perceptions (Goudas, Biddle, & Fox, 1994; Papaioannou, 1998; Standage, Treasure, Hooper, & Kuczka, 2007). The aim of this pilot study was to evaluate the effectiveness of an eight week gymnastics curriculum ('LaunchPad') developed by Gymnastics Australia, which was designed to develop all aspects of children's movement skill competence. The study also examined whether this curriculum influenced the children's physical self-concept. It was predicted that the gymnastics intervention group would see improvements beyond the control group in terms of general body coordination, locomotive and object control skills. In addition, it was predicted that the gymnastics group would experience greater improvements in physical self-perceptions compared to the control group due to the task-oriented nature of the gymnastics curriculum.

### 4.2      Method

#### 4.2.1 *Participants*

Data was collected in one Melbourne school (Australia) over a whole school term. A total of 113 children (56 intervention and 57 control) between the ages of 7-12 (*M* age = 9.4; *SD* 1.8) participated. For each participant, written informed consent was obtained from the parents or guardian. The study was approved by Victoria University Ethics

Committee and the Department of Education and Early Childhood Development (Appedix C and D).

### 4.2.2 *Study design*

In order to investigate the effects of the gymnastics curriculum across the whole primary school spectrum, years 2, 4, and 6 were selected in a quasi-experimental design. Two classes from each of these year groups were assigned to either a control or intervention group. Both groups had a controlled dose of two hours PE per week which lasted a total of eight weeks and all groups underwent pre- and post-assessment testing during weeks 1 and 10 using the KTK (Kiphard & Schilling, 1974) and TGMD-2 (Ulrich, 2000) to examine changes in movement skill competence. The intervention group received two hours per week of gymnastics training taught by a Gymnastics Australia coach for the first hour and by the school's PE teacher for the second hour. The control group received two hours of their standard PE curriculum, which comprised athletics, with both lessons taught by the regular PE teacher.

### 4.2.3 *Measurements*

#### 4.2.3.1 *Movement skill competence tests*

The TGMD-2 (Ulrich, 2000) assesses proficiency in six locomotor skills (run, hop, slide, gallop, leap, horizontal jump) and six object control skills (strike, dribble, catch, kick, overhand throw, and underhand roll). Each participant completes all 12 skills of the TGMD-2 and is provided with one practice attempt and two assessment trials for each skill. For each skill, skill components are marked as 'present' or 'absent' (Appendix H).

The KTK was administered according to the manual guidelines (Kiphard & Schilling, 1974, 2007). The KTK consists of four outcome-based subtests. RB requires participants to walk backwards along three different balance beams, with increasing levels of difficulty due to the decreasing width of the beams from 6 cm to 4.5 cm to 3 cm respectively. Three trials are provided for each balance beam with a maximum score of 72 steps (i.e., maximum 8 steps per trial). HH requires participants to hop on one leg over an increasing number of 5 cm foam blocks to a maximum of 12 blocks. Participants have to begin hopping 1.5 m away from the foam blocks, hop up to and over the foam block and complete a further two hops on landing for the trial to be deemed successful. Three trials are given for each height with 3, 2 or 1 point(s) given for a successful performance during 1st, 2nd or 3rd trial respectively. CS requires participants to complete as many sideways jumps as they can, with feet together, over a wooden slat in 15 seconds. MP requires participants to move across the floor during 20 seconds using two wooden platforms. Participants step from one platform to the next, move the first platform, step on to it, and repeat the same process travelling as far as possible in 20 seconds. Two trials are provided for both jumping sideways and moving sideways. The KTK requires little time to set-up and takes approximately 15-20 minutes to administer (Appendix I).

Raw item scores were converted into standardised, German normative data (Kiphard and Schilling 1974, 2007) which adjusts for age (all items) and gender (Hopping for Height and Continuous Lateral Sideways Jumping). In turn, standardised score items were summed and transformed into a total Movement Quotient (MQ).

### 4.2.3.2    *Anthropometry*

Height and weight were measured with an accuracy of 0.1 cm and 0.1 kg respectively. Height was assessed with a Mentone PE087 portable stadiometer (Mentone Educational Centre, Melbourne, Australia) and weight was assessed using a SECA 761 balance scale (SECA GmbH & Co. KG., Birmingham, UK). Height and weight values were used to calculate body mass index (BMI) [BMI = weight (kg) / height$^2$ (m$^2$)].

### 4.2.3.3    *Physical- self description questionnaire short form (PSDQ-s)*

The PSDQ-s (Marsh et al., 2005) is comprised of nine factors or scales specific to physical self-concept: activity, appearance, body fat, coordination, endurance, flexibility, health, sport, strength, and two global scales – global physical and global esteem (Appendix G). The PSDQ-s has been shown to have good validity and reliability for Australian children. For example, Marsh et al. (2010) reported Cronbach alphas between .57 and .90 and in the present study alphas ranged between .68 and .91.

### 4.2.4 *Procedure*

The physical self-description questionnaire short form (PSDQ) was completed one day prior to the actual movement competence testing. For Year 2 and 4 children, a research assistant sat close at hand to support small groups of children with question comprehension if required.

All motor competence assessments were conducted by 10 trained assessors in a large sports hall. For the physical assessment, children were barefooted and wore their regular PE attire. First, anthropometric measurements (height, weight and grip strength) were taken. Secondly, children's motor competence was assessed with the KTK and TGMD-2.

Groups of five participants rotated around four skill stations and one anthropometric station. The TGMD-2 was split between two stations, a locomotor skills station (run, hop, slide, gallop, leap, horizontal jump) and an object control skills station (strike, dribble, catch, kick, overhand throw, and underhand roll). The four KTK tasks were split into two stations with the Reverse Balance and Lateral Jumping tasks on one station and the Moving Platforms and Hopping for Height tasks at the other station. Before undertaking each task, children watched a live and pre-recorded demonstration.

### *4.2.4.1      Intervention group curriculum*

LaunchPad is designed for children aged under 12 years and its resources are divided into three levels: KinderGym aimed at 0-5 years; GymFun for children aged 5-7 years; and GymSkills for children aged 8-10 years. For this study the GymSkills curriculum was extended to 8-12 years. The rationale for this was that at Year 6 children have been found to have poor movement competence (Hardy, 2011; Tester, Ackland, & Houghton, 2014) and would most likely benefit from the intervention. All LaunchPad lessons have five teaching sections that follow a set sequence: warm-up, brain challenge, main activity, circuit and cool down. Importantly, each of these sections contains clear content descriptors of what should be taught and each section has a recommended timeframe for how long the specific section should be taught. While these resources are broadly age related they are not age dependent. This means that deliverers should use age as a guide to the selection of resources but the deciding factor should be the children's actual competence level. Each set of resources contains a set of chronological lesson plans, with each lesson building upon the previous one, with skill cards to complement the lesson plans (see Table 4-1).

Table 4-1: Gymnastics curriculum overview (a detailed description of the gymnastics curriculum can be found at  http://www.launch-pad.org.au/ )

| GYMFUN | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Grade 2 Themes | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | Hand apparatus | Revision | School Olympics |
| Content | Balances with and without partner: <br><br> Shapes <br><br> Partner mirror <br><br> Front support <br><br> Counter balance <br><br> Bench balances | Various jumps <br><br> On and off equipment: <br><br> Jump off and on small box <br><br> Bunny hop over bench <br><br> Jump back and land <br><br> Hoop step in and out | Jumping sequence: <br><br> Hop scotch <br><br> Obstacle course <br><br> Rope skipping <br><br> Jump back land and roll | Various rolls <br><br> Ball rolls on body <br><br> Forward roll down a wedge <br><br> Jump turns with partner <br><br> Jump back to land and roll off apparatus | Locomotion: <br><br> Over and under front supports <br><br> Under monkey walks <br><br> Giraffe walks along bench <br><br> Through hoop pass <br><br> Bunny hops <br><br> On and off equipment roll | Hoop Combo activities <br><br> Ball combination Blind <br><br> Ball Pass <br><br> Throw hand to hand | Movement to music <br><br> Partner various rolls <br><br> Counter balances <br><br> Static shapes <br><br> Partner jumps <br><br> Group balances | Long jump <br><br> Badminton <br><br> Swimming Synchro diving <br><br> Javelin <br><br> Show jumping |

| GYM SKILLS | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Grade 4 and 6 Theme | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | Hand apparatus | Revision | School Olympics |
| Content | Balances with and without partner: Plank Shapes Partner shapes Counter balance Partner apparatus balance | Various jumps On and off equipment: Synchro jumps Jump off box catch a ball Bunny hop over bench Skipping Karate air time | Jumping sequence: Triple jump Chain jump Obstacle course Indoor Kayaking salmon Upper body obstacle course | Various rolls Hanging monkey Mini cartwheels Forward roll with ball | Locomotion: Through hoop Along bench Rolls with partner Around body hoop spin Cartwheel over bench | Hoop activities Blind tennis Hoop hand rotation Shapes & pass ball or hoop Two ball juggle | Movement to music Partner front supports Partner jumps Static shapes with ball Partner forward roll Group balances | Pole Vault Rowing Weight lifting Shot put Basketball Tennis |

*4.2.4.2* ***Control group curriculum***

The control group received eight two hour lessons of their normal standard PE curriculum. This was conducted in the summer term with athletics scheduled in the curriculum (see Table 4-2).

Table 4-2: Control group curriculum overview

| Athletics | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Grade: 2 | Basic Running | Circular Relay | Jumping | Skipping and Hopping | Throwing | Throwing | Athletic 5 of 5 | Athletic 5 of 5 |
| Grade: 4 | Running technique | Sprint vs long distance | Long Jump | High Jump | Shot Put | Discus | Athletic 5 of 5 | Athletic 5 of 5 |
| Grade: 6 | Sprinting | Distance Running | Long Jump | High Jump | Shot Put | Discus | Relays | Athletic 5 of 5 |

4.2.5 *Reliability*

A total of ten RAs each received six hours training in the administration of the TGMD-2 and KTK. At the end of this training period six RAs and the lead author coded 12 children live completing all four of the KTK tests. A comparison of the RAs' and lead author's summed scores on the KTK showed 100% percent agreement, indicating all RA's and lead author scored the same on reliability assessment. Two of the RAs received an additional three hours training on coding each of the 12 TGMD-2 skills. These two RAs and the lead author independently coded videos of 15 children who

completed the 12 TGMD-2 skills. Inter-rater reliability was assessed through intra-class correlation coefficients (ICC) and subtest scores were found to be good for both locomotor (r = .94, CI [.58 - 99]) and object control skills (r = .86, CI [.44 - .98]). This was carried out prior to pre-testing.

### 4.2.6 *Fidelity*

Six out of the 16 lessons were observed (weeks 2, 4 and 6) using a teacher observation checklist. The checklist included general teacher initiated behaviour and traits, lesson preparation, lesson presentation, safety and behavior management; this was adapted from the school's teacher peer assessment tool. All observed lessons were graded on a four point Likert scale with 1= poor, 2 = fair, 3 = good, and 4 = excellent.

### 4.2.7 *Data analysis*

Data were analysed using SPSS Statistics 21 for Windows (IBM Corp, 2012). Alpha levels were set at $p < 0.05$ and considered statistically significant for all analyses. Multivariate analysis of co-variance (MANCOVA) was conducted on the difference score (post-test – pre-test) for the KTK (reverse balancing, moving platforms, hoping for height, continuous lateral jumping). The main factor under investigation was condition (intervention vs. control) with age, gender and BMI included as co-variates. Univariate analysis of co-variance (ANCOVA) was conducted on the difference scores for KTK Motor Quotient (MQ), total TGMD-2 score (combined object control and locomotive raw scores), locomotive and object control subtest scores separately and the summed PSDQ-s. In this instance, age was found to be a significant covariate, so separate analysis was conducted on the lower (year 2 & 4) and upper (year 6) year groups.

### 4.3 **Results**

Retention rate for the assessment of movement skill competence was 100%. However, for physical self-concept, 13 children were unable to complete post testing due to non-attendance. Follow up attempts were made throughout the week of post testing though no absent children returned to school. It was decided no further follow up would be undertaken as this was the last week of the school term before a six week break. Table 4-3 provides summed scores for the KTK, TGMD-2 and PSDQ-s (see Table 4-3).

Table 4-3: Descriptive statistics [Means and standard deviations (M ± SD)] of movement competence measurements stratified by intervention, pre/post testing and lower or upper primary school

| Grades | Variables | | Pre | Intervention | Post | | Pre | Control | Post | |
|---|---|---|---|---|---|---|---|---|---|---|
| Lower Primary | | N | 41 | | 41 | | 42 | | 42 | |
| | | | M | SD | M | SD | M | SD | M | SD |
| | TGMD-2 | | 66.8 ± | 9.7 | 72.0 ± | 8.1 | 71.6 ± | 4.9 | 71.7 ± | 8.1 |
| | Locomotor | | 35.3 ± | 5.3 | 37.2 ± | 5.4 | 36.0 ± | 4.9 | 36.1 ± | 5.1 |
| | Object Control | | 31.5 ± | 7.5 | 34.8 ± | 5.7 | 35.5 ± | 6.4 | 36.1 ± | 5.1 |
| | Reverse Balance | | 40.3 ± | 14.1 | 42.7 ± | 15.5 | 44.3 ± | 13.6 | 45.5 ± | 13.6 |
| | Lateral Jumping | | 53.8 ± | 17.4 | 64.4 ± | 16.1 | 51.4 ± | 15.0 | 59.7 ± | 13.7 |
| | Moving Sideways | | 36.4 ± | 7.8 | 43.2 ± | 7.6 | 36.2 ± | 6.2 | 41.9 ± | 9.0 |
| | Block Hopping | | 46.2 ± | 17.9 | 52.7 ± | 17.7 | 49.2 ± | 12.6 | 55.3 ± | 13.8 |
| | MQ KTK | | 104.9 ± | 14.9 | 113.7 ± | 15.6 | 102.8 ± | 11.6 | 112.4 ± | 14.9 |
| | PSDQ-s | | 197.5 ± | 28.9 | 204.5 ± | 27.9 | 199.4 ± | 25.7 | 196.9 ± | 25.6 |
| Upper Primary | | N | 15 | | 15 | | 15 | | 15 | |
| | TGMD-2 | | 75.7 ± | 7.6 | 78.6 ± | 6.7 | 75.0 ± | 6.2 | 83.5 ± | 5.4 |
| | Locomotor | | 37.9 ± | 3.6 | 39.4 ± | 5.5 | 35.3 ± | 4.4 | 41.9 ± | 1.7 |
| | Object Control | | 37.8 ± | 6.6 | 39.4 ± | 5.3 | 39.6 ± | 5.1 | 41.6 ± | 4.9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reverse Balance | 47.7 | ± | 10.3 | 54.4 | ± | 10.2 | 53.6 | ± | 9.0 | 51.5 | ± | 10.1 |
| Lateral Jumping | 72.8 | ± | 11.3 | 73.0 | ± | 16.2 | 72.1 | ± | 10.2 | 84.6 | ± | 5.6 |
| Moving Sideways | 41.5 | ± | 7.3 | 49.1 | ± | 8.7 | 44.4 | ± | 9.3 | 55.5 | ± | 6.9 |
| Block Hopping | 63.4 | ± | 13.7 | 66.8 | ± | 12.7 | 73.0 | ± | 5.9 | 74.1 | ± | 6.8 |
| MQ KTK | 97.2 | ± | 14.7 | 106.5 | ± | 15.6 | 100.8 | ± | 16.8 | 117.5 | ± | 8.8 |
| PSDQ-s | 192.6 | ± | 23.6 | 197.2 | ± | 27.9 | 195.0 | ± | 25.0 | 186.9 | ± | 35.2 |
| Total | N | *56* | | | *56* | | | *57* | | | *57* | |
| TGMD-2 | 69.2 | ± | 9.9 | 73.7 | ± | 8.2 | 72.5 | ± | 7.6 | 74.8 | ± | 9.2 |
| Locomotor | 36.0 | ± | 5.0 | 37.7 | ± | 5.04 | 35.8 | ± | 4.8 | 37.7 | ± | 4.5 |
| Object Control | 33.2 | ± | 7.7 | 36.07 | ± | 5.9 | 36.6 | ± | 6.3 | 37.6 | ± | 5.6 |
| Reverse Balance | 42.3 | ± | 13.5 | 45.8 | ± | 15.1 | 46.8 | ± | 13.1 | 47.1 | ± | 12.7 |
| Lateral Jumping | 58.8 | ± | 18.0 | 66.7 | ± | 16.5 | 56.8 | ± | 16.6 | 66.3 | ± | 16.3 |
| Moving Sideways | 37.7 | ± | 7.9 | 44.7 | ± | 8.3 | 38.4 | ± | 7.9 | 45.5 | ± | 10.4 |
| Block Hopping | 50.8 | ± | 18.3 | 56.5 | ± | 17.6 | 55.5 | ± | 15.4 | 61.7 | ± | 14.4 |
| MQ KTK | 102.8 | ± | 15.1 | 111.7 | ± | 15.7 | 102.2 | ± | 13.0 | 113.7 | ± | 13.7 |
| PSDQ-s | 195.0 | ± | 27.2 | 202.2 | ± | 25.6 | 198.0 | ± | 23.4 | 193.8 | ± | 28.9 |

### 4.3.1 *Koorperkoordination test fur kinder*

The MANCOVA for the four KTK raw test scores did not show a condition main effect (Wilk's λ =.96; p = .42; $η^2p$ = .04). However, age was found to be a significant covariate (Wilks' λ = .84; P < .001; $η^2p$ = .16) whereas gender (p = .97) and BMI (p = .51) did not influence the findings. The ANCOVA for the KTK MQ did not show a condition main effect (F(1,112) = 3.40; p = .07; $η^2p$ = .03). Age and gender were not included in this analysis as the process of standardising the scores accounts for this. BMI did not influence findings (p > .05).

### 4.3.2 *Fundamental movement skills*

Total FMS summed score ANCOVA did not show a significant condition main effect (F(1,76) = 2.10; p =.15; $η^2p$ = .09). Age was found to be a significant co-variate (F(1,76) = 5.1; p =.05; $η^2p$ = .04) whereas both gender and BMI did not influence findings (P > .05). The ANCOVA for locomotive skills did not show a significant condition main effect (p = .72). Age (p = .08), gender (p = .67) and BMI (p = .30) did not influence the findings. Finally, the ANCOVA for object control skills provided a near significant condition main effect (p = .06). Near significant differences was also observed for age (p = .06), but there were no difference for gender (p = .91) or BMI (p = .51).

Due to age being a significant covariate in the KTK raw and overall FMS score, and approaching significance for the object control skills, it was decided to examine results separately for the lower and upper school children.

### 4.3.3 *Results for lower primary (years 2 and 4)*

*Kooperkoodination Test Fur Kinder:* The MANCOVA for the KTK did not show a condition main effect (Wilks' $\lambda$ = .84; p = .50; $\eta^2$p = .04). BMI and gender did not influence results (p > .05). The ANCOVA for the KTK MQ did not show a condition main effect either (F(1,76) = .21; p = .65; $\eta^2$p = .03). In addition, BMI and gender did not influence the findings (p > .05).

*Fundamental movement skills:* Summed FMS score ANCOVA showed a significant condition main effect (F(1,76) = 7.80; p = .006; $\eta^2$p = .09) with the intervention group showing larger gains; neither gender or BMI influenced the findings (P > .05). The ANCOVA for locomotive skills subset score did not show a condition main effect F(1,76) = 1.30;  p= .24; $\eta^2$p = .02), and both gender and BMI did not influence findings (p > .05). The object control skills were largely responsible for the significance in total FMS score, as the ANCOVA for object control skills did show a significant main effect in favour of the intervention group (F(1,76) = 4.52; p = .04; $\eta^2$p = .06).

### 4.3.4 *Results for Year 6*

*Kooperkoordination Test Fur Kinder:* The MANCOVA for the KTK showed a condition main effect (Wilks' $\lambda$ = .56; p = .008; $\eta^2$p = .44). Follow-up ANCOVA showed larger gains in the control group in comparison to the intervention group. The ANCOVA for the KTK MQ showed a significant condition main effect (F(2,26) = 4.42; p = .045; $\eta^2$p = .15) with the control group showing larger improvements. BMI and gender did not influence the findings (p > .05).

*Fundamental Movement Skills:* Total FMS ANCOVA showed a significant condition effect in favour of the control group F(1,26) = 9.50; p = .005; $\eta^2$p = .27), both gender and BMI did not influence findings (p > .05). The ANCOVA for locomotive skills

subset score also showed a significant condition main effect (F(1,26) = 11.50; p = .002; η2p = .31). Both gender and BMI did not influence findings (p > .05). ANCOVA for object control skills did not show a significant main effect (F(1,26) = 4.41; p =.52; η2p = .02).

### 4.3.5 *Physical self-description questionnaire- s (overall)*

The ANCOVA for the total score of the PSDQ showed a significant condition main effect (F(1,97) = 6.12; p = .02; $\eta^2$p = .06) with the intervention group showing larger gains in overall PSDQ scores compared to the control group which showed a decrease in PSDQ scores. Gender and BMI did not influence findings (p > .05).

### 4.3.6 *Lower primary (Year 2 and 4)*

ANCOVA showed a significant condition main effect (F(1,66) = 5.80; P = .02; $\eta^2$p = .08) with the intervention group showing larger gains. Neither gender or BMI influenced the findings (p > .05).

### 4.3.7 *Year 6 (only)*

The ANCOVA for the PSDQ did not show a significant condition main effect for upper primary school children (F(1,28) = 1.61; p =.22; $\eta^2$p = .05); neither gender or BMI influenced the findings (p > .05).

## 4.4 **Discussion**

The aim of this study was to examine the efficacy of a gymnastics curriculum on the development of movement skill competence and physical self-concept in primary school children compared to the school's standard PE curriculum. Overall, no difference was found between the two curricula in terms of improvements in actual movement skill competence when combining all grades. However, age was found to be a significant

covariate for overall FMS and general body coordination variables. When examining the findings for the upper and lower primary children separately, it was found that the lower primary school children responded more positively to the gymnastics intervention than upper primary school children. In particular, children who participated in the gymnastics curriculum demonstrated a significant improvement in total FMS score, object control skills and in their physical self-concept compared to the control condition.

Children in the lower primary intervention condition showed significant improvements in total FMS when compared to the control condition. This was mainly due to improvements in object control skills. Object control skills are deemed to be the most complex and hardest skills to learn in the FMS family (Morgan et al., 2013). A possible explanation for the intervention group's improvement in object control skills is that they developed foundational skills which underlie object control skills. The improvement in object control skills is important as these skills have been associated with increased fitness and physical activity outcomes later in life (Barnett et al., 2008; Stodden et al., 2014; Vlahov et al., 2014).

It is not clear why children in the upper intervention group did not show similar improvements as both groups started with similar pre–test scores. One possible explanation is that, since the gymnastics curriculum was not designed for Year 6 children, the task and environment constraints acting on the children's neuro-biological systems may not have been challenging enough to formulate the acquisition of FMS and general coordination (Newell, 1986). The previous chapter demonstrated that general body coordination, object control and locomotor skills are independent constructs in a movement competence model. It has been suggested that FMS, in this respect, will only

develop from rudimentary into mastery if a child is exposed to practice and guidance for between 240 and 600 minutes (Walkley et al., 1993). Since both the intervention and control groups were exposed to 800 minutes of PE over the 8-week study period, it is not surprising that both groups showed improvements in FMS skills.

The development of efficient general body coordination is not, however, a learnt skill. It is developed in response to the tasks and environmental conditions encountered and, as such, it may be developed by implicit processes that do not appear to have a fast track solution (Newell, 1986). The lack of challenge for the upper primary school gymnastics group, coupled with the relatively short time frame, may be the reason that little change was seen in the older children's general body coordination. A possible explanation for the lack of significant differences in the lower primary children in relation to general body coordination performance might also be the duration of the study.  Longer exposure to a gymnastic based curriculum might be required to demonstrate benefits to general body coordination. This is in line with Lenoir et al. (2014) who found children who underwent a multi-move programme in addition to normal PE improved FMS but not general body coordination. Movement development models (Burton et al., 1998; Burton & Rogerson, 2001; Gallahue et al., 2012) detail that underlying movement skills are a child's ability to orient and stabilise themselves in their surroundings though each uses different terminology. Gallahue et al., (2012) call these stability skills and Burton and Rogerson, (2001) label this as postural control and balance. Research has shown that a child's postural control system is underdeveloped in terms of its ability to integrate information from multiple sources to maintain sufficient postural control in complex movements (Barela et al., 2003). Interestingly, Garcia et al., (2011) found that younger gymnasts aged five to seven presented greater postural control when compared

to younger non-gymnasts. This was explained by the younger children being able to integrate multiple sensory systems which allowed them to have a superior kinaesthetic awareness of their body in space. In this study we did not examine stability skills but there is a need to better understand the role stability skills/ postural control play in a child's development. In this study the PE teacher was involved in the delivery of all lessons (with the support of a coach in the gymnastics lessons). This was observed to be a real strength of the study. As a collegial partnership between the PE teacher, and specialist (gymnastics) coach, provides a complementary synergy of content (coach) and pedagogical knowledge of child learning (PE teacher). From a theoretical position this encourages teachers and coaches to engage in the social construction of knowledge and understanding (Lave & Wenger, 1991; Wenger et al., 2002). In this study the gymnastics group showed improved physical self-concept and this may be explained by the fact that gymnastics is non-competitive and this may therefore lead to a less threatening learning environment, which is more aligned to a task oriented mastery climate.

## 4.5     Conclusion and recommendations

Overall, the gymnastics intervention was found to be beneficial in terms of developing children's movement skill competence and their physical self-concept, particularly for the younger age groups. The improvements in object control skills are of particular interest given that these skills are known to be both complex and difficult to learn and are associated with increased levels of fitness and physical activity. A positive physical self-concept is also associated with higher engagement levels, skill development, and motor learning.  In view of these findings, further investigations into the efficacy of a gymnastics curriculum area would be of value for children in lower to middle primary

school. A limitation of the present study was the relatively short intervention period. Another limitation was that children under eight years of age needed significant external support to comprehend a number of the concepts contained within the PSDQ. In view of this, the main study in this thesis should explore the influence of an extended intervention period and the availability of more simplistic questionnaires which use pictures or symbols to help younger children's comprehension. In addition, the role stability skills play in the development of movement skill competence, (and object control skills in particular) is an important area of investigation for the main study.

# CHAPTER - 5  FUNDAMENTAL MOVEMENT SKILLS ARE MORE THAN RUN, THROW AND CATCH: THE ROLE OF STABILITY SKILLS

(Published Paper)

*"People who are crazy enough to think they can change the world, are the*

*ones who do."*

*Apple Inc*

5.1     **Introduction**

The ability to perform various FMS (e.g. running, catching, hopping, throwing) in a consistent and proficient manner, is often defined as motor competence (Gabbard, 2011; Gallahue et al., 2012).  As noted in the literature review high levels of FMS competence in childhood are related to a number of health and physical activity outcomes (Lubans et al., 2010a). Children who possess high FMS levels have a greater chance of maintaining good health, are more likely to participate in physical activity and possess better fitness in later life (Barnett et al., 2008; Jaakkola, Yli-Piipari, Huotari, Watt, & Liukkonen, 2015).

Yet Australian research has demonstrated trends of low and decreasing levels of FMS (Hardy, Barnett, et al., 2013; Okely & Booth, 2004; Tester, Ackland, Houghton, et al., 2014). The reported decline in FMS in the last 30 years in Western Australia (Tester, Ackland, & Houghton, 2014) and the stagnant levels of poor FMS reported over the past 13 years in New South Wales (Hardy, Barnett, et al., 2013) may be due to many children missing out on the foundations of movement which were routinely developed by children in previous generations through incidental physical activity. Australia has seen a 42% decline in active transport between 1971 and 2013 (Active Healthy Kids, 2014) and children's top ten preferred play spaces have seen a marked transition from outdoors to indoors between 1950 to 2000 (Active Healthy Kids, 2014) .

Gallahue and Ozmun, (2012) state that there are three constructs which make up FMS: locomotor skills (run, hop, jump, slide, gallop and leap); object control skills (strike, dribble, kick, throw, underarm roll and catch); and stability skills (non-locomotor skills such as body rolling, bending, twisting). Object and locomotor skills have been widely evaluated in children's FMS development, for example: (Barnett et al., 2008; Hardy,

Barnett, et al., 2013; Lubans et al., 2010a).  The same cannot be said for stability skills which have been described as the most basic skills within the FMS family (Gallahue et al., 2012).

Stability skills can be defined as the ability to sense a shift in the relationship of the body parts that alter one's balance, as well as the ability to adjust rapidly and accurately to these changes with the appropriate compensating movements (Gallahue et al., 2012). The system responsible for the ability to maintain balance and sense shifts in balance is generally termed postural control and enables the body's positioning in space for the dual purposes of stability and orientation. Postural stability refers to the ability to maintain, achieve or restore a specific state of balance, whilst postural orientation is the competence to maintain an appropriate relationship between the body and the environment for a task (Horak, 2006).

Faigenbaum et al., (2014) examined a similar concept to stability skills in children. Their study used a product based assessment tool called the Lower Quarter Y Balance Test (YBT-LQ) requiring children to maintain single-leg balance and reach as far as possible with the contralateral leg in the anterior, posteromedial and posterolateral directions. The YBT-LQ was found to have good inter-rater and retest reliability and as such was found to be a reliable measure of dynamic postural control in children. Predictive validity could not be established with year group as a predictor of performance, as grade three children out performed grade five and six children on some aspects of the tests. The authors concluded that other factors need to be considered alongside chronological age such as somatotype, muscular strength and habitual physical activity as these may all influence stability. They also proposed that grade three children may have developed more efficient movement strategies which resulted in

higher stability scores, however, this could not be confirmed or investigated due to the limitations of the instrument which only provides an outcome score.

The idea that previous motor skill and physical exercise experiences will significantly impact a child's postural control development is reinforced by Garcia et al., 2011 who studied the influences of gymnastics on postural control. The authors found significant improvements on bipedal (static upright two foot stance) postural control in 5 -7 year old gymnasts compared to non-gymnasts, though they did not find a difference between gymnasts and non-gymnasts aged 9-11. It was suggested that participation in gymnastics promotes improvements in the performance of postural control of younger children. Specifically, this improvement is related to the use of the available sensory cues that gymnasts have in such a way that they can use them to better estimate body dynamics and, therefore improve the performance of postural control. Such training effects were not present in the older cohort. This might be due to the bipedal stance being too basic a task resulting in a ceiling effect. The authors suggested that future research should look at different postural control stances that place higher demands on children's postural control system. This provides a unique insight that gymnastics skills may offer a suitable vehicle for the assessment of stability skills.

Currently, there are limited process based tools in the motor development field to investigate the level of children's stability skills in a school setting. This study will therefore aim to develop a process based assessment tool focused upon gymnastics skills as an alternative to the current product based assessment test batteries. It was decided to measure the process/form of the movement rather than measuring the outcome of the skill as it was believed this would provide a deeper understanding of the strategies employed by children who have developed more efficient movement

strategies in the stability skills domain. Indeed, empirical evidence suggests that there are associations between skill process and skill outcome (Miller et al., 2007; Roberton & Konczak, 2001). To date, no specific research has looked at how SES affects the level of stability skill, despite the fact that it has been found to influence maturational development (Buck & Frosini, 2012; Mitchell et al., 2013), weight status and the acquisition of FMS skills (Booth et al., 1999; Hardy et al., 2012).

The second aspect of this chapter is to investigate the relationship between stability skills and locomotor and object control skills. This description of stability skills, as a separate construct of FMS has not previously been empirically examined. Rather, research has focused on the importance of a child's basic ability to maintain balance and how it is related to FMS performance (DeOreo & Keogh, 1980; Espenschade & Eckert, 1967; Saeterbakken, Van den Tillaar, & Seiler, 2011; Wickstrom, 1977). As a result, findings have been inconclusive. Ulrich and Ulrich, (1985) in 3-5 year olds, showed that the composite balance test from the Bruiniks-Osertsky test of motor proficiency significantly predicted a qualitative rating of hopping, jumping and striking proficiency, but not other key FMS. Ulrich speculated that the composite score for balance may be too insensitive to assess the specific types of balance control required in other FMS. Chew-Bullock et al., (2012) did find a significant correlation between single leg balance and kicking accuracy, but not with kicking velocity. These findings are consistent with the notion that when kicking for velocity, the centre of gravity will be outside of the body, to utilise momentum so as to increase power, making it unlikely that maintaining static balance would be of importance (see Butterfield & Loovis, 1994 for similar results). These studies highlight that balance is dynamic task specific and a dynamic process, and that one specific type of balance test is potentially an unreliable measure

for stability skills which are underpinned by a child's postural control system. Therefore, this study will investigate the construct of stability skills as defined by Gallahue et al., (2012) and see how this construct fits into the more prominent constructs in the FMS family.

The first aim of this study was to validate a test battery to assess stability skills in children aged 6 to 10 years old in order to measure the development of the underpinning sub-domains of postural control system, orientation and stability. The second aim of this study was to assess where stability skills fit into a FMS model which includes locomotive and object control skills.

### 5.2    Method

The method is divided into three parts. Part One sets out the procedure for developing the stability skills assessment tool to measure the face and content validity of the test battery. Part Two reports the methods used to assess predictive validity inter and retest reliability. Part Three explains the methods used to assess how stability fits into a fundamental movement skill model, which involved two steps: a) confirmatory factor analysis to determine if the three stability skills examined load on to the stability construct and b) structural equation modelling to develop a complete model of FMS which includes stability, locomotor and object control skills.

#### 5.2.1 *Part One*

##### *5.2.1.1    Stability skill test protocol development*

The development of the postural control test protocols was guided by the Delphi approach (De Villiers, De Villiers, & Kent, 2005). In particular a panel of experts was used to determine face and content validity.

### *5.2.1.2 Face validity*

Four experts (three academic experts in human movement and skill acquisition and one PE teacher) identified movement skills demanding postural control. Due to the relationship between superior postural control and gymnastics (Garcia et al., 2011), the experts also reviewed 32 gymnastics skills (taken from the Gym Mix Gymnastics for All national programme) for potential inclusion in the postural control assessment tool. These skills were then ranked according to the demands they place on the two subdomains of the postural control system and the method by which this could be assessed.

In the first iteration, nine skills were identified: cartwheel, handstand, arabesque (a body position in which one stands on one leg with the other leg extended behind the body, both legs should be held straight), forward roll, backward roll, rock (a training method for the forward roll), front support, back support (a static wedge shape with arms straight and legs straight and together) and log roll (a sideways roll with arm and legs straight and slightly raised off the ground).

The second iteration assessed the feasibility of the skills as an assessment tool in a school setting, resulting in four skills being deemed unsuitable because of safety concerns (cartwheel, handstand, forward roll and backward roll) and one skill (arabesque) being similar to YBT-LQ a single leg balance. This would indicate difficulties with developing a process scoring system. Another reason was that ceiling effects have been observed in the one leg balance task in children (van Beurden et al., 2002).

This left four skills: rock, log roll, front support and back support. The front and back support are very similar skills so it was decided only one needed to be included. The

back support task was selected as it was reasoned that it would be more challenging due to it being a more unnatural position for the body to hold and therefore would require higher torso strength and postural stability.

As each of these skills measure different aspects of postural control, i.e. the rock has high orientation demands, the back support requires high whole body stability and the log roll requires both postural orientation and stability, it was believed that when combined they would provide a holistic picture of participants' postural control ability and as such be a good measure for the stability skills construct.

### *5.2.1.3    Content validity*

A process-oriented assessment was developed for the three gymnastics skills similar to other FMS test batteries (e.g. TGMD2: Ulrich, 2000). This was achieved by filming (JVC GY/HM100E) an elite gymnast from two angles (90 degrees and front on) executing the three skills. The same team of experts involved in the development of face validity analysed each skill in slow-motion and agreed upon the key components for successful execution for each skill. This was the first iteration of a scoring system for each skill which enabled an assessor to determine if key components were present or absent.

Following this, a different team of nine experts (five academics, two PE teachers and two state level gymnastics coaches) were invited to assess the skill components. To be included on the expert panel researchers had to have published papers internationally in the areas within or related to movement sciences; teachers had to have taught PE or coached gymnastics to primary school aged school children; and, gymnastic coaches needed to have advanced coach accreditation and be currently coaching.

Using email, each panel member was provided with the assessment elements and procedure of the rock, log roll and back support and were asked to examine whether the identified components were the key elements for successful skill execution and to rank each of the two postural control demands (orientation and stability) of each skill on a Likert scale (1 = low; 5 = high). All panel members provided extensive feedback which centred around three themes: 1) the wording of the components was overly scientific for mainstream use; 2) separate components overlapped in the same skill; 3) two of the three skills were deemed to be eliciting low levels of postural orientation or stability demands. Based on this feedback a number of changes were made.

Rock: Changes were made to the protocol whereby the participants were required to complete two rocks and then come to a stand in a single motion to enhance the postural orientation demands of the skill. This was broken down into four components (see Figure 5-1).
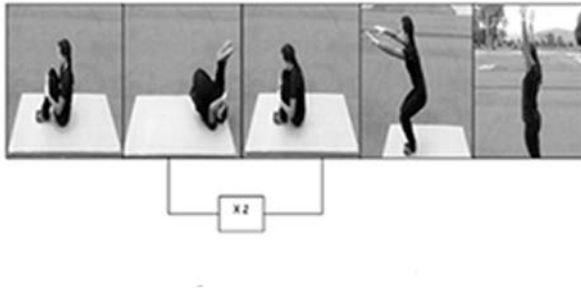


| NAME | | | DOB | | GENDER | | TEST DATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|

| | Materials | Directions | Perfomance Criteria | T1 | T2 | Score |
|---|---|---|---|---|---|---|
| **ROCK** | Two foam mats | Place the mats together, length ways (short sides touching). Child should sit in the centre of the two mats. The child's feet should be on the mat throughout the rock. | Component 1: Able to maintain and hold a seated tuck position (legs should be pulled in tight to chest). | | | |
| | | | Component 2: Rocks backwards onto nape of neck and shoulders keeping legs pulled into the body at all times. Rock back to seated postion. | | | |
| | | | Component 3: Rock back for a second time, keeping legs pulled into body (tuck shape). | | | |
| | | | Component 4: During the second rock, when returning to the seated position, transfers weight to feet and drives up to standing position without placing hands on the floor at any stage. | | | |
| | | | *Skill Score* | | | |

Figure 5-1: Rock scoresheet

Log Roll: The log-roll protocol underwent the least revisions as it was felt it was the most demanding of skills, requiring orientation to roll in a straight line and stability to keep legs extended and slightly off the ground. The skill was condensed into three components (see Figure 5-2).
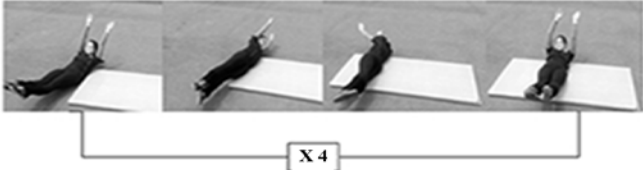
| | Materials | Directions | Performance Criteria | T1 | T2 | Score |
|---|---|---|---|---|---|---|
| **LOG ROLL** | Two foam mats | Place the mats together length ways (short sides touching). <br><br> Child lies face up at one end of the mat. | Component 1: <br> Rolls in a straight across the matt, the child's path does not deviate to the left or right. <br><br> Child demonstrates four complete rotations. | | | |
| | | | Component 2: <br> Child's arms are are extended above their head throughout the roll. <br><br> Legs are extended throughout the roll with toes pointing. | | | |
| | X 4 | | Component 3: <br> Child demonstrates control throughout the roll. Arms and legs do not touch the ground. | | | |
| | | | **Skill Score** | | | |

NAME　　　DOB　　　GENDER　　　TEST DATE

Figure 5-2: Log-roll scoresheet

Back Support: Feedback from the panel of experts resulted in the inclusion of two time based outcome components. In addition, successful completion of this task was deemed to include a high level of body stability as well as maintaining all-round body tension and strength. The new assessment break down was comprised of three process components and two timed product components (see Figure 5-3). If a child was unable to maintain any of the process components (1-3) they would be given one prompt to re-hold the correct position, if they failed to maintain that position for a second time the test would be terminated. Alternatively, the test would be ended if the participant held

the position for 45 seconds. This brought the protocol in line with another protocol developed for the front support for 8-12 year old children (Boyer et al., 2013) which had both a process and outcome assessment. That is, children were required to hold the position in the appropriate way and do so for as long as possible (strength endurance component).
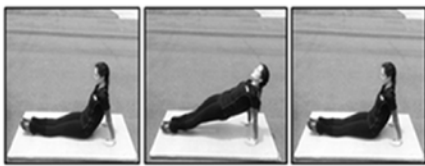


| NAME | | DOB | GENDER | | TEST DATE | | | |
|---|---|---|---|---|---|---|---|---|
| | Materials | Direction | Performance Criteria | | | T1 | T2 | Score |
| BACK SUPPORT | Two foam mats | Place the mats together length ways (short sides touching). | Component 1: Hands and arms positioned under shoulders. Arms should be straight and fingers pointing towards feet. | | | | | |
| | | Child sits on the mat with legs straight and together. Arms should be extended and placed at a comfortable position behind the body. | Component 2: Legs straight and together with feet extended (heels should be the only part of the feet touching the floor. | | | | | |
| | | | Component 3: The child exhibits good body tension by maintaining a straight diagonal line running from head to feet. | | | | | |
| If a child's hips sag or legs bend at the knee during the test, they should be prompted to maintain the original shape through either lifting hips or straightening legs. If a child needs to be prompted more than once the test is stopped. | | When the test is about to begin the child should raise their hips up off the ground, forming a wedge shape with the body. | Component 4: Back support is held for 30 seconds. | | | | | |
| *Child should be given 3 minutes rest between trials* | | As soon as the child is in position start the timer. | Component 5: Back support is held for 45 seconds. | | | | | |
| | | | Skill Score | | | | | |

Figure 5-3: Back-support scoresheet

### 5.2.2 *Part Two predictive validity and inter and retest reliability*

#### *5.2.2.1 Participants*

Assessments to test the predictive validity of the stability skills involved a total of 337 children aged 6-10 (*M* age = 8.2 SD 1.2), of which 152 were girls (53%). Predictive validity was tested in both gymnasts and children of differing SES backgrounds. To ensure a representative sample of children, the Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Advantage and Disadvantage developed by the Australian Bureau of Statistics (ABS) was used to identify the schools to ensure a

diverse selection of schools. Overall, children were drawn from four cohorts; 37 (11.0%) gymnasts of mixed SES, 108 (32%) high SES children, 128 (38%) medium SES and 64 (19%) low SES.

In order to assess the construct validity, confirmatory factor analysis was undertaken on the school sample only. This included a total of 300 school children (*M* age = 8.2, SD 1.1), of whom 155 (52%) were boys and 145 (48%) were girls. The school groups were assessed on the postural skills and FMS (TGMD-2). A University Ethics Committee and Victorian Department of Education and Early Childhood Development approved the study and parental consent was obtained for all participants (Appendix A and B).

### 5.2.2.2    *Assessment tools*

Height was assessed with a Mentone PE087 portable stadiometer (Mentone Educational Centre, Melbourne, Australia) and weight was assessed using a SECA 761 balance scale (SECA GmbH & Co. KG., Birmingham, UK). To ensure reliability two measures were taken and the average of the two was used. Body mass index (BMI) was calculated as weight divided by height squared (kg/m2).

Isometric handgrip dynamometer (TTM Dynamometer, Tsutsumi, Tokyo) was used as a measure of muscular strength. Measurements were repeated two times on the child's dominant hand and the two trials were conducted with a pause of 30 seconds to avoid muscle fatigue. The result of each trial was recorded to the nearest 0.1kg kilogram. If the difference between the two trials was within 0.5 kg, the test was complete, if the difference was greater than 0.5 kg, then the test was repeated once more after a 30 seconds rest period.  The maximum score of the dominant hand was used in this study.

The TGMD-2 (Ulrich, 2000) assesses proficiency in six locomotor skills (run, hop, slide, gallop, leap, horizontal jump), and six object control skills (striking a stationary ball, stationary dribble, catch, kick, overhand throw, underhand roll). Each participant completes all 12 skills of the TGMD-2. For each skill, components are marked as 'present' or 'absent'.

To measure stability three additional gymnastics training skills were assessed. These are the rock (see Figure 5-1), log-roll (see Figure 5-2) and back support (see Figure 5-3).

### 5.2.2.3     *Procedure for data collection*

The full test battery comprised: the stability skills and TGMD-2. The movement competence assessments were carried out in a large sports hall with groups of four participants rotating around three skill stations and one anthropometric station. The TGMD-2 was split between two stations, a locomotor skills station (run, hop, slide, gallop, leap, horizontal jump) and an object control skills station (striking a stationary ball, stationary dribble, catch, kick, overhand throw,  underhand roll). The three stability skills (rock, log roll and back support) made up the third skill station. Before the start of each skill the children watched a live and pre-recorded demonstration, they were then are given one practice attempt and two assessment trials for each skill.

### 5.2.2.4     *Intra, inter and retest reliability*

Before testing could be completed, four research assistants (RAs) each undertook 26 hours of inter reliability training.  RA1 and RA2 were trained to code each of the 12 TGMD-2 skills and RA3 and RA4 were trained to assess the three stability skills. RA1 and RA2 were paired and each scored 15 pre-recorded videos of children (5% of the total sample) completing the TGMD-2 test. RA3 and RA4 were paired and scored 25 pre-recorded videos of children (8% of total sample) completing the three stability

skills. Retest reliability and intra reliability were assessed for the stability skills through the level of agreement of a single observer over a seven day period and was carried out on 8% of the total sample. (ICC values < 0.4 were rated as poor, > 0.4 to 0.8 as moderate and > 0.8 as excellent) (Gwet, 2014).

### 5.2.2.5 *Statistical analysis*

Raw mean descriptive results were reported for the stability skills and TGMD-2 tests for each cohort. Prior to statistical analysis, the stability skills and TGMD-2 data were z-transformed. In addition, data was assessed for violation of the assumptions of normality and for outliers. Ceiling and floor effects were assessed looking at the percentage of children who scored zero or a maximal score on the three stability skills. To examine the predictive validity, the cohort differences were investigated. Analysis of covariance (ANCOVA) was conducted for the combined score of the three stability skills and controlling for the potentially confounding factors BMI and grip- strength. Multivariate analysis of covariance (MANCOVA) was conducted for the three stability skills separately with follow-up ANCOVAs in the instance of a significant main effect. Post-hoc comparisons were conducted using Bonferroni. Significance level was set at 0.05 and partial effect sizes were reported.

### 5.2.3 *Part Three assessing how stability fits into a FMS model*

### 5.2.3.1 *Confirmatory factor analysis*

CFA was used to examine the factorial structure of the three stability skills and if they loaded onto a single construct named stability skills using AMOS 22. CFA was conducted with the maximum likelihood method of estimation. In order to specify a model containing latent variables for all factors, error variance was set at zero. Several

goodness of fit measures were used to describe the models. In addition to the Chi square ($\chi^2$) statistic, which is influenced by sample size and as such can be unreliable, the following fit indices were considered: Chi square/DF ($X^2$/DF); Comparative fit index (CFI); Root mean square error of approximation; Standardised root mean residual (SRMR); and the PCLOSE.

The $\chi^2$ statistic is a measure of overall fit of the model to the data with a non-significant P-value (P > .05) indicating a good fit. Also, $\chi^2$ divided by the degrees of freedom ($\chi^2$/df) provides an indicator of fit with values of < 2 considered adequate fit. CFI values of .90 or above indicate an adequate fit. RMSEA values of .06 or lower and SRMR values of .08 or lower indicate a close fit when these statistics are taken together. Finally, the PCLOSE should be non-significant (P > .05).

### 5.2.3.2 *Model specification*

First the original FMS model comprised of locomotive and object control skills (Ulrich 2000) was tested with the current cohort. In the instance of an adequate fit in both the postural control CFA and FMS CFA the new extended model of FMS would be tested; this would be comprised of stability skills, locomotive skills and object control skills.

## 5.3 **Results**

### 5.3.1 *Descriptive data*

Mean scores and standard deviations for children's anthropometric, locomotor, object control and stability skills for the four cohorts are reported in Table 5-1. Test for multivariate kurtosis did not show problematic levels of skewness or kurtosis (Kline, 2011; Mardia, 1970).

Table 5-1: Descriptive statistics [Means and standard deviations (M ± SD)] of Anthropometrics and aspects of Movement competence for each cohort

|  | Gymnasts | School | School | School |
|---|---|---|---|---|
|  | Mixed SES | High SES | Middle SES | Low SES |
| N | 37 | 108 | 128 | 64 |
| BMI | 16.1 ± 2.7 | 16.9 ± 2.6 | 16.9 ± 3.2 | 17.6 ± 3.0 |
| Grip Strength | 14.1± 5.1 | 15.5± 3.7 | 15.2 ± 3.4 | 14.8 ± 4.5 |
| Stability Skills | 21.5 ± 2.2 | 15.0 ± 4.9 | 12.9 ± 4.4 | 9.7 ± 4.5 |
| Locomotive | 32.0 ± 6.8 | 30.5 ± 7.3 | 28.6 ± 5.9 | 29.5 ± 6.5 |
| Object Control | 29.5 ± 8.2 | 30.7 ± 7.4 | 26.8 ± 8.3 | 30.3 ± 7.6 |

### 5.3.2 *Stability skills feasibility*

The log roll had the largest floor effect with 29% scoring zero. The other two skills had 3% and 2% of children scoring zero for the rock and back support respectively. The back support and rock showed the largest ceiling effect with 25% and 22% of children respectively achieving a maximal score followed by 6% for the log roll.

### 5.3.3 *Inter, intra and test re-test reliability*

The Intra Class Correlations (ICC) for inter rater reliability for the TGMD-2 skills and the Stability Skills provided adequate ICCs: locomotor skills (ICC = 0.90; 95% CI: 0.73 - 0.98), object control skills (ICC = 0.82; 95% CI: 0.58 - 0.96) and the three stability skills rock: (ICC = 0.87; 95% CI: 0.73 - 0.94), log roll (ICC = 0.81; 95% CI: 0.52 - 0.93) and back support (ICC = 0.87; 95% CI: 0.72 - 0.95).

The intra reliability for the overall stability skills for the assessor was excellent over a seven day period (ICC = 0.92; 95% CI: 0.75 - 0.98). Test re-test reliability over a seven day period also demonstrated excellent consistency for each of the three skills: rock (ICC = 0.95; 95% CI: 0.83 - 0.98), log roll (ICC = 0.87; 95% CI: 0.59 - 0.95) and back support (ICC =0 .88; 95% CI: 0.65 - 0.96).

### 5.3.4 *Predictive validity stability skills*

Individual stability skills and total mean scores and standard deviations are reported in Table 5-1 for each of the four cohorts separately. ANCOVA for summed stability skills controlling for BMI and grip-strength showed a significant main effect (F(3,333) = 61.56;  p = .001; η2 = .36).

 Post hoc comparisons revealed that all cohorts performed as expected with Gymnasts mixed SES having superior stability skills to all other groups, high SES scored better than mid and low SES and finally mid SES out performed low SES.
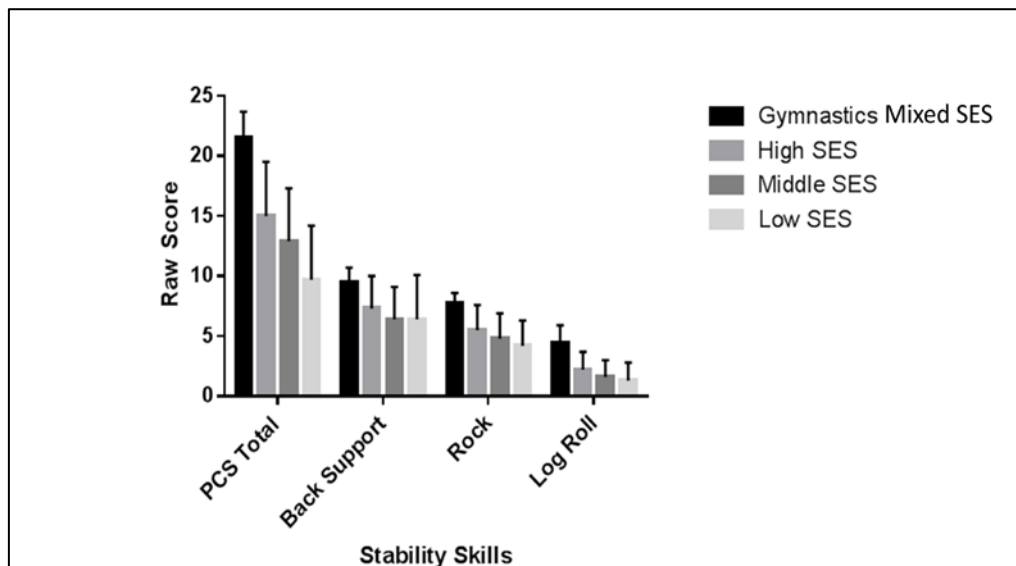


Figure 5-4: Mean scores and standard deviations for the four cohorts on the three stability skills

MANCOVA for the three stability skills showed a significant main effect (Wilk' $\lambda$ = .61; $F(3,9)$ = 20.67, p = .001; η2p = .16). Follow-up ANCOVA showed significant main effect for the rock ($F(3,333)$ = 28.9, p = 0.01; η2p = .21), log-roll ($F(3,333)$ = 32.65, p = .001; η2p =.23) and back-support ($F(3,33)$ = 35.84, p = .001; η2p = .25). Gymnasts mixed SES scored significantly higher than all school cohorts on all of the stability skills. The high SES cohort scored significantly better than low SES on all of the stability skills while the medium SES scored significantly better than low SES on back support and rock (all p < .05) (see Figure 5-4).

BMI and grip-strength were significant covariates for all three skills except log roll where BMI did not have a significant effect. Effects sizes for BMI ranged from 0.004 - 0.04 and for grip-strength between 0.02 - 0.11.

### 5.3.5 *Construct Validity for the three stability skills*

The Confirmatory Factor Analysis for the three stability skills (see Figure 5.5) provided an adequate model fit ($\chi^2$ (2df) = 1.03; p = .6; $\chi^2$/df = 0.52; CFI = 1.00; SRMR= .02; RMSEA = .01; PCLOSE = .78). In this model the three skills had a moderate to strong effect on the latent variable stability skills (back support r = .60, rock r = 59, logroll r =.59). The total variance explained in stability skills was 56.5%.
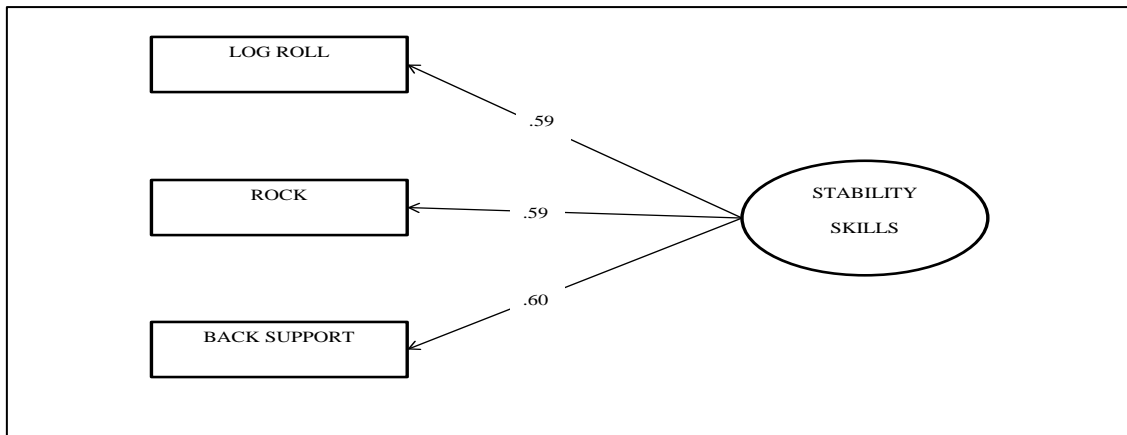
Figure 5-5: CFA for the three stability skills on the latent variable stability

### 5.3.6 *Construct validity of the fundamental movement skill model*

The original model of FMS was rebuilt according to Ulrich (2000). CFA for locomotive skills demonstrated an adequate fit ($\chi^2$ (9df) = 10.80; p = .30; $\chi^2$/df = 1.2; CFI = .98; SRMR= .03; RMSEA = .03; PCLOSE = .76). The CFA for object control skills also demonstrated an adequate fit ($\chi^2$ (5df) = 3.70; p = .60; $\chi^2$/df = 0.76; CFI = 1.0; SRMR= .02; RMSEA = .001; PCLOSE = .86). These two constructs were then combined into a SEM model as proposed by Ulrich (2000). This model showed an adequate fit ($\chi^2$ (48df) = 95.46; p = .01; $\chi^2$/df = 1.98; CFI = .90; SRMR = .06; RMSEA = .06; PCLOSE = .30). In this model both latent variables had high factor loadings (object control r =.75, locomotor r = .91) on FMS.

The final step was to combine the locomotor, object control and stability skills into a combined model of FMS (see Figure 5-4). An adequate fit was achieved following some modifications (inclusion of correlating of error terms within individual factors) ($\chi^2$ (85) = 145.7; p = .001; $\chi^2$/df = 0.58; CFI = .91; SRMR= .06; RMSEA = .05; PCLOSE =

.60). In this model locomotor (r = .88), object control (r = .76) and stability skills (r = .81) loaded on FMS (see Figure 5-6).
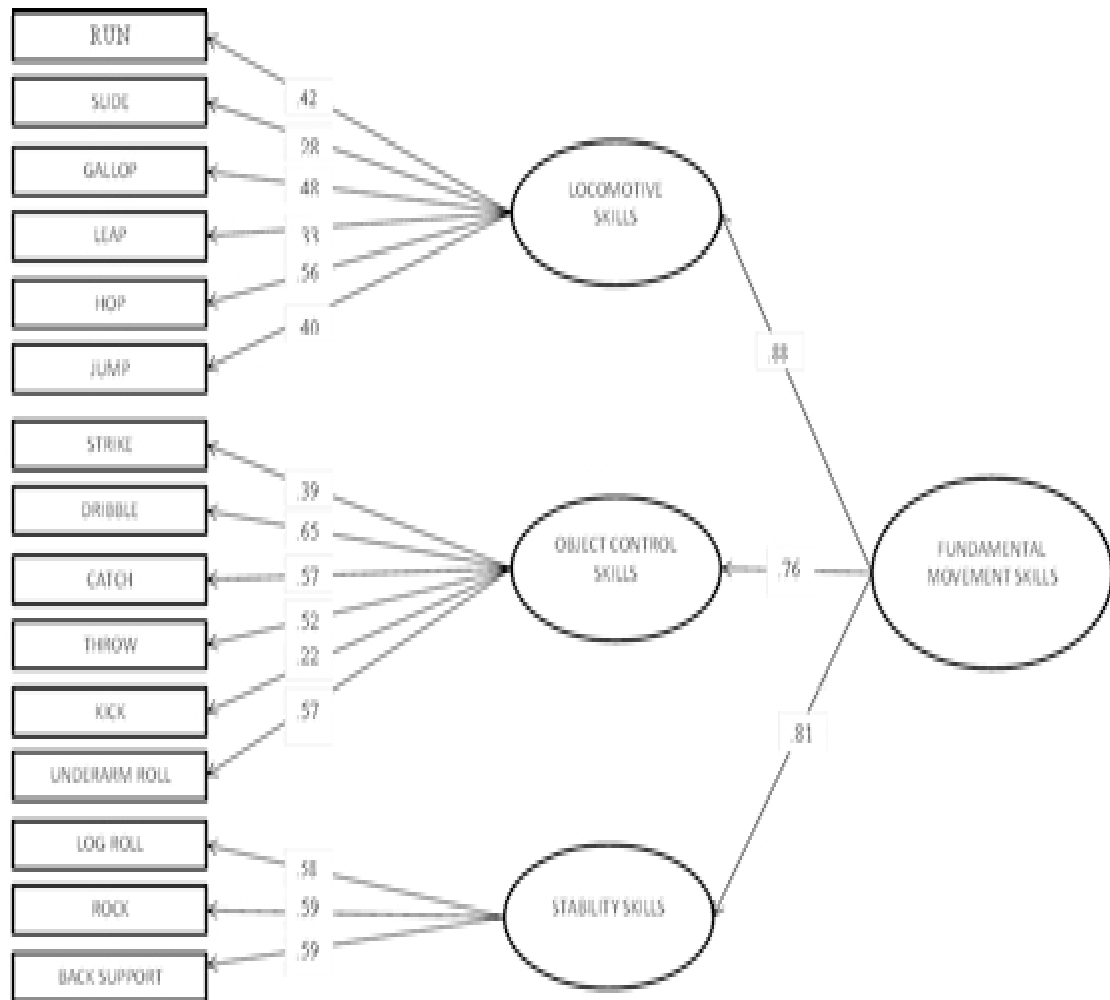


Figure 5-6 Complete model of Fundamental Movement Skills

### 5.4 Discussion

This study aimed to a) develop a process based assessment tool to examine stability skills in children aged 6-10 years old; and, b) better understand the role of stability skills and their role in the development of FMS. A three-skill stability test battery was developed consisting of the rock, log-roll and back support task which had good face and content validity and inter rater and test-retest reliability. In addition, it was

demonstrated that the individual skills as well as the stability skills as a whole had predictive and construct validity. Overall, the stability skills were found to be an independent factor in a fundamental movement skill model and consequently it is argued these should be assessed separately to other facets of movement competence.

The systematic development of the stability skills test battery resulted in the selection of three gymnastics skills which can be used to examine children's ability to orient and stabilise their bodies in space within a field setting. The rock and log roll were deemed to assess both orientation and stability while the back-support mainly assessed stability and torso strength. Using a mix of a process and outcome (back support only) assessment methodology the three skills collectively fitted well in a construct of defined stability skills. The gymnasts outperformed the non-gymnasts in all skills; this finding is in line with Garcia's (2011) research that participation in gymnastics develops superior stability skills through enhanced integration of where the body is in space during a task. The idea that stability skills can be accelerated through training and previous experience is further supported with high SES outperforming medium SES and low SES on stability skill performance. This is in line with previous research which shows children's SES background impacts upon their maturational development (Buck & Frosini, 2012; Mitchell et al., 2014), and the acquisition of FMS skills (Booth et al., 1999; Hardy et al., 2012).

Overall, the children's scores were distributed across the stability skills construct, though all were low compared to the gymnasts. The log roll appeared to be the most challenging skill for the children, as hypothesised during the validation stage, whilst the rock and back support were found to show ceiling effects. The three stability skills were successful in creating high postural demands on the postural control system leading to

the development of an assessment battery which is able to differentiate across all children aged six to ten years showing superior sensitivity to its predecessors, such as the bipedial stance as used in Garcia's (2011) study, or the YBT-LQ used in Faigenbaum's (2014) study. Two potentially confounding factors, BMI and muscular strength were found to have some, albeit minimal, effect on the sensitivity of the three stability skills in predicting stability skills performance showing the importance of adjusting for these factors.

The second aim was to examine how the newly defined "stability skills" construct fitted into the fundamental movement skill model. The original model by Ulrich (2000) showed that locomotive and object control skills are measuring discrete constructs in a model of FMS. Findings suggest that stability skills should be included into a model of FMS. The finding that the stability skills construct is largely discrete is an important finding and has consequences for development of test-batteries and the assessment of FMS/competence.

The results of this study suggest that children should practice stability skills alongside object control and locomotor skills as there is no guarantee that these skills will reach their full potential if children only practice the FMS outlined in current popular FMS assessment tools (Ulrich, 2000; Walkley et al., 1993). Stability skills are better viewed as a separate construct that can be developed independently through a series of skills which challenge and place high demands on the postural control system. Appropriate practice would be gymnastics training or related whole body exercises that promote opportunities for children to rotate, invert and support their bodies using different body parts. These stability skills will place stress on the postural control

system and result in children further developing sensory cues which will result in superior orientation and stabilisation strategies.

This new model of FMS, whereby stability skills sit adjacent to locomotive and object control skills (see Figure 5.6), may be the result of changes in society which have created conditions where children's basic skills are far diminished compared to previous generations. Children now possess lower levels of movement competence than their parents' generation, scoring poorly across the board, with low levels of object and locomotor skills (Hardy, Barnett, et al., 2013; Tester, Ackland, & Houghton, 2014). This chapter also shows that the stability skills of children who have not experienced gymnastics training are poor compared to children who have. It is possible therefore that the decline is not only the result of children having decreased experience of incidental activity and spending more time indoors but is also due to the marginalisation of PE in the primary school (Hardy, King, Farrell, Macniven, & Howlett, 2010; Moneghetti, 1993; Morgan & Hansen, 2008). Educational gymnastics used to be a cornerstone of PE in the Australian schools system (Kirk, 2012), but that is now a distant memory as gymnastics teaching has declined due to a lack of teaching expertise, safety and liability concerns.

The strengths of this chapter are the reporting of a reliable and valid instrument to assess stability skills and the process element of this tool which gives instructors greater insights into children's current movement strategies. This will aid them in delivering quality feedback and enable them to plan suitable interventions to improve stability skills.

This study has a number of limitations. First, the sample consisted of children from Australia only and therefore may not generalise to other countries. Secondly, the rock

and back support demonstrate ceiling effects, with over one fifth of children scoring top marks for the assessments. The rock has already been refined in the content validation in an effort to enhance the orientation element and there may be little more that can be done. However, the back support task required participants to hold this position for 45 seconds and this could be extended.  Future research should explore the relationship between the stability skills construct and how it correlates with other assessment tools which measure general coordination, rather than FMS, such as the KTK (Kiphard & Schilling, 2007) which is popular in mainland Europe.

In conclusion, to date the stability skill construct has been poorly measured in field based movement competence research in children. This study provides a tool which teachers, practitioners and researchers can use to measure stability skills. This tool could be used alongside other FMS assessments to provide a better understanding of a child's FMS development. In addition, this chapter suggests that stability skills can be viewed as an independent factor in a model of FMS and should be included in the main study of this thesis.

# CHAPTER - 6  EFFECTIVNESS OF A 16 WEEK GYMNASTICS CURRICULUM AT DEVELOPING MOVEMENT SKILL COMPETENCE AND PERCEIVED MOVEMENT SKILL COMPETENCE IN CHILDREN

*"Do not confine your children to your own learning for they were born in another time."*

*Hebrew Proverb*

6.1     **Introduction**

As already discussed, the ability to perform various movement skills (e.g. running, kicking, jumping) in a proficient manner is often defined as movement skill competence (Gabbard, 2011; Gallahue et al., 2012; Haga et al., 2008) and can be separated into three discrete constructs (Gallahue et al., 2012): locomotor; object control; and stability skills. Collectively, these are known as FMS, and are considered to be the foundation for more specialised movement required in many sports and physical activities (Seefeldt, 1980). Mastery of FMS is associated with a number of health benefits (Lubans et al., 2010a) and longitudinal evidence suggest children who have better FMS skills are more likely to possess superior cardiovascular fitness at 16 years of age (Barnett et al., 2008).

Typically interventions designed to improve children's FMS have focused on the development of object control and locomotor skills (Cohen, Morgan, Plotnikoff, Callister, et al., 2015; Foweather et al., 2008; Martin et al., 2009). Consistent with Gallahue et al., (2012) the last chapter suggested stability skills are a separate construct in the FMS family and that currently these are not adequately assessed or developed. Furthermore, European assessment of movement skill competence does not typically focus on FMS but instead examines a child's movement coordination via their ability to undertake novel and unfamiliar gross motor tasks (D'Hondt et al., 2011; Vandorpe et al., 2011). Collectively, the absence of stability skills and general body coordination, may contribute to a lack of movement skill competence. Burton and Rogerson (2001) argued that practice in PE should be consistent with a theoretical model of movement skill competence. As such, interventions based in the PE setting should develop and measure all aspects of a child's movement skill competence in order to gain a full understanding of studies efficacy.

The last chapter suggested that Australian children have poor stability skills. This is in line with current research that shows children are significantly behind their Belgian counterparts in general non-sport specific body coordination (Bardid, Rudd, Lenoir, Polman, & Barnett, 2015) and repeatedly perform poorly in locomotor and object control skills (Barnett, Hardy, et al., 2013; Hardy, Barnett, et al., 2013). This may be attributed to diminished PE time on school timetables (Hardy, King, Espinel, Cosgrove, & Bauman, 2013; Moneghetti, 1993; Morgan & Hansen, 2008) and an increased focus on the development of skills required for team sports at the cost of perceived feminist sports such as gymnastics (Wright, 2006). The last chapter highlighted that gymnastics training has been found to produce superior stability. A lack of gymnastics training may be a contributing factor for children failing to develop more complex object control skills (Hardy et al., 2012) and having poorly developed general coordination and stability skills (Bardid et al., 2015).

The ultimate aim of PE is for children to leave the education system with positive attitudes which facilitate lifelong adherence to being physically active (Commonwealth of Australia, 2010; Australian Curriculum and Authority, 2012). There is emerging research that if children perceive that they are poor at ball skills they are less likely to engage in physical activity and sport and that this will have a negative effect on their future health (Robinson et al., 2015). This is why it is so important to assess children's perceived movement skill competence as well as their actual movement skill competence. Stodden (2008) and Harter (2012) highlight that the relationship between actual and perceived movement skill competence strengthens throughout childhood. Young children's actual and perceived movement skill competence are loosely associated, this is due to young children reporting an over inflated perception of their

competence compared to their actual competence. Harter (2012) explains that young children engage in 'temporal comparisons' in which they compare themselves to how they performed on a previous occasion. This phase has been likened to a 'window of opportunity' and the ideal time for intervention, as children (even if low skilled) may still be keen on participation in activity (LeGear et al., 2012).

In the main study it was decided to omit the use of the physical self-description questionnaire (PSDQ) which had been used in the pilot study (Chapter 4) to assess physical self-concept. The reason for this was that children under eight years of age needed significant external support to comprehend a number of the concepts contained within the PSDQ and given time constraints this level of support would not be feasible in the larger study. In the main study it was decided that the Pictorial Scale of Perceived Movement Skill Competence (PMSC) would be a more appropriate measure to adopt in the main study. This measure aligns physical and perceived constructs by assessing locomotor and object control skill competence perceptions among children (Barnett, Ridgers, et al., 2015). The PMSC, assesses the same 12 skills as used in the TGMD- 2 (Ulrich, 2000) and since perceived movement competence being a subset of overall physical self-concept and is perceived to be an important predictor of continued physical activity (Barnett et al. 2008) it appears to be a more appropriate measure to be used in the main study.

The study aim was to evaluate the effectiveness of a 16 week gymnastics curriculum developed by Gymnastics Australia (GA) on stability, locomotive and object control skills, general body coordination and perceived movement skill competence. It was hypothesised that the children receiving the gymnastics intervention would demonstrate

significant improvements beyond a regular control group following their usual standard PE curriculum.

## 6.2    Method

### 6.2.1  *Study design*

This study used a non-randomised control design taken from the CONSORT statement (see Figure 6-1). Children in three schools were allocated to intervention or control groups based upon their class grouping. The study followed the TREND statement for reporting. Power analysis, using a medium effect size $d = 0.39$ taken from the meta–analysis of the effectiveness of motor skill interventions in children (Logan et al., 2012) indicated that it would require 140 participants in each condition to have 90% power for detecting a medium sized effect when employing the traditional .05 criterion of statistical significance.
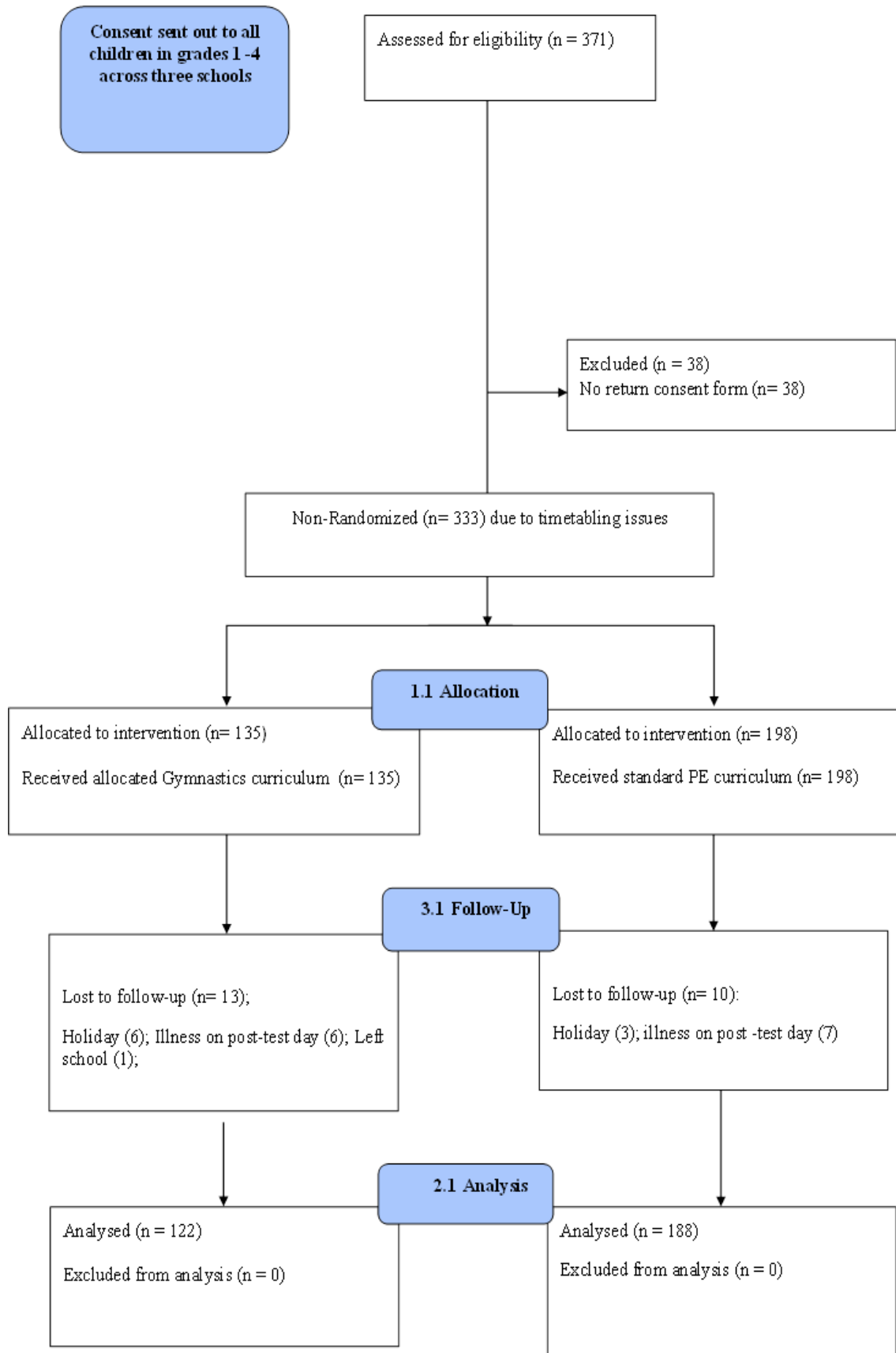
Figure 6-1: The CONSORT flow diagram

### 6.2.2 *Participants*

The Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Advantage and Disadvantage developed by the Australian Bureau of Statistics (ABS) was used to identify a low, medium and high SES school. The study was approved by Victoria University Ethics Committee and the Department of Education and Early Childhood Development (Appendix E and F). Children were asked to return written informed consent from the parents or guardians, with 89.5% returning consent. This resulted in 333 children (intervention $n = 135$; control $n = 198$), 51% girls, with a mean age of 8.1 years (SD = 1.1), 252 of these children (intervention $n = 96$; control $n = 159$) of which 51% were boys and 49% girls completed the PMSC questionnaire. It was not possible to randomly select the control or intervention classes across the three schools. These were identified by the school principals, although it was requested that they make their decisions based on timetabling rather than other considerations. As a result, six intervention classes (three from year 1/2; 3 from year 3/4) and eight control classes (four from year 1/2; four from year 3/4) were selected.

### 6.2.3 *Measurement of movement skill competence*

The stability skills test battery described in the previous chapter was used to examine postural stability. These skills were scored individually and summed together to produce a stability composite score. The TGMD-2 (Ulrich, 2000) was used to assess proficiency in six locomotor skills (run, hop, slide, gallop, leap, jump) and six object control skills (strike, dribble, catch, kick, throw, roll). For each task, skill components were marked as 'present' or 'absent' and then the components for the six locomotor skills were summed for a locomotor score, and likewise for the object control score. Non-sport specific body coordination was assessed using the KTK (Kiphard &

Schilling, 1974, 2007) using four outcome-based subtests; RB, walk backwards on balance beams decreasing in with); HH, hop on one leg over an increasing number of 5 cm foam blocks to a maximum of 12 blocks); CS, number of sideways jumps with feet together over a wooden slat in 15 seconds); and MP, moving across the floor during 20 seconds using two wooden platforms). These scores were summed together to give an overall general movement coordination score.

### 6.2.4 *Perceptions of movement skills instrument*

The PMSC for Young Children (Barnett, Ridgers, Zask, & Salmon, 2015) was used to assess children's perceived movement skill competence in six object control and six locomotor skills. This instrument was modified from an earlier instrument (Harter & Pike, 1984) and has acceptable face validity, good test-retest reliability (object control ICC = .78, locomotor ICC = .82, and all 12 skills ICC = .83) and internal consistency (alpha range = .60–.81) in an Australian sample (Barnett, Ridgers, et al., 2015). The PMSC asks simple questions regarding how the participants feel about their own movement skills. The survey has pairs of pictures of children engaging in specific movement skills. One picture shows a child performing the skill competently (e.g., catching the ball) and the adjacent picture shows an unskilful attempt (e.g., not catching the ball).
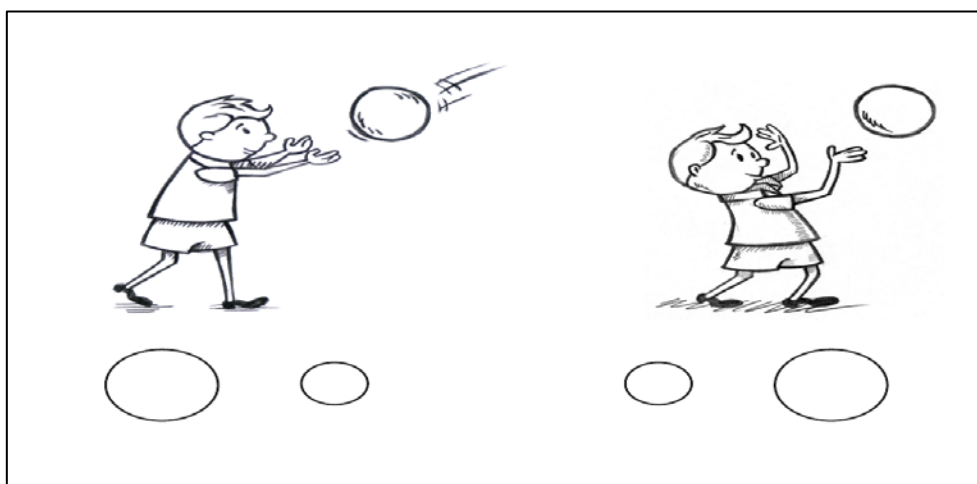
Figure 6-2: A sample picture from the PSPMC (Barnett, Ridgers, Zask, & Salmon, 2015)

The children were asked which picture is like them, and were given four possible answers on a scale from 1-4 (1 = Not too good, 2 = sort of good, 3 = pretty good and 4 = really good). A total of 12 skills were shown, six locomotor skills (e.g. running and hopping), and six object control skills (e.g. kicking and throwing). A total of score of 24 could be awarded for each subcategory and a combined total score of 48. The PMSC assesses self-perceptions for the same FMS skills which were assessed using the TGMD-2.

### 6.2.5 *Reliability analysis*

Prior to live assessments in the field setting, 10 Research Assistants (RAs) received six hours training in administration. Then the six RAs who had been selected to administer the KTK watched a battery of gold standard videos of each test. RAs scored all children in the videos according to KTK guidelines; percent agreement found the RAs collectively achieved 94% agreement. A further two RAs were trained to code each of the 12 TGMD-2 skills, whilst another two RAs were trained to assess the three stability

skills. Inter-rater reliability between each of the RAs and trainer was assessed through intra-class correlation coefficients (ICC). Subtest scores were found to be good for locomotor (Pre - test: ICC = 0.90; 95% CI: 0.73 - 0.98, Post - test: ICC = 0.91; 95% CI: 0.75 - 0.96) , object control (Pre -test: ICC = 0.82; 95% CI: 0.58 - 0.96, Post - test: ICC = 088; 95% CI: 0.70 - 0.97, ) and stability skills (Pre – test: ICC = 0.82; 95% CI: 0.53 - 0.93, Post- test ICC = 0.90; 95% CI: 0.73 - 0.97). One week prior to post assessment the RAs and trainer undertook further reliability to ensure consistency (ICC ranged between 0.88 - 0.91). The lead researchers carried out an additional 10% convenience inter-rater reliability during field assessment on each of the different testing stations. RAs were blind to which classes were in the intervention and control groups.

### 6.2.6 *Procedure*

Whilst completing the assessment, children wore light sport clothes (children completed the KTK, stability skills and anthropometrics in bare feet). All assessments were conducted by the 10 RAs in a large sports hall with groups of five participants rotating around five skill stations (two TGMD-2 and KTK stations, one stability station and one anthropometric station). Before the execution of each skill, children watched a live and pre-recorded demonstration. Each participant had one practice attempt and two assessment trials for each of the stability skills and TGMD-2 test battery. The KTK was administered according to the manual guidelines (Kiphard & Schilling, 2007). The PMSC was completed on the morning of the actual movement competence testing.  A one to one ratio was used, with an RA sitting with each child and taking them through the survey to ensure they understood what was being asked of them.

### 6.2.7 *Intervention period*

Both groups received two hours PE per week for two school terms (16 weeks intervention plus pre- and post-assessment testing during week 1 and 18). The intervention group received the gymnastics based PE curriculum taught by a GA gymnastics coach for the first hour during the first term, shadowed by the classroom teacher. The second hour of gymnastics was taught by the school's PE teacher. During the second semester the PE teacher and classroom teacher taught one hour each. The control group received two hours of their normal standard PE curriculum for 16 lessons which comprised team sports with one lesson taught by the PE teacher and one by the classroom teacher (see Table 6-1).

Table 6-1: Standard PE Curriculum

**Standard PE CURRICULUM: GRADE 1 AND 2**

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Modified Games running and stopping | Modified Games skipping and hopping | Modified Games skipping and hopping | Modified Games agility and balance | Modified Games Jumping and landing | Rope Skipping and hula hooping | Modified games focussed on bouncing | Minor games and modified sports focused on ball skills |

|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
|---|---|---|---|---|---|---|---|---|
| Theme | Athletics<br><br>Running technique | Athletics Standing start, simple crouch start | Athletics Relays | Athletics Shot put | Athletics 5 of 5 | AFL Catch and handpass | AFL Catch and handpass | AFL Modified games |

**STANDARD PE CURRICULUM: GRADE 3 AND 4**

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Teeball/ Softball<br><br>Using mitts to field and catch | Teeball/ Softball<br><br>Throwing technique | Teeball/ Softball<br><br>Batting | Teeball/ Softball<br><br>Modified game | Soccer<br><br>Basic passing and trapping | Soccer<br><br>Lob passing, chesting, heading | Soccer<br><br>Straight line dribbling | Soccer<br><br>Advanced ball control |

|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
|---|---|---|---|---|---|---|---|---|
| Theme | Athletics<br><br>Basic running technique. Sprint vs long distance | Athletics Standing starts, crouch starts, use starting block | Athletics Long Jump and triple jump | Athletics 5 of 5 | AFL Catching and hand passing | AFL Kicking | AFL Modified game | AFL Modified game |

The gymnastics intervention "LaunchPad" was designed for children up to 12 years of age with resources divided into three levels: KinderGym (2-5 years); GymFun (5-7 years); and GymSkills (8-10 years). All LaunchPad lessons have five teaching stages. Although the content differed in each lesson, all followed a set sequence: warm-up, brain challenge, main activity, circuit, and cool down. Importantly, each of these stages contained clear content descriptors of what should be taught and had a recommended timeframe. Each set of resources contained a set of chronological lesson plans, with each lesson building upon the previous one, and skill cards to complement the lesson plans (see Table 6-2).

Table 6-2: Gymnastics Australia LaunchPad curriculum (a detailed description of the gymnastics curriculum can be found at  http://www.launch-pad.org.au/ )

GYMFUN: GRADE 1 AND 2

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | Hand apparatus | Revision | School Olympics |
|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
| Theme | Inverts and rolls | Springs and Landings and shape balances in groups | Hoop sequences and jumps on and off apparatus | Ball and body rolls | Hanging bar circuit | Rolling circuit | Routine with partner all elements on ground | Partner routine all elements on apparatus |

GYMSKILLS: GRADE 3 AND 4

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | Hand apparatus | Revision | School Olympics |
|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
| Theme | Inverts and rolls | Partner Balances and inverts | Hoop sequences and jumps on and off apparatus | Ball and body rolls and partner counter balance | Hanging bar circuit including inverts | Individual sequence | Routine with partner all elements on ground | Partner routine all elements on apparatus |

### 6.2.8 *Fidelity*

In total 192 gymnastic lessons were delivered, with over 10% (a total of 20) observed to ensure the fidelity of the instructor (PE teacher, class teacher or coach) to deliver the lesson as intended. This was achieved through the RA coding: a) whether all five stages of the LaunchPad lesson plan were covered, with a score of one awarded for each stage;

and b) whether the instructor delivered each of the five sections in the appropriate time frame +/- 2 minutes, with again, a score of one awarded for each stage. These two scores were summed together to give a total lesson fidelity score out of 10.

### 6.2.9 *Statistical analyses*

All analyses were performed using MLwiN 2.33 (Rasbash., Charlton., Browne., Healy and Cameron, 2009) and SPSS (IBM Corp, 2012)

*Fidelity of the LaunchPad curriculum*

To examine the fidelity of the LaunchPad curriculum delivery two one-way ANOVA's were conducted (lesson content and lesson timing), with instructor type (PE teacher, class teacher and coaches) and school as independent factors.

*Actual movement skill competence*

To examine the effect of the gymnastics based PE intervention a series of multilevel linear mixed models were used with the fixed factors condition (intervention vs. control), gender and age. The outcome variables in the respective models were 1) stability skills, 2) locomotor 3) object control skills and 4) general body coordination (KTK). Class and child were random factors. The fixed effect of this variable was expressed by the regression coefficient.

To determine the hierarchical nature of the data, the relation between random intercept effects using ICC to compare the variation between class and child as a fraction of the total variance were investigated. For the post intercepts only model, three sets of regression models were constructed. Model 1 included gender (dummy variable male) as a predictor, model 2 included gender and chronological age in months as a predictor and model 3 included gender, age and treatment by time interaction effect (dummy

variable intervention). To assess overall model fit the 2*loglikelihood measure was used. This measure will decrease if independent variables have improved the ability to predict the dependent variable accurately. To assess if this was a significant or trivial improvement in the ability to predict the dependent variable, the difference value between the 2*loglikelihood values in the base model and the model including explanatory variables was calculated using the Chi-Square statistic.

### *Perceived movement skill competence*

Separate multivariate analysis of co-variance (MANCOVA) was conducted on the difference score (post-test – pre-test) for the PMSC total score (Perceived locomotor skill plus Perceived object control skill). Age and BMI were included as co-variates. In the instance of significant main effects, follow-up univariate analysis of co-variance (ANCOVA) was conducted for perceived locomotor and perceived object control skills. The PMCS data was found to be positively skewed, log transformations were run on all perceived object control and locomtor skills. The log transformed results were identical to the untransformed variables and as such, the untransformed results are reported for ease of interpretation.

### 6.3    **Results**

Retention rate at post-test was 93% for movement skill competence and 100% for perceived movement skill competence (see Figure 6-1). The absent children were similar to the remaining participants in terms of gender, age, locomotor, object control, stability and body coordination performance (all $p > .05$). Participating children's mean scores for locomotor, object control, stability skills, general body coordination and both perceived locomotive and object control skills split by condition are shown in table 6-3.

There was no significant difference between coaches, teachers and PE teachers' adherence to delivery of the lesson plans ($F_{(2,17)} = 0.16$; $p = .85$; $\eta^2 p = .02$) and no significant difference between the three schools in how the teachers, PE teachers and coaches delivered the intervention ($F_{(1,17)} = 0.73$; $p = .49$; $\eta^2 p = .08$).

Table 6-3: Descriptive statistics [Means and standard deviations (M ± SD)] of movement competence measurements stratified by intervention, gender and pre/post testing.

| Variables | | Intervention | | | | Control | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Boys | | Girls | | Boys | | Girls | |
| | | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| | N | 69 | 63 | 66 | 59 | 102 | 99 | 96 | 89 |
| Stability | | 11.7 ± 5.2 | 17.3 ± 4.8 | 13.9 ± 5.2 | 18.3 ± 3.7 | 12.0 ± 4.8 | 15.0 ± 3.8 | 13.6 ± 4.8 | 16.8 ± 3.6 |
| Locomotor | | 28.3 ± 6.3 | 31.2 ± 7.3 | 31.0 ± 6.1 | 32.3 ± 5.3 | 28.0 ± 7.2 | 30.5 ± 7.2 | 30.4 ± 5.9 | 32.2 ± 5.6 |
| Object Control | | 30.0 ± 8.5 | 34.6 ± 6.7 | 27.0 ± 7.0 | 32.6 ± 5.8 | 32.0 ± 7.8 | 34.6 ± 7.0 | 26.6 ± 7.4 | 31.3 ± 6.6 |
| General body coordination | | 146.3 ± 46.2 | 168.8 ± 53.4 | 144.4 ± 44.6 | 170.1 ± 48.8 | 144.4 ± 47.4 | 159.1 ± 46.9 | 141.8 ± 35.8 | 159.7 ± 40.9 |
| | N | 46 | 46 | 49 | 49 | 82 | 82 | 75 | 75 |
| PMSC Locomotor | | 20.0 ± 2.8 | 20.4 ± 2.8 | 19.8 ± 3.1 | 19.6 ± 3.3 | 19.7 ± 2.5 | 19.3 ± 2.8 | 19.6 ± 2.8 | 19.7 ± 2.8 |
| PMSC Object control | | 20.9 ± 2.5 | 20.7 ± 2.5 | 18.8 ± 3.1 | 18.9 ± 3.2 | 19.8 ± 3.3 | 20.3 ± 2.9 | 18.8 ± 2.9 | 19.0 ± 2.4 |

Table 6-2: Gymnastics Australia LaunchPad curriculum (a detailed description of the gymnastics curriculum can be found at  http://www.launch-pad.org.au/ )

GYMFUN: GRADE 1 AND 2

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | apparatus |  | Olympics |

|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
|---|---|---|---|---|---|---|---|---|
| Theme | Inverts and rolls | Springs and Landings and shape balances in groups | Hoop sequences and jumps on and off apparatus | Ball and body rolls | Hanging bar circuit | Rolling circuit | Routine with partner all elements on ground | Partner routine all elements on apparatus |

GYMSKILLS: GRADE 3 AND 4

|  | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Theme | Statics | Springs and Landings | Rhythm and coordination | Rotation | Swing Rhythm and spatial awareness | Hand apparatus | Revision | School Olympics |

|  | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 |
|---|---|---|---|---|---|---|---|---|
| Theme | Inverts and rolls | Partner Balances and inverts | Hoop sequences and jumps on and off apparatus | Ball and body rolls and partner counter balance | Hanging bar circuit including inverts | Individual sequence | Routine with partner all elements on ground | Partner routine all elements on apparatus |

### 6.2.8 *Fidelity*

In total 192 gymnastic lessons were delivered, with over 10% (a total of 20) observed to ensure the fidelity of the instructor (PE teacher, class teacher or coach) to deliver the lesson as intended. This was achieved through the RA coding: a) whether all five stages of the LaunchPad lesson plan were covered, with a score of one awarded for each stage;

Table 6-4: Effect of a gymnastics intervention on all aspects of FMS stability, locomotor and object control skills controlling for gender and age (intercept and model 3 only displayed in this table)

| Fixed Part | Stability Skills | | | | Locomotive Skills | | | | Object Control Skills | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | SE | β | SE | β | SE | β | SE | β | SE | β | SE |
| Intercept (cons) | 14.6*, | 0.4 | 3.4 | 1.6 | 30.4** | 0.5 | 19.6** | 2.4 | 30.7** | 1.0 | 8.5** | 2.7 |
| Gender (male) | | | -1.5 | | | | -5.1* | 0.5 | | | 3.8* | 0.5 |
| Age | | | 1.4 | | | | 1.5 | 0.3 | | | 2.9** | 0.3 |
| Treatment*Time (intervention) | | | '"1.6* | 0.3 | | | 0.7 | 0.4 | | | 4⍰2** | 0.5 |

| Random'Part intercept | Intercept | | Treatment*Timg | | Intercept | | Treatment* Time | | Intercept | | Treatment* Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | σ² | SE | σ² | SE | σ² | SE | σ² | SE | σ² | SE | σ² | SE |
| Class'level variance | 2.3 | 1.1 | 3⍰5 | 0.5 | 2.4 | 1.3 | 1.3 | 0.8 | 14 | 5.6 | 5.9 | 2.5 |
| Pupil'level variance | 22.7 | 1.3 | 42⍰0 | 3⍰3 | 41.1 | 2.3 | 39.3 | 2.3 | 47.3 | 2.7 | 40.7 | 2.3 |
| ICC | 0.09 | | 0.03 | | 0.08 | | 0.03 | | 0.23 | | 0.13 | |

** p = 0.03        * p = 0.05

The gymnastics intervention group did not show a significant improvement relative to the control group in general body coordination ($p > .05$). Gender was found to be significant covariate with girls performing better than boys on the test battery, whilst age was not found to be a significant covariate (see Table 6-5). However, overall model fit for general body coordination showed a significant improvement with the inclusion of gymnastics intervention (general body coordination $X^2$ ($\Delta$ 3 df) = 174; $p < .001$).

| | General body coordination | | | |
|---|---|---|---|---|
| Fixed Part | $\beta$ | SE | $\beta$ | SE |
| Intercept (cons) | 18.7** | 2.4 | 9.0 | 8.9 |
| Control for gender | | | -2.8* | 1.5 |
| Control for Age | | | 1.4 | 1.0 |
| Treatment* Time (intervention) | | | 3.9 | 2.; |
| | Intercept | | Treatment* Time | |
| Random Part intercept | $\sigma^2$ | SE | $\sigma^2$ | SE |
| Class level variance | 71.1 | 29.6 | 65.4 | 27.8 |
| Pupil level variance | 350.1 | 19.8 | 350.5 | 20.1 |
| ICC | 0.17 | | 0.16 | |

** p  0.03          * p = 0.05

Table 6-5: Effect of a gymnastics intervention on all aspects of general movement coordination for gender and age (intercept and model 3 displayed in this table).

### 6.3.2 *Intervention effects on perceived competence*

The MANCOVA for the two PMSC (locomotive and object control) scores did not show a condition main effect (Wilk's $\lambda$ =.98; $p = .14$; $\eta^2p = .01$). Age (Wilks' $\lambda = .99$; $p < .76$; $\eta^2p = .01$) gender (Wilks' $\lambda = .99$; $p = .76$; $\eta^2p = .01$) and BMI (Wilks' $\lambda = .99$; $p = .72$; $\eta^2p = .03$) did not influence the finding.

6.4        **Discussion**

The study aim was to examine the efficacy of the gymnastics curriculum on movement skill competence in children in grades 1-4. Children participating in the gymnastics curriculum showed significantly larger improvements in stability skills and object control skills. Children participating in the gymnastics curriculum showed no significant benefit or decline in their locomotor skills, general body coordination or perception of their locomotive or object control skills ability compared to the children participating in their normal PE curriculum. A child's age, BMI or gender were not found to influence these findings either.

As predicted, children in the gymnastics curriculum showed significantly larger improvements in stability skills relative to control children. Stability skills are tightly coupled with the sensory system. Children possess mature feedback process capabilities to maintain balance, but the feedforward mechanism which allows them to integrate and downgrade certain sensory inputs during performance are immature throughout childhood (Bair et al., 2007). In line with previous findings (Garcia et al., 2011) this study provides evidence that a gymnastics based PE curriculum can improve dynamic balance.

The gymnastics curriculum also resulted in greater improvements in object control skills. Whilst not specifically targeting object control, the improved development shown is important due to the positive association between object control skills, physical activity and fitness outcomes later in life (Barnett et al., 2008; Stodden et al., 2014; Vlahov et al., 2014). Object control skills may be more difficult to improve than locomotive skills due to their greater skill complexity and perceptual demand (Morgan et al., 2013). The superior development of stability skills may have contributed to

greater perceptual capacity. In particular, improved integration of a feedforward mechanism may have led to greater stabilisation and orientation of the body in space, especially during the more complex components which require rotation of multiple body segments and weight transfer during the kinematic chain of skills (e.g., throw). This explanation as to why object control skill improved is consistent with the suggestion that underdeveloped postural control in children can act as a limiter on learning to catch (Davids et al., 2000).

No differences between conditions were found for locomotor skills. Importantly, despite the control condition engaging in many locomotor activities they did not show a larger improvement in this area compared to the gymnastics intervention group. This suggests that the gymnastics intervention, whilst improving other aspects of movement skill competence, did not hinder development of locomotor skills. The gymnastics group did not show any significant improvement in general movement coordination tasks relative to the control group. The KTK tasks are more akin to locomotor skills, than object control skills and this may explain the lack of improvement.

Perceived movement skill competence remained stable across the 16 week period. There is no obvious answer as to why the gymnastics group improved their actual object control skills, but not perceived object control skills, as the two constructs have been found to be strongly linked(Barnett, Ridgers, & Salmon, 2015; Slykerman, et al., in press). It is possible that perceived movement skill ability is more stable over time than actual movement skill ability and it is possible that a follow up study may have revealed a lag effect with perceived competence improving subsequently. It is also possible that due to the fact that the children in both the control and gymnastics group received the same dose of physical education that this caused them to perceive movement

competence in a similar way. This opens up the possibility that the relationship between perceived movement skill competence and actual competence is more complex and that the amount of time children spend in physical activity and physical education may also have an effect on this relationship. Skilled performance in PE or a sport activity is the product of a continually evolving dynamical organisation of the human body to meet the demands of the environment (Renshaw, Chow, Davids, & Hammond, 2010). Currently PE in Australia is not given priority in the school curriculum from both a time allocation or teacher professional development perspective (Hardy, 2011; Moneghetti, 1993; Morgan & Bourke, 2005, 2008). This may be restraining the development of movement skill competence in children. This study has highlighted that two hours of quality PE in the form of a gymnastics-based curriculum can lead to improvements in children's movement skill competence, especially if supported by a collegial partnership between the PE teacher, class teacher and specialist (gymnastics) coaches. The model employed in the current study of coaches and class teachers working together provides a complementary synergy of content (coach) and pedagogical knowledge of child learning (class teacher). From a theoretical position this encourages teachers and coaches to engage in the social construction of knowledge and understanding (Lave & Wenger, 1991; Wenger et al., 2002). From a practical perspective, the model of delivery adopted in the present study is relatively easy to implement and sustainable in the long run with sufficient teacher development opportunities.

The study has a number of limitations. First, it was not possible to randomise class allocation which could have led to bias in class selection. Secondly, the study only examined the immediate effects of the intervention (Lai et al., 2014). Ideally, follow-up assessments could identify whether the improvement in stability skills impacted on

other areas of movement skill competence. Future research should investigate a child's perceived movement skill competence over a longer time-period (e.g. six months) after post testing as this would provide opportunity for a child to return to normal activities and it could be seen whether their improved object control skills had led to improved perceived competence. Finally, it would be interesting to examine whether the enhanced movement skill competence influences physical activity patterns of the children in the short and long-term (Robinson et al., 2015).

This study demonstrated that a gymnastics-based PE curriculum had an accelerated effect on movement skill competence in comparison to a standard school PE curriculum. This was indexed by larger gains in stability and object control skills. In addition, following a period of coach shadowing, the gymnastics curriculum was taught by the regular classroom teacher suggesting this model is sustainable and could be implemented on a larger scale.

# CHAPTER - 7  FINAL MODEL OF MOVEMENT SKILL COMPETENCE IN PRIMARY SCHOOL CHILDREN

*"That theory is worthless. It isn't even wrong!"*

*Wolfgang Pauli*

7.1     **Final Model of Movement Skill Competence in Primary School children**

The final stage of this thesis was to develop a model of movement skill competence in primary school children encompassing all four constructs. The model was initially developed using the pre-test data, and then the post-test data was used to validate the model and determine if it was robust over time, as children become more competent.

In the first instance a SEM model (see Figure 7-1) was developed using pre-test data. This showed an adequate fit ($\chi^2$ (143df) = 266.94; $p$ = .01; $\chi^2$/df = 2.56; CFI = .91; SRMR = .06; RMSEA = .05; PCLOSE = .27). In this model both latent variables had high factor loadings (object control r =.84, locomotor r = .83, stability r= .79 and general coordination r = .92) on movement skill competence.
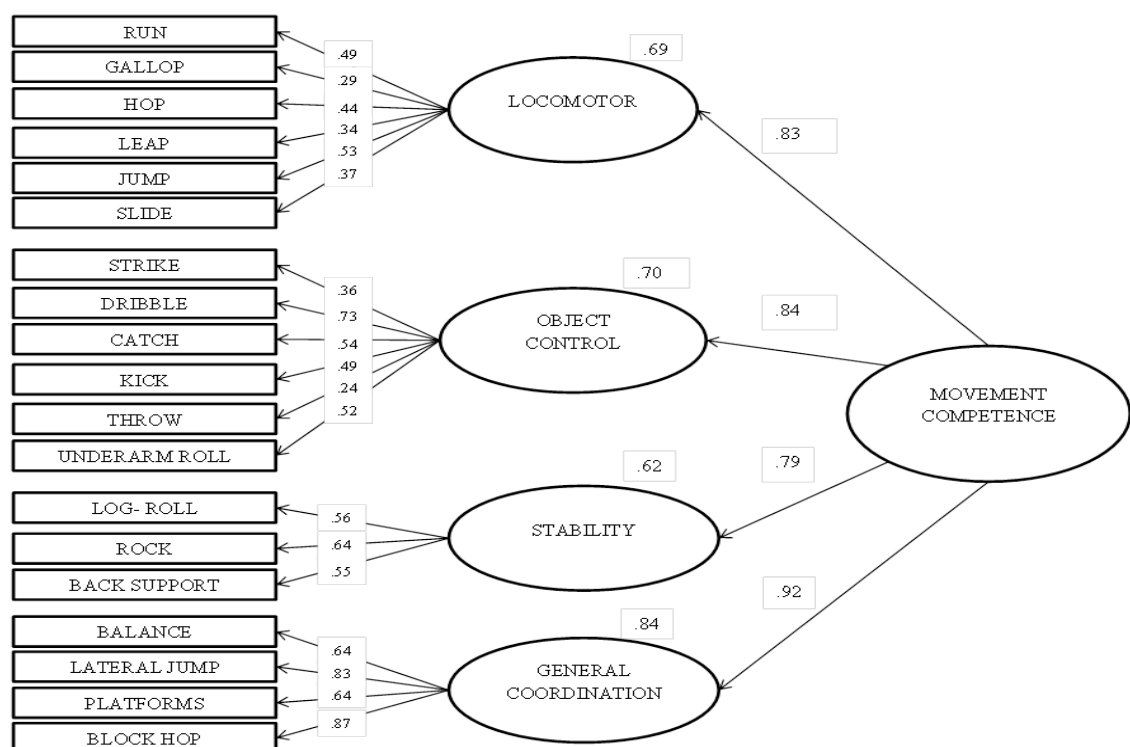


Figure 7-1: Model of movement skill competence containing all four constructs, developed using pre-assessment data.

This model suggests that in order to assess children's movement skill competence, a wide range of tools are needed which are capable of covering each construct, since each tool is measuring discrete aspects of overall movement skill competence. The discriminant validity of the latent constructs in the model shows correlations between the constructs of around .7 (see Figure 7-2). This suggests that the tests have some shared variance (around 50%), however this is not unexpected, for if a child is to demonstrate mastery over a kick, the child must first perform an elongated stride, which is similar to a leap. The important point here is that the highest correlation is .75 and the general rule is that correlations of .8 or above might cause problems in discriminate validity between latent variables because of multicolinearity (Kline, 2011).
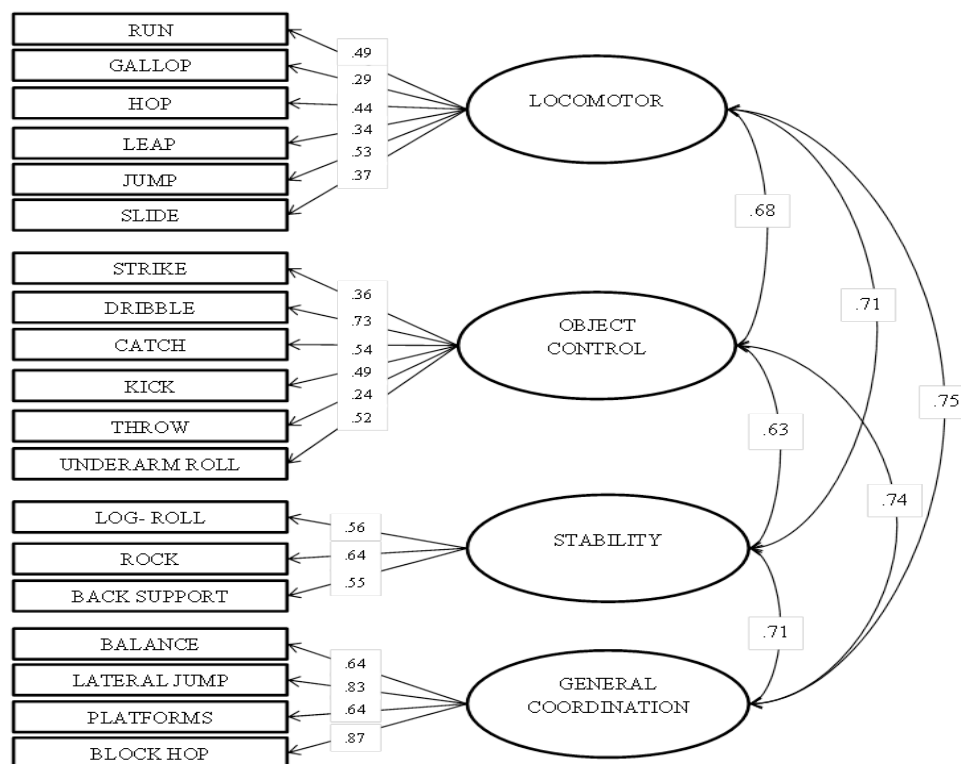


Figure 7-2: Model of correlations between the four constructs pre-assessment data.

The model was then re-run using the post-test data of the main intervention study in order to explore whether, as children become more skilled, the model maintains a good fit and retains discriminant validity. The model fit was found to be adequate ($\chi^2$ (143df) = 217.01; $p$ = .01; $\chi^2$/df = 1.51; CFI = .95; SRMR = .05; RMSEA = .04; PCLOSE = .927). The latent variables had high factor loadings (object control r =.77, locomotor r = .86, stability r = .89 and general coordination r = .92) on movement skill competence. The shared variance of three of the four constructs in this model was found to be highly correlated and above .8. Despite an adequate model fit these high correlations were a matter of concern (see Figure 7-3).
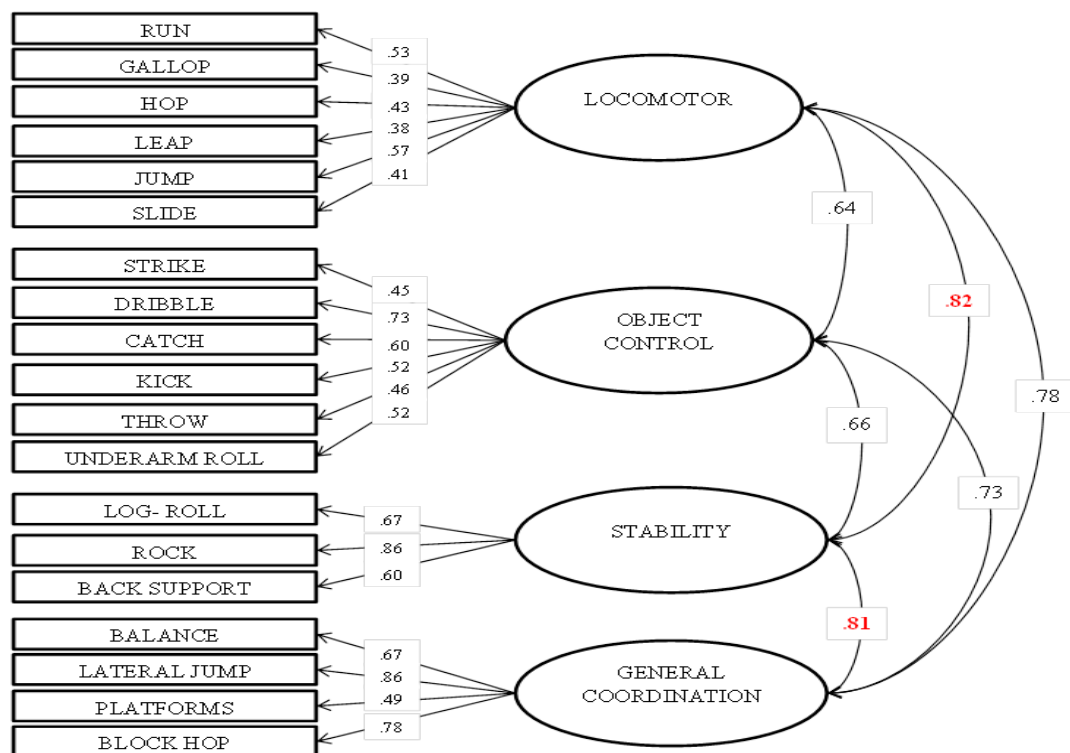


Figure 7-3: Model of correlations between the four constructs using post assessment data

The high correlations (above .8) between the latent variables in Figure 7-3 point to clustering of tests and as such it was thought that they were likely to be measuring similar aspects of movement skill competence. The nature of the correlations seemed to indicate a clustering of what might be thought of as foundation skills and more complex skills. In view of this, a new model was tested which collapsed the highly correlated constructs into a single construct which was labelled 'foundation skills' and a separate construct termed 'complex skills'.

This new model is supported from both an empirical and theoretical perspective; that is, the complex skills construct contains skills that are not easily learned without a significant amount of practice or instruction. These complex skills are the skills which have been found to be associated with positive health and physical activity levels in children (Barnett et al., 2008). The foundation skills construct consists of locomotor, general body coordination and stability skills. These skills are easier to learn with minimal practice, and as such, are not necessarily associated with health and physical activity, but they are nevertheless important skills for children to develop as they enable the efficient development of more complex skills.

To test this new model, two CFAs of the data were run. The CFA for foundation skills demonstrated an adequate fit ($\chi2$ (65df) = 131.58; P = .01; $\chi2$/df = 2.02; CFI = .93; SRMR= .05; RMSEA = .06; PCLOSE = .19) and the CFA for complex skills also demonstrated an adequate fit ($\chi2$ (9df) = 21.07; P = .02; $\chi2$/df = 2.3; CFI = .97; SRMR= .04; RMSEA = .06; PCLOSE = .21). A final SEM model was run on the final model of movement skill competence and an adequate fit was achieved ($\chi^2$ (151df) = 291.35; $p$ = .01; $\chi^2$/df = 1.92; CFI = .91; SRMR = .05; RMSEA = .05; PCLOSE = .30) (see Figure 7-4). In this model both latent variables had high factor loadings (complex skills r =.89, and foundation skills .81); the model was also found to have adequate discriminate validity with complex and foundation latent variables having a correlation of .72.
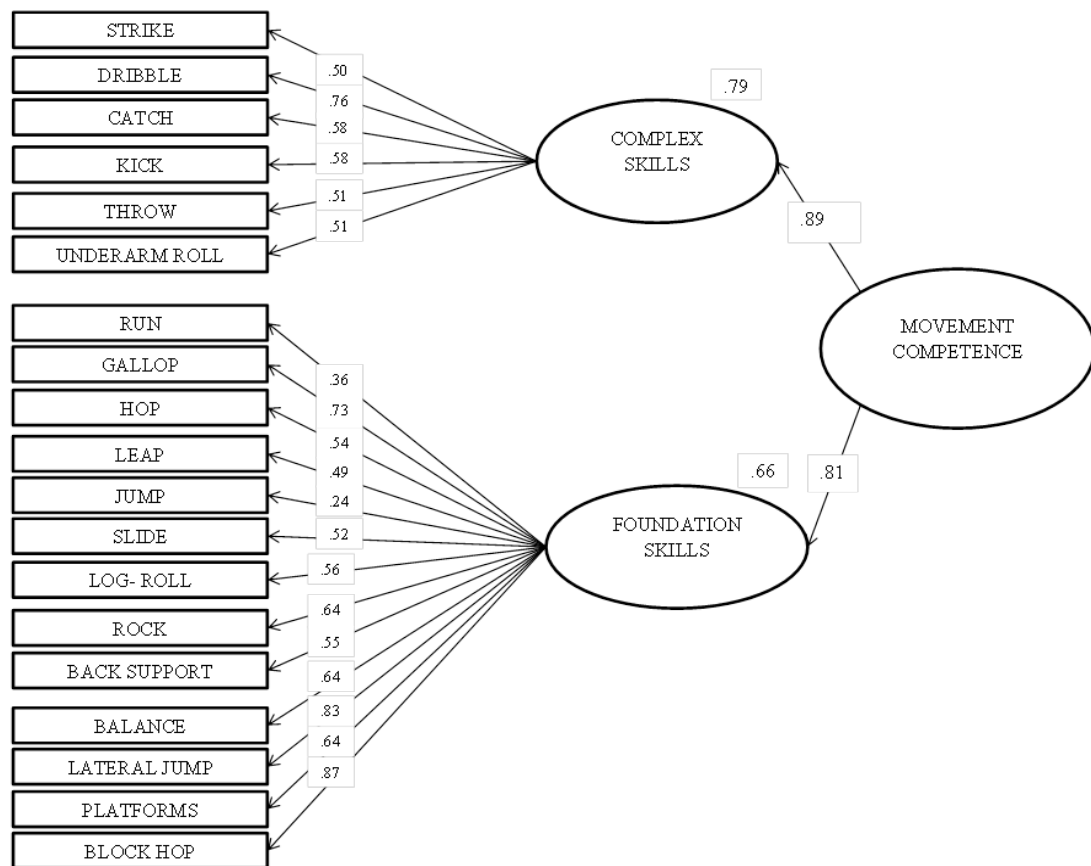


Figure 7-4: Model of movement skill competence undertaken on post-assessment data

At post-testing, all children showed a significant improvement on the pre-test data. The model of movement skill competence has therefore transitioned from four constructs into a two construct model measuring foundation skills and complex skills. The complex skills require substantial specific practice to master but this can be aided by the early development of foundation skills - specifically stability skills.

### 7.2    Theoretical and practical implications of the proposed models of movement skill competence

The final model is reminiscent of the now debunked categorisation of phylogenetic and orthogenetic skills (Gesell, 1954; Shirley, 1931). Phylogenetic activities were viewed as those indigenous to us as a species, such as walking and running, in the sense that all members of the species engage in these activities. Ontogenetic activities were regarded as skills that appeared to be peculiar to the short-term and subject to variable influences of the individuals' social context which influenced their development, such as pole vaulting, or a golf swing. This idea that there are two distinct sets of skills falls short when we try to categorise FMS. A good example of this is the overarm throw which has been categorised both as phylogenetic and ontogenetic (Espenschade & Eckert 1967, 1980). Langendorfer and Roberton, (2002) highlighted that most individuals are able to perform a rudimentary throwing technique, but not everyone can demonstrate a masterful throwing pattern.

This thesis offers new insights into the development of FMS in children and provides evidence for the premise of two different types of skill, similar to the proposed idea of ontogenetic and phylogenetic skills. However, in this model it is highlighted that there are no truly phylogenetic activities as even the most basic stability skills are affected by the environment (Turvey, 1990). This is in line with the contemporary evidence that all

movement skills are developed through interactions between a person's biology and their environmental surroundings (Newell, 1986). This study confirms that stability skills are not developed by maturation alone; they can be accelerated through the practice of gymnastics and these skills may in turn support the development of other more complex FMS. This is an area which has not been considered in previous research, and as such, this thesis offers a step forward in our understanding of how we should assess and facilitate the development of all FMS.

### 7.3    New hypothesised model of movement skill competence

Previous models of movement skill competence such as the phylogenetic and ontogenetic skills model are regarded as too simplistic and, as a result, have been critiqued as lacking rigour in accounting for longitudinal changes in movement skill competence (Newell, 1986). Similarly, the model proposed by Burton and Rogerson (2001) 'New Perspectives on the Assessment of Movement Skills and Motor Abilities' has some important limitations. Whilst on face value it appears more complex, it lacks rigour, as it is impossible to carry out any predictive or construct validity to empirically test the model. There is need for a model which underpins the development of children's movement skill competence to address the current shortfalls in applied research and practice specific to the development of children's movement skills. The final aspect of this section is therefore to propose a new Longitudinal Model of Movement skill competence (LMMC) (see Figure 7-5) which on the face of it is appealing and integrates a level of complexity which can be tested and, as such, validated in future studies overtime.
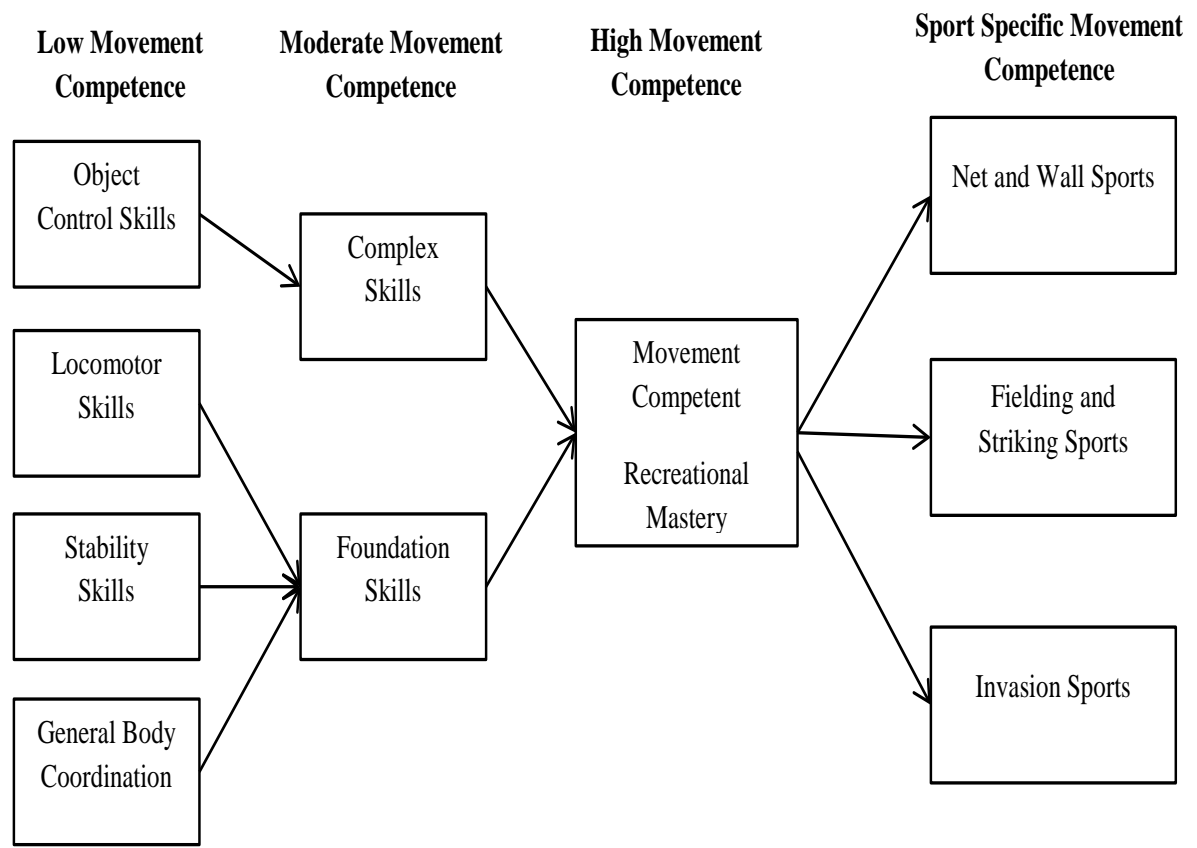
Figure 7-5: Longitudinal model of movement skill competence (LMMC)

Whilst this model is hypothetical, it has the advantage of being grounded in empirical evidence, as the first and second phase of the LMMC have been found to be preliminarily valid on the cohort of Australian children who participated in the final study of this thesis. Overall, mean scores for pre-test data in the final study found levels of movement skill competence to be low, and when a CFA was undertaken, skills clustered across four constructs. The post-test data showed that as children became more movement competent the CFA provided a better fit when three constructs (stability skills, locomotor skills, and general motor coordination) were merged to create a single foundational skill construct whilst the more complex skills remained an independent construct. It is hypothesised that this pattern of development will continue

until the foundational skills and complex skills eventually merge into a single construct, which is simply, movement skill competence. One area for future study is to explore how the complex and foundational skills merge together. It appears that there may be a shared reciprocal arrangement operating between them although it has not been possible to pursue this line of thinking within the timeframe of this PhD project. A potential strength of the LMMC is it reflects a current aim of the primary school PE curriculum, that by the time children leave primary school they should have the competence to participate in a wide variety of physical activities and sporting pursuits.

The LMMC also offers a framework for transition to an elite sport pathway as the model proposes that children should first develop competence in a broad range of skills before learning the specific skills which will enable them to strive for excellence in a sport of their choosing. The final stage of the LMMC therefore provides support for the view that athletes with the potential to become elite should not specialise in a specific sport until early adolescence and that all children should participate in multiple sports from an early stage which will increase their likelihood of succeeding in elite sports (Berry et al., 2008; Côté & Fraser-Thomas, 2008;).

# CHAPTER - 8  CRITICAL DISCUSSION

*"Logic will get you from A to B.*

*Imagination will take you everywhere."*

*Albert Einstein*

8.1      **Introduction**

The primary aim of this thesis was to evaluate the effectiveness of a gymnastics intervention designed by Gymnastics Australia for improving movement skill competence relative to the standard PE curriculum being delivered in schools. In order to achieve this, it was important to gain a better understanding of the constructs which underpin movement skill competence in children and consequently, a secondary aim of this thesis was to evaluate the role which general coordination, locomotive, object and stability skills play in movement skill competence. In this chapter, the overall results of the efficacy of the LaunchPad program will be considered, followed by a discussion of how this thesis can contribute to both our theoretical and practical understanding of movement skill competence. Finally, consideration is given to the limitations arising from this work and possible directions for future research.

8.2      **Main Findings**

8.2.1 *Effectiveness of a gymnastics intervention in improving children's movement skill competence relative to the school's standard PE curriculum*

Two hours of compulsory PE per week was found to improve all aspects of movement skill competence in children, regardless of which curriculum they followed, although in the case of younger children, a gymnastics based curriculum was found to accelerate object control and stability skills compared to the standard curriculum. This is, potentially, an important finding in view of the positive association that exists between object control skills, physical activity and fitness outcomes later in life (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008). Children participating in the gymnastics curriculum showed larger improvements in stability skills and object control skills relative to the control group following the standard PE curriculum. Whilst it had been

expected that children in the group following the gymnastics curriculum would show significantly larger improvements in stability skills, the consistent improvements found in object control skills across both the pilot and main study had not been predicted.

No differences between conditions for locomotor skills or general coordination were found in children from lower primary school years in the pilot or main study. It is possible that the reason for this is simply that the TGMD-2 (which measures the locomotor skills subset) and the KTK (which assesses general coordination) lacked the necessary sensitivity to detect any small changes in locomotive and general body coordination between the intervention and control groups. An alternative explanation is related to the finding that gymnastics accelerates the development of stability skills and that improvement in stability skills has beneficial effects upon children's ability to perform object control skills. The development of a child's stability skills leads to superior orientation and stabilisation which, according Woollacott and Shumway-Cook, (1990) improves their ability to downgrade information obtained from the visual stability system in favour of other postural senses. It is suggested that these benefits are most apparent when a child requires a large amount of integration from multiple senses in order to execute complex skills. Object control skills such as the throw, kick and strike require a child to manipulate an object, in the same instance as performing locomotion and twisting and turning the body through multiple axes in one fluid motion. This level of complexity is not required when executing skills such as running, jumping and hopping which are prevalent in both the locomotor and general body coordination tasks. It is significant that the children in the control condition, who were engaged in mainly locomotor type activities, did not display superior development of

locomotor ability compared to the gymnastics condition. This suggests that adopting a gymnastics based curriculum is not a hindrance to the development of locomotor skills.

### 8.2.2 *Effectiveness of a gymnastics intervention in improving physical self-concept and children's perceived movement skill competence*

The results of the pilot study were in line with previous research which had found that gymnastics leads to superior overall physical self-concept, covering a broad set of psychological domains (Halliburton & Weiss, 2002; Lattimore, 2000). The pilot results were also similar to other research which has investigated the effect of gymnastics on children's physical self-concept and found that primary school children benefit from PE lessons being task-oriented and focused around the development of skills in a non-pressured environment (Goudas, Biddle, & Fox, 1994; Papaioannou 1998; Standage et al., 2007). For the pilot study it was decided to use the PSDQ-s a questionnaire which assesses the nine constructs of physical self-concept and two global measures of self-concept. The improvement in physical self-concept displayed by the gymnastics cohort compared to the control cohort, whilst interesting, was limited. According to Stein, Riddell, and Fowler, (1988) children between the ages of 5 and 8 years are developing the formation of self-concept. It was revealed in the pilot that children aged 8 and below found it very difficult to comprehend the written questions being asked of them and, as such, their perceptions of physical-self-concept appear unreliable.

In view of this finding it was decided in the main study to use the PMSC a picture based questionnaire that assesses a child's perceived ability at six locomotor and six object control skills and aligns to the TGMD-2. This was adopted as available literature pointed to a child's perceived competence being the most important factor contained within physical self-concept for positive physical activity experiences and important to

movement skill development (Babic et al., 2014; Robinson et al., 2015; Stodden et al., 2008). The PMSC also aligned physical and perceived constructs by assessing locomotor and object control skill competence perceptions among children (Barnett, Ridgers, Zask, & Salmon, 2015). Using the PSMC, the main study did not find a significant change in children's perceived movement skill competence amongst either the gymnastics or standard PE curriculum groups over the 16 week period. It is not known why the gymnastics group improved their actual object control skills, but not their perceived object control skills. One possible explanation is that a child's perceived movement skill ability is stable over time and it takes many experiences of successfully catching, throwing or striking a ball for their perceived movement skill competence to change. This could suggest that as children gain more experience and improve their skills they develop a more accurate perception of their actual ability. However, as this hypothesis was not tested in this thesis it would need to be the subject of further research.

### 8.2.3 *Insight into the constructs which underpin movement skill competence, specifically general coordination, locomotive, object and stability skills*

Although this thesis did not start out with the intention of reviewing how to define movement skill competence in children, this became an essential element of the literature review due to the apparent gap between our theoretical understanding of movement skill competence and the different ways in which movement skill competence is assessed in the field. It was viewed as important for this thesis that the constructs that each measurement tool was measuring were understood and that the tools were valid. It was decided therefore to adopt an iterative process and, in the first instance, the KTK and TGMD-2 were examined to understand the constructs which

underpinned them. The finding that they were measuring different aspects of movement skill competence was important and warranted the inclusion of both instruments in the pilot intervention in order to test three FMS constructs: locomotor skills, object control skills and general non-sport specific motor coordination.

The results of the pilot study showed that the children who had undertaken the gymnastics curriculum had significantly improved their object control skills compared to the control group, but not their locomotive or general coordination skills. Due to the nature of gymnastics, with its focus on coordination and control, it had been anticipated that improvements in children's general movement skill competence (i.e. motor coordination as signified by the KTK) would occur. The improvement in object control skills was more surprising although research has found children's postural control can constrain their catching performance (Davids et al., 2000). Also, according to Gallahue et al. (2012), children's locomotor and object control skills are underpinned by stability skills which are synominous with a child's postural control. Previous research from the area of motor control has shown that gymnastics can improve postural control (Garcia et al., 2011). This improvement goes beyond simple balance, because postural control is integrated within our perceptual awareness of our body and as such could be regarded as an important aspect of object control skills. For the main study it was therefore decided to include an additional assessment tool to measure the stability skill construct.

### 8.2.4 *Creation of an assessment tool to measure stability skills in primary school children*

For the main study, a new assessment tool was developed using gymnastics training skills in order to gain a better understanding of whether the gymnastics intervention was accelerating stability skills, which might in turn, be leading to an improvement in object

control skills. Three postural control tasks: log roll, rock and back support were found to have good face and content validity. These skills also demonstrated good predictive validity; with gymnasts scoring significantly better than children without gymnastic training; children from a high socio economic status (SES) school performing better than those from mid and low SES schools; and, the mid SES children scoring better than the low SES children. The finding that stability skills are affected by children's SES is in line with studies which have investigated the influence of SES on locomotive and object control skills (Booth et al., 1999; Okely & Booth, 2004). Until now, it has been thought that stability skills are developed by maturation. However, the evidence from this thesis suggests that stability skills are best viewed as a separate construct that can be developed independently through a series of skills which challenge and place high demands on the postural control system. Appropriate practice would include gymnastics training or related whole body exercises that promote opportunities for children to rotate, invert and support their bodies using different parts of the body. Practicing stability skills places stress on the postural control system which leads to the development of sensory cues which result in superior orientation and stabilisation strategies.

For the 16 week main study it was therefore decided that all four constructs of movement skill competence should be assessed. The results of the main study confirmed the findings of the pilot study, with the intervention group demonstrating an improvement in object control skills, whilst there was no change in locomotor or general coordination skills compared to the control group. The main study also found a significant improvement in the stability skills construct. This provides indirect evidence that improving stability skills results in enhanced object control skills. This is an area

which has not been considered in previous research, and as such, this thesis offers a step forward in our understanding of how we should assess and facilitate the development of all FMS.

The series of models presented in this thesis highlights that movement skill competence development is dynamic. Stability skills, locomotor skills and non-sport specific coordination were found to be independent in pre-test data but at post-testing they became homogenous and lost their independent discriminant validity. This suggests that as children progress from low movement skill competence to moderate movement skill competence their skills converge into two constructs, foundation skills and complex movement skills such as object control skills. The implications of this model are that children with low levels of movement skill competence need to develop a broad battery of skills which nestle within each of the four constructs. It is suggested that stability skills should also be assessed throughout childhood as there is emerging evidence from this thesis and from Davids, et al, (2000) that there is an association between object control skills and stability skills and that improving stability skills can play a significant part in the development of object control skills. This is an important finding since moderate competence in object control skills has been found to be a significant predictor of physical activity and health benefits later on in life (Barnett et al., 2008;; Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; Lubans et al., 2010b) and this is therefore, arguably, the most important construct to develop in lower primary school children.

This is significant because it is a commonly held view, in certain countries, that to measure movement skill competence it is only necessary to assess locomotive and object control skills, using the TGMD-2 (Ulrich, 2000). This would be adequate if all

children were at the moderate stage of movement skill competence development in primary schools. However, this is not the case today as children typically possess low levels of movement skill competence and score poorly on all FMS - object, locomotor, general body coordination and stability skills (Bardid, Rudd, Lenoir, Polman, & Barnett, 2015; Hardy, 2011). In view of these findings, it is suggested that, when starting school, all children should be assessed using a holistic battery of movement skill competence to ascertain whether their foundation skills need to be developed.

### 8.2.5 *Practical applications*

Governmental policy documents highlight that primary schools offer a critical window of opportunity for developing movement skill competence (Hardy, Barnett, et al., 2013; Hardy, 2011; Project Play, 2015; Tremblay & Lloyd, 2010) but there is little evidenced-based information about how teachers and practitioners can develop competent movers. For example, guidelines suggest that it takes ten hours of practice for each FMS for a child to transition from rudimentary to mastery in a set skill, but these suggestions lack rigour as there is a lack of empirical evidence and an absence of a theoretical rationale underpinning this recommended time frame (Morgan et al., 2013; Project Play, 2015; Walkley, Holland, Treloar, & Probyn-Smith, 1993).

Systematic reviews of the FMS and movement skill competence literature have struggled to provide compelling evidence for a formula for developing movement skill competence in the school setting (Dudley et al. 2011; Logan, Robinson, Wilson, & Lucas, 2012; Morgan et al., 2013) and all have concluded there is a lack of evidence to provide a clear formula for the development of movement skill competence in children. This thesis suggests this is partly due to a lack of rigour in a number of the studies included and, in particular, the lack of information provided on key aspects of the

studies, such as details of the curriculum taught and dose of intervention for the control group. It is also contested that the absence of a theoretical framework for improving movement skill competence, makes the majority of studies largely a-theoretical. This is an important issue because, whilst the manipulation of key variables might seem logical, they are not helping to gain a systematic understanding of the underpinning reason for change and this will lead to a lack of insight and overall confusion about why movement skill competence changes.

There are calls from the area of motor learning and skill acquisition for PE to focus on the individual needs of a child and promote a non-linear pedagogy, meaning that children should take charge of their own learning and teachers should facilitate this through presenting the child with opportunities to undertake many different types of sporting activities thereby building a wide base of movement skill competence (Chow et al., 2007; Renshaw et al., 2010). Whilst there is strong theoretical underpinning for this approach, there is a lack of evidence that this approach is practical and would be feasible in the current primary school PE curriculum. A non-linear approach requires teachers to have high levels of expertise and confidence to facilitate this type of curriculum, however, primary school PE is generally taught by generalist classroom teachers, who lack these skills (Morgan & Bourke, 2008). It has also been found that PE specialist do not feel confident in teaching FMS this way (Lander, Barnett, Brown, & Telford, 2015).

A lack of confidence to teach PE was identified as an issue in the literature review. To address this, both the pilot and main study interventions were designed to create a supportive and collegial working relationship between the PE teacher, class teacher and gymnastics coach. The results of the main study showed qualitatively that teachers felt

this had been beneficial. After the initial eight weeks of observation three of the six teachers felt fairly confident that they understood how to develop movement skill competence and the other three believed they had an excellent understanding of how to develop movement skill competence in their children. Furthermore, all felt they had, as a result of the intervention, developed an excellent understanding of how to teach gymnastics based primary school PE curriculum. All the teachers exposed to the LaunchPad curriculum reported that this was an excellent model of professional development as teachers and schools do not currently have the curriculum time or expertise to improve children's movement skill competence. The quantitative data reinforced this finding, as when viewing the data from the perspective of the effectiveness of the PE teacher, class teacher or coach in delivering the intervention, there was little variance in the data between groups at the class level. This model, whereby PE teachers, classroom teachers and coaches work together, is a promising step forward. However, it still does not provide a solid framework or theoretical underpinning model that teachers can utilise to support the teaching of movement skill competence.

### 8.2.6 *New hypothesised model of movement skill competence*

Gulbin et al. (2013) developed a working framework called the Foundations, Talent, Elite & Mastery (FTEM) which provides practical methods to help sporting stakeholders construct a more functional athlete and sport development system. Within this paper they call for a systematic programme of research that will serve to further validate the FTEM framework. The LMMC model offers a hypothetical model for the foundation phase of the FTEM framework. It has the advantage of being grounded in empirical evidence, as the first and second phase of the LMMC have been found to be

preliminarily valid on the cohort of Australian children who participated in the final study of this thesis. Overall, mean scores for pre-test data in the final study found levels of movement skill competence to be low and when a CFA was undertaken skills clustered across four constructs. The post-test data showed that as children became more movement competent the CFA provided a better fit when three constructs (stability skills, locomotor skills, and object control skills) were merged to create a single foundational skill construct whilst the more complex skills remained an independent construct.

It is hypothesised that this pattern of development will continue until the foundational skills and complex skills eventually merge into a single construct, which is simply, movement skill competence. This model reflects a current aim of the primary school PE curriculum: that is, by the time children leave primary school they should have the competence to participate in a wide variety of physical activities and sporting pursuits which will enable them to engage and enjoy varying physical activities throughout life. The final stage of the LMMC therefore provides support for the view that athletes with the potential to become elite should not specialise in a specific sport until early adolescence and that all children should participate in multiple sports from an early stage. This will improve the chances of athletes succeeding in elite sports which is in line with the FTEM model.

### 8.3 **Summary**

The primary aim of this thesis was to evaluate whether a gymnastics programme embedded within the PE curriculum could develop children's movement skill competence. Previous studies evaluating the impact of gymnastics in the PE curriculum had a number of limitations including: small sample size, simplistic statistical analysis

increasing the chance of type one error, in the case of Alpkaya (2013) different doses for the control and intervention groups and, for Culjak et al. (2014), no control group. This thesis has found that a gymnastics curriculum enhances object control skills and stability skills in lower primary school aged children without hindering the development of locomotor skills or general non-sport specific coordination compared to the standard PE curriculum. The improved development of object control skills is important as, according to the literature, children who have mastered object control skills in childhood are more likely to be physically active and fitter in adolescence (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009; Cohen, Morgan, Plotnikoff, Callister, et al., 2015; Lopes et al., 2012).

### 8.4 Strengths of this thesis

Previous research investigating movement skill competence has arisen from the human movement sciences and as such has lacked a unified theoretical underpinning. In order to achieve the primary aim of this thesis, it was deemed necessary to gain a greater understanding of the constructs which underpin movement skill competence in children. Consequently, understanding the development of movement skill competence in children became an important and essential aspect of this thesis.

This is the first body of research to provide a robust evaluation of a gymnastics curriculum taught in primary schools. This thesis considers the benefits of developing children's movement skill competence. It examines the links with physical self-concept and it proposes a sustainable delivery model whereby the class, PE teacher and coach can work together to deliver a high quality PE curriculum.

The design of a two phased intervention to assess the gymnastics curriculum is a particular strength of this body of research. The initial implementation of a pilot study

enabled the testing of the efficacy of the gymnastics curriculum and the evaluation of the methodology before a large scale study was undertaken. The large scale intervention followed the design of the CONSORT statement and TREND checklist to ensure a rigorous and strong research design (Dudley et al. 2011; Riethmuller et al. 2009).

The thesis has also started to develop a greater synergy between our theoretical understanding of movement skill competence and the assessment of movement skill competence. This is an important step forward as it provides a more systematic approach for researchers and practitioners who wish to understand and develop children's movement skill competence. The LMMC provides an underpinning framework to develop a long-term plan for meeting curriculum goals and provides assessment tools to track progress. This is essential if we are to create a generation of confident and competent holistic movers.

## 8.5 Limitations of this thesis

Like any programme of work this thesis has a number of limitations. The lack of a six or twelve month follow up assessment is an important limitation which could have answered a number of important questions (Lai et al., 2014). For example, it could have established the impact of enhanced stability skills on the continued development of object control skills. It could also have provided a greater understanding of what impact the development of improved object control skills has upon on a child's own perception of their movement skill competence over time. A follow-up assessment would have created a better understanding of the longitudinal development of movement skill competence, either by providing further evidence for validity of the LMMC or the need for it to be respecified. However, a follow-up assessment was not feasible in the timeframe of this PhD project.

Although the rigour of the intervention studies undertaken was a great improvement upon the previous studies which had investigated the role gymnastics plays in the development of movement skill competence (Alpkaya, 2013; Culjak et al., 2014), it was not possible to randomise class allocation which could have led to bias in class selection.

It is important to acknowledge limitations in the assessment tools used throughout this thesis. The biggest challenge faced in carrying out this body of research was ensuring that all the data collected was of the highest possible standard and contained minimal error. A number of steps were taken to ensure error was minimalized. All assessment tools used had previously undergone extensive validity and reliability testing and were to be considered gold standard within the movement skill competence field. All assessors who supported data collection underwent extensive training and were assessed for reliability before undertaking work on the project. However, as with any testing undertaken in field settings there is still a risk of assessor error, assessor bias or limitations with the assessments tools themselves due to ceiling and floor effects given the complexity of measuring children's movement skill competence (Barnett, Minto, Lander, & Hardy, 2015).

Another limitation was not being able to collect data on children's habitual physical activity in both the control and intervention groups during the pilot and main study. This could have been a potential confounding factor as a clear link has been found between mastery of FMS and children's physical activity levels. This however was beyond the scope of this body of work but should be considered in future research investigating the effects of a specific intervention on children's movement skill competence.

The LMMC is very much in its infancy and whilst initial validation provides evidence that it could be an important step forward in our understanding of how to develop movement skill competence, the sample size is relatively small for validation purposes and is only valid for an Australian sample.

### 8.6 Future research directions

Future research should seek to better understand the relationship between stability and object control skills given the earlier findings that object control skills are a strong predictor of physical activity and health outcomes later on in life.

Further research is also needed to understand the relationship between actual skill levels and perceived skill levels and how this changes over time. This is of particular significance in view of Stodden's (2008) hypothesis that young people who have poor object control skills, coupled with an over-inflated perception of their movement skills, are more likely to encounter negative social experiences during physical activity which may lead to a stronger disengagement in physical activity participation. It is suggested that the PMSC for Young Children (Barnett, Ridgers, Zask, & Salmon, 2015) should be explored in future and used longitudinally to see if children's perceptions of their movement skill competence do, as this study thesis hypothesises, become more accurate over time.

The SEM models proposed throughout this thesis should also be tested longitudinally, across different age groups as well as with children from differing cultures (Marsh, 1997). Future research should investigate the bidirectional relationship between foundation skills and complex skills. A better understanding of these models could be used either to validate or debunk the LMMC. Regardless of this, developing models based upon actual measurement will help to inform interventions and by carrying out

more focused interventions it will be possible to ascertain how the PE curriculum can be developed to support children moving from the low levels of movement skill competence towards sports specific movement skill competence.

This study found that class teachers lacked the training and confidence to teach movement skill competence. It was found that when coaches worked alongside teachers a collegial relationship developed which helped to improve the class teachers' confidence, knowledge and experience. Further research is needed coupling this approach with targeted interventions to improve movement skill competence (Dudley, Okely, Cotton, Pearson, & Caputi, 2012; Dudley et al., 2011).

### 8.7 Concluding statement

Children who are deemed to be movement competent have the ability to perform various movement skills (e.g., running, kicking, jumping, throwing) (Gabbard, 2011; Gallahue, Ozmun, & Goodway, 2012; Haga, Pedersen, & Sigmundsson, 2008). There is however a lack of understanding on how we develop movement skill competence in children. Interventions to improve FMS have demonstrated large effect sizes for locomotor skills but only modest effect sizes for object control skills (Morgan et al.,2013). There is longitudinal evidence that children who have high object control skills when leaving primary school possess superior cardiovascular fitness at 16 years of age (Barnett et al., 2008; Cohen, Morgan, Plotnikoff, Callister, et al., 2015; Lopes et al., 2012). Children have continuously been found to have low scores in object control skills and are entering adolescence without having mastered these skills (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009; Hardy, 2011; Tester, Ackland, Houghton, et al., 2014). Previous work has mainly focused on development and assessment of locomotor and object control skills (Booth et al., 1999; Cohen et al., 2015; Hardy et al.,

2012) and interventions directly focused on improving these complex skills (Cliff, Wilson, Okely, Mickle, & Steele, 2007; Martin et al., 2009). The evidence put forward in this thesis highlights that this is a limited view of movement skill competence and suggests that this approach might need to be revised in order to enhance children's movement performance. The Australian PE curriculum of the last two decades has witnessed an increased presence of sport education and sport pedagogy in which PE has explicitly become focused on the development of skills required for team sports whilst the development of gymnastics skills has been largely ignored (Wright, 2006). Without realising it, this may have deprived our children of a strong foundational base which is needed to reverse the decline we have seen in children's movement skill competence.

The systematic approach of this thesis to test constructs and challenge the assumptions of current measurements has increased our understanding of how we develop movement skill competence in children. This body of research has shown that young children need to develop stability skills and, like all FMS, these will not develop through maturation alone. It has also shown that these skills are measurable, and most importantly it has raised the possibility that learning stability skills might enable children to develop more complex skills which are vital for ongoing health and physical activity.

# CHAPTER - 9  REFERENCES

Active Healthy Kids. (2014). *Is Sport Enough? The 2014 Active Healthy Kids Australia Report*

   *Card on Physical Activity for Children and Young People:* 2014. Retrieved from

   http://flosse.dss.gov.au/fahcsiajspui18/handle/10620/4077

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, *3*(2),

   111–150.

Afonso, J., Coutinho, P., Araújo, R., Almond, L., & Pot, N. (September 28, 2014). *Fundamental*

   *Movement Skills - A seriously misguided approach,*. Retrieved from

   https://www.youtube.com/watch?v=sLNppM8UmPg

Ahnert J, Schneider W, Bös K. (2009). Developmental changes and individual stability of motor

   abilities from the preschool period to young adulthood. In:Schneider W, Bullock M (Ed.),

   *Human Development From Early Childhood to Early Adulthood: Evidence from the Munich*

   *Longitudinal Study on the Genesis of Individual Competencies* (LOGIC). Erlbaum: Mahwah,

   New Jersey.

Almond, L. (2014). Serious flaws in an FMS interpretation of physical literacy. *Science & Sports*,

   *29*, 60.

Alpkaya, U. (2013). The effects of basic gymnastics training integrated with physical education

   courses on selected motor performance variables. *Educational Research and Reviews*, *8*(7),

   317–321.

Anson, G., Elliott, D., & Davids, K. (2005). Information processing and constraints-based views

   of skill acquisition: divergent or complementary? *Motor Control*, *9*(3), 217–241.

Arnold, B. L., & Schmitz, R. J. (1998). Examination of balance measures produced by the Biodex

   Stability System. *Journal of Athletic Training*, *33*(4), 323.

ACARA. (2012). Draft Shape of the Australian Curriculum: Health and Physical Education. ACARA Sydney.

Babic, M. J., Morgan, P. J., Plotnikoff, R. C., Lonsdale, C., White, R. L., & Lubans, D. R. (2014). Physical activity and physical self-concept in youth: Systematic review and meta-analysis. *Sports Medicine*, *44*(11), 1589–1601.

Bair, W. N., Kiemel, T., Jeka, J. J., & Clark, J. E. (2007). Development of multisensory reweighting for posture control in children. *Experimental Brain Research*, *183*(4), 435–446. http://doi.org/10.1007/s00221-007-1057-2

Balyi, I., & Hamilton, A. (2004). Long-term athlete development: Trainability in childhood and adolescence. *Olympic Coach*, *16*(1), 4–9.

Bardid, F., Rudd, J. R., Lenoir, M., Polman, R. C. J., & Barnett, L. M. (2015). Cross-cultural comparison of motor competence in children from Australia and Belgium. *Frontiers in Psychology*, *6:964. doi: 10.3389/fpsyg.2015.00964.*

Barela, J. A., Jeka, J. J., & Clark, J. E. (2003). Postural control in children. Coupling to dynamic somatosensory information. *Experimental Brain Research*, *150*(4), 434–442. http://doi.org/10.1007/s00221-003-1441-5

Barela, J. A., Whitall, J., Black, P., & Clark, J. E. (2000). An examination of constraints affecting the intralimb coordination of hemiparetic gait. *Human Movement Science*, *19*(2), 251–273.

Barnett, A. L., & Peters, J. (2004). Motor proficiency assessment batteries. In Dewey D, Tupper E (Eds) *Developmental Motor Disorders: A Neuropsychological Perspective*, New York: Guilford Press, pp.66–109.

Barnett, L. M., Hardy, L. L., Lubans, D. R., Cliff, D. P., Okely, A. D., Hills, A. P., & Morgan, P. J. (2013). Australian children lack the basic movement skills to be active and healthy. *Health Promotion Journal of Australia, 24*(2), 82–84. http://doi.org/10.1071/HE12920

Barnett, L. M., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Child, family and environmental correlates of children's motor skill proficiency. *Journal of Science and Medicine in Sport*, *16*(4), 332–336.

Barnett, L. M., Minto, C., Lander, N., & Hardy, L. L. (2015). Interrater reliability assessment using the Test of Gross Motor Development-2. *Journal of Science and Medicine in Sport*, *17*(6), 667–670. http://doi.org/10.1016/j.jsams.2013.09.013

Barnett, L. M., Morgan, P. J., Van Beurden, E., Ball, K., & Lubans, D. R. (2011). A reverse pathway? Actual and perceived skill proficiency and physical activity. *Medicine & Sciences in Sports & Exercise*, *43*(5), 898–904.

Barnett, L. M., Ridgers, N. D., Zask, A., & Salmon, J. (2015). Face validity and reliability of a pictorial instrument for assessing fundamental movement skill perceived competence in young children. *Journal of Science and Medicine in Sport*, *18*(1), 98–102.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2008). Does childhood motor skill proficiency predict adolescent fitness? *Medicine and Science in Sports and Exercise*, *40*(12), 2137–2144. http://doi.org/10.1249/MSS.0b013e31818160d3

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health*, *44*(3), 252–259.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., Zask, A., & Beard, J. R. (2009). Six year follow-up of students who participated in a school-based physical activity intervention: a longitudinal cohort study. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 48.

Barrow, H. M., McGee, R., & Tritschler, K. A. (1989). *Practical measurement in physical education and sport*. Philadelphia: Lea & Febiger.

Beilock, S. L., Carr, T. H., MacMahon, C., & Starkes, J. L. (2002). When paying attention becomes counterproductive: impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, *8*(1), 6.

Bencke, J., Damsgaard, R., Sækmose, A., Jørgensen, P., Jørgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Medicine & Science in Sports*, *12*(3), 171–178.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*(2), 238.

Bernstein, N. (1967). *The coordination and regulation of movements.* Oxford, New York, Pergamon Press.

Berry, J., Abernethy, B., & Côté, J. (2008). The contribution of structured activity and deliberate play to the development of expert perceptual and decision-making skill. *Journal of Sport and Exercise Psychology*, *30*(6), 685–708.

Bertenthal, B. I., Boker, S. M., & Xu, M. (2000). Analysis of the perception-action cycle for
visually induced postural sway in 9-month-old sitting infants. *Infant Behavior and
Development*, *23*(3), 299–315.

Biddle, S. J. H., & Mutrie, N. (2007). *Psychology of physical activity: Determinants, well-being
and interventions*. London: Routledge.

Blair, R. (2006) Planning for pupils' learning in broader dimensions of the curriculum 2, Key
skills and the use of information communication technology, in: S. Capel, P. Breckon and J.
O'Neill (Eds) A Practical Guide to teaching Physical Education in Secondary School (London,
Routledge), 80 – 89.

Blake, D. T., Byl, N. N., & Merzenich, M. M. (2002). Representation of the hand in the cerebral
cortex. *Behavioural Brain Research*, *135*(1), 179–184.

Bland, M. J., & Altman, D. G. (1986). Stastical Methods for Assessing Agreement between two
Methods of Clinical Measurements. *The Lancet*, *327*(8476), 307–310.
http://doi.org/10.1016/S0140-6736(86)90837-8

Bollen, K. A. (1989). A new incremental fit index for general structural equation models.
*Sociological Methods & Research*, *17*(3), 303–316.

Bompa, T. O. (1990). *Theory and Methodology of Training.* Dubuque, Iowa: Kendal/Hunt
Publishing Company.

Booth, M. L., Okely, T., McLellan, L., Phongsavan, P., Macaskill, P., Patterson, J., … Holland, B.
(1999). Mastery of fundamental motor skills among New South Wales school students:
prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, *2*(2),
93–105.

Bös, K. (2003). Motorische Leistungsfähigkeit von Kindern und Jugendlichen. In W. Schmidt, I. Hartmann-Tews, & W.-D. Brettschneider (Eds.), *Erster Deutscher Kinder und Jugendsportbericht* (pp. 1–23). Schorndorf: Verlag Karl Hofmann.

Boyer, C., Tremblay, M., Saunders, T. J., McFarlane, A., Borghese, M., Lloyd, M., & Longmuir, P. (2013). Feasibility, Validity, and Reliability of the Plank Isometric Hold as a Field-Based Assessment of Torso Muscular Endurance for Children 8–12 Years of Age. *Pediatric Exercise Science*, *25*(3), 407–422.

Browne, M. W., Cudeck, R., & Bollen, K. A. (1993). Alternative ways of assessing model fit. *Sage Focus Editions*, *154*, 136.

Bruininks, R., & Bruininks, B. (2005). *Bruininks-Oseretsky Test of Motor Proficiency* (2nd ed.). Minneapolis, MN: Pearson Assessment.

Buck, D., & Frosini, F. (2012). *Clustering of unhealthy behaviours over time: implications for policy and practice*. Kings Fund: London, UK.

Burton, A. W., Miller, D. E., & Miller, D. (1998). *Movement skill assessment*. Human Kinetics Champaign, IL.

Burton, A. W., & Rogerson, R. (2001). New perspectives on the assessment of movement skills and motor abilities. *Adapted Physical Activity Quarterly*, *18*, 347 – 365.

Butterfield, S. A., & Loovis, E. M. (1994). Influence of age, sex, balance, and sport participation on development of kicking by children in grades K-8. *Perceptual and Motor Skills*, *79*(1), 691–697. http://doi.org/10.2466/pms.1994.79.1.691

Calavalle, A. R., Sisti, D., Rocchi, M. B. L., Panebianco, R., Del Sal, M., & Stocchi, V. (2008). Postural trials: expertise in rhythmic gymnastics increases control in lateral directions. *European Journal of Applied Physiology*, *104*(4), 643–649.

Castelli, D. M., Centeio, E. E., Beighle, A. E., Carson, R. L., & Nicksic, H. M. (2014). Physical literacy and Comprehensive School Physical Activity Programs. *Preventive Medicine*, *66*, 95–100.

Cattuzzo, M. T., Dos Santos Henrique, R., Ré, A. H. N., de Oliveira, I. S., Melo, B. M., de Sousa Moura, M., … Stodden, D. (2014). Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport / Sports Medicine Australia*. http://doi.org/10.1016/j.jsams.2014.12.004

Chappell, A (2006) Safe practice, risk assessment and risk management, in: S. Capel, P. Breckon and J. O'Neill (Eds) A Practical Guide to teaching Physical Education in Secondary School. London: Routledge pp.100–119.

Chew-Bullock, T. S.-Y., Anderson, D. I., Hamel, K. A., Gorelick, M. L., Wallace, S. A., & Sidaway, B. (2012). Kicking performance in relation to balance ability over the support leg. *Human Movement Science*, *31*(6), 1615–1623. http://doi.org/10.1016/j.humov.2012.07.001

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research*, *77*(3), 251–278.

Cliff, D. P., Okely, A. D., Morgan, P. J., Steele, J. R., Jones, R. A., Colyvas, K. I. M., & Baur, L. A. (2011). Movement skills and physical activity in obese children: randomized controlled trial. *Med Sci Sports Exerc*, *43*(1), 90–100.

Cliff, D. P., Wilson, A., Okely, A. D., Mickle, K. J., & Steele, J. R. (2007). Feasibility of SHARK: A physical activity skill-development program for overweight and obese children. *Journal of Science and Medicine in Sport*, *10*(4), 263–267.

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Barnett, L. M., & Lubans, D. R. (2015). Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. *Journal of Sports Sciences*, (ahead-of-print), 1–11.

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Callister, R., & Lubans, D. R. (2015). Physical Activity and Skills Intervention: SCORES Cluster Randomized Controlled Trial. *Medicine and Science in Sports and Exercise*, *47*(4), 765–774.

Collins, D. R., & Hodges, P. B. (2001). *A comprehensive guide to sports skills tests and measurement*. Lanhan, MD: Scarecrow Press.

Cools, W., Martelaer, K. De, Samaey, C., & Andries, C. (2009). Movement Skill Assessment of Typically Developing Preschool Children: A Review of Seven Movement Skill Assessment Tools. *Journal of Sports Science & Medicine*, *8*(2), 154–168.

Côté, J., & Fraser-Thomas, J. (2007). Youth involvement in sport. In P. Croker (Eds) *Sport Psychology: A Candian Perspective*, pp 270-298. Toronto, ON: Pearson.

Côté, J., & Fraser-Thomas, J. (2008). *Play, practice, and athlete development.* In D Farrow, J. Baker & C. MacMahon (Eds), Developing sports expertise 1st ed. (pp.17-28),  New York: Routledge

Cozby, P. C., & Bates, S. C. (2012). *Methods in behavioral research*. New York: McGraw-Hill

Culjak, Z. P., Miletic, D. P., Kalinski, S. D. P., Kezic, A. P., & Zuvela, F. P. (2014). Fundamental Movement Skills Development under the Influence of a Gymnastics Program and Everyday Physical Activity in Seven-Year-Old Children. *Iranian Journal of Pediatrics*, *24*(2), 124–130.

D'Hondt, E., Deforche, B., Vaeyens, R., Vandorpe, B., Vandendriessche, J., Pion, J., … Lenoir, M. (2011). Gross motor coordination in relation to weight status and age in 5- to 12-year-old boys and girls: a cross-sectional study. *International Journal of Pediatric Obesity 6*(2-2), e556–64. http://doi.org/10.3109/17477166.2010.500388

Davids, K., Bennett, S., Kingsbury, D., Jolley, L., & Brain, T. (2000). Effects of postural constraints on children's catching behavior. *Research Quarterly for Exercise and Sport*, *71*(1), 69–73. http://doi.org/10.1080/02701367.2000.10608882

Davids, K., Button, C., & Bennett, S. J. (2008). Dynamics of skill acquisition: A constraints-led approach. Champaign, IL: Human Kinetics.

De Villiers, M. R., De Villiers, P. J. T., & Kent, A. P. (2005). The Delphi technique in health sciences education research. *Medical Teacher*, *27*(7), 639–643. http://doi.org/10.1080/13611260500069947

DfE. (2013). *National curriculum in England: physical education programmes of study*. (N. curriculum S. statutory guidance, Ed.). England: GOV.UK. Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-physical-education-programmes-of-study/national-curriculum-in-england-physical-education-programmes-of-study

Dudley, D., Okely, A. D., Cotton, W. G., Pearson, P., & Caputi, P. (2012). Physical activity levels and movement skill instruction in secondary school physical education. *Journal of Science and Medicine in Sport 15*(3), 231–237. http://doi.org/10.1016/j.jsams.2011.10.005

Dudley, D., Okely, A., Pearson, P., & Cotton, W. (2011). A systematic review of the effectiveness of physical education and school sport interventions targeting physical activity, movement skills and enjoyment of physical activity. *European Physical Education Review*, *17*(3), 353–378.

Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, *11*(1), 1–42.

Eklund, R. C., Whitehead, M., & Welk, G. J. (1997). Validity of the children and youth physical self-perception profile: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, *68*(3), 249–256.

Ellis, K. (2010). Australian Sport: The pathway to success, Commonwealth of Australia, Canberra.

Ericsson, I. (2008). To measure and improve motor skills in practice. *International Journal of Pediatric Obesity*, *3*(S1), 21–27.

Espenschade, A. S., & Eckert, H. M. (1967). *Motor development*. Columbus, Ohio: Merrill

Faigenbaum, A. D., Myer, G. D., Fernandez, I. P., Carrasco, E. G., Bates, N., Farrell, A., … Kang, J. (2014). Feasibility and reliability of dynamic postural control measures in children in first through fifth grades. *International Journal of Sports Physical Therapy*, *9*(2), 140–148.

Fiez, J. A. (1996). Cerebellar contributions to cognition. *Neuron*, *16*(1), 13–15.

Fitts, P. M. (1964). *Perceptual- Motor skill Learning*. In A. W. Melton, (Ed.), Categories of human learning (pp 243-285)  New York: Academic Press.

Fitts, P. M., & Posner, M. I. (1967). *Human performance*. Oxford, England: Brooks/Cole.

Fleishman, E. A. (1975). Toward a taxonomy of human performance. *American Psychologist*, *30*(12), 1127.

Foweather, L. (2010). Fundamental movement skill competence among 10-11 year old children: *Year 2 PEPASS physical activity project.* Comissioned by Wigan Council. Merseyside, England: Foweather.

Foweather, L., Mc Whannell, Ni., Henaghan, J., Lees, A., Stratton, G., & Batterham, A. M. (2008). Effect of a 9-wk. after-school multiskills club on fundamental movement skill proficiency in 8-to 9-yr.-old children: an exploratory trial 1. *Perceptual and Motor Skills*, *106*(3), 745–754.

Fox, K. R. (1990). *The Physical Self-perception: Profile Manual*. Northern Illinois: University Press.

Forster, D. (2015) School Sport Partnerships. London.

Fransen, J., D'Hondt, E., Bourgois, J., Vaeyens, R., Philippaerts, R. M., & Lenoir, M. (2014). Motor competence assessment in children: Convergent and discriminant validity between the BOT-2 Short Form and KTK testing batteries. *Research in Developmental Disabilities*, *35*(6), 1375–1383. http://doi.org/10.1016/j.ridd.2014.03.011

Gabbard, C. (2011). *Lifelong Motor Development*. (6th Ed.). San Francisco:Pearson-Benjamin Cummings.

Gallahue, D. L., Ozmun, J. C., & Goodway, J. D. (2012). *Understanding Motor Development: Infants, Children, Adolescents, Adults* (7th ed.). New York: McGraw-Hill.

Garcia, C., Barela, J. A., Viana, A. R., & Barela, A. M. F. (2011). Influence of gymnastics training on the development of postural control. *Neuroscience Letters*, *492*(1), 29–32. http://doi.org/10.1016/j.neulet.2011.01.047

Gehris, J., Kress, J., & Swalm, R. (2010). Students' views on physical development and physical self-concept in adventure-physical education. *Journal of Teaching in Physical Education*, *29*(2), 146–166.

Gesell, A. (1954). The ontogenesis of infant behaviour. In L. Carmichael (Ed.), *Manual of Child Psychology* (2nd ed.). New York: Wiley.

Giblin, S., Collins, D., & Button, C. (2014). Physical Literacy: Importance, Assessment and Future Directions. *Sports Medicine*, 1–8.

Goodway, J. D., & Branta, C. F. (2003). Influence of a motor skill intervention on fundamental motor skill development of disadvantaged preschool children. *Research Quarterly for Exercise and Sport*, *74*(1), 36–46.

Goodwin, D. L. (2001). The meaning of help in PE: Perceptions of students with physical disabilities. *Adapted Physical Activity Quarterly*, *18*(3), 289–303.

Goodwin, S. C. (1999). Developing self-esteem in physical education. *Physical Educator*, *56*(4), 210.

Goudas, M., Biddle, S., & Fox, K. (1994). Perceived locus of causality, goal orientations, and perceived competence in school physical education classes. *The British Journal of Educational Psychology*, *64 ( Pt 3)*, 453–463.

Griggs, G. (2007). Physical education: Primary matters, secondary importance. *Education*, *35*(1), 59–69.

Griggs, G. (2010). For sale – primary physical education. £20 per hour or nearest offer. *Education 3-13*, *38*(1), 39–46. http://doi.org/10.1080/03004270903099793

Gulbin, J. P., Croser, M. J., Morley, E. J., & Weissensteiner, J. r. (2013). An integrated framework for the optimisation of sport and athlete development: A practitioner approach. *Journal of Sports Sciences*, *31*(12), 1319–1331.

Gwet, K. L. (2014). *Handbook of Inter-Rater Reliability, 4th Edition: The Definitive Guide to Measuring The Extent of Agreement Among Raters*. Advanced Analytics, LLC.

Gymnastics Australia. (2011). *Gymnastics Australia Participation Plan*. Melbourne Australia

Haga, M., Pedersen. V., & Sigmundsson, H. (2008). Interrelationship among selected measures of motor skills. *Child: Care, Health and Development*, *34*(2), 245–248. http://doi.org/10.1111/j.1365-2214.2007.00793.x

Halliburton, A. L., & Weiss, M. R. (2002). Sources of competence information and perceived motivational climate among adolescent female gymnasts varying in skill level. *Journal of Sport and Exercise Psychology*, *24*(4), 396–419.

Hardy L.L., King, L., Espinel, P., Cosgrove. C., & Bauman A. NSW Schools Physical Activity and Nutrition Survey (SPANS) 2010: Sydney: NSW Ministry of Health. http://sydney.edu.au/medicine/public-health/panorg/pdfs/SPANS_shortReport_2010.pdf (accessed January 2015).

Hardy, L. L., Barnett, L. M., Espinel, P., & Okely, A. D. A. D. (2013). Thirteen-year trends in child and adolescent fundamental movement skills: 1997-2010. *Medicine and Science in Sports*

*and Exercise*, *45*(10)

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement
skills among Australian preschool children. *Journal of Science and Medicine in Sport*, *13*(5),
503–508. http://doi.org/10.1016/j.jsams.2009.05.010

Hardy, L. L., Reinten-Reynolds, T., Espinel, P., Zask, A., & Okely, A. D. (2012). Prevalence and
correlates of low fundamental movement skill competency in children. *Pediatrics*, *130*(2),
2012–0345. http://doi.org/10.1542/peds.2012-0345

Harter, S. (1982). The perceived competence scale for children. *Child Development*, 87–97.

Harter, S. (1999). *The construction of the self: A developmental perspective.* New York. Guilford
Press.

Harter, S., & Pike, R. (1984). The pictorial scale of perceived competence and social acceptance
for young children. *Child Development*, 1969–1982.

Henderson, S. E., Sugden, D. A., Barnett, A. L., & Smits-Engelsman, C. M. (1992). *Movement
assessment battery for children*. Psychological Corporation  London.

Higgs, C., Balyi, I., Way, R., Cardinal, C., Norris, S., & Bluechardt, M. (2014). *Canadian Sport
for Life Physical Literacy*. McAllister, Vancouver.

Horak, F. B. (2006). Postural orientation and equilibrium: what do we need to know about neural
control of balance to prevent falls? *Age and Ageing*, *35*

Hornig, M., Aust, F., & Gullich, A. (2014). Practice and play in the development of German top-
    level professional football players. *European Journal of Sport Science*, 1–10.
    http://doi.org/10.1080/17461391.2014.982204

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis:
    Conventional criteria versus new alternatives. *Structural Equation Modeling: A
    Multidisciplinary Journal*, *6*(1), 1–55.

IBM Corp. (2012). IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.

Ignico, A. A. (1991). Effects of a competency-based instruction on kindergarten children's gross.
    motor development. *Physical Educator*, *4*(48), 188 –191.

Iivonen, K. S., Sääkslahti, A. K., Mehtälä, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., &
    Poskiparta, M. (2013). Relationship Between Fundamental Motor Skills and Physical Activity
    in 4-Year- Old Preschool Children 1, 2, 3. *Perceptual & Motor Skills*, *117*(2), 627–646.

Jaakkola, T., Yli-Piipari, S., Huotari, P., Watt, A., & Liukkonen, J. (2015). Fundamental
    movement skills and physical fitness as predictors of physical activity: A 6-year follow-up
    study. *Scandinavian Journal of Medicine & Science in Sports*, n/a–n/a.
    http://doi.org/10.1111/sms.12407

Jacobs, D. M., & Michaels, C. F. (2002). On the apparent paradox of learning and realism.
    *Ecological Psychology*, *14*(3), 127–139.

Karaboutniotis, D., Evaggelinou, C., Tzetzis, G., & Kourtessis, T. (2002). Curriculum enrichment
    with self-testing activities in development of fundamental movement skills of first-grade
    children in Greece. *Perceptual and Motor Skills*, *94*(3c), 1259–1270.

Katene, W., Edmondson, G. (2004) Teaching Safely and Safety in PE, in: S. Capel (ed.) Learning to Teach in Physical Education in the Secondary School: A Companion to School Experience. London: Routledge, pp.120-140.

Kegan, S., & Telford, R. D., (2013). Inadequacy of physical education in our primary schools. Conference paper, Canberra, Australia: Be Active.

Kelso, J. A. S., Case, P., Holroyd, T., Horvath, E., Rączaszek, J., Tuller, B., & Ding, M. (1995). Multistability and Metastability in Perceptual and Brain Dynamics. In P. Kruse & M. Stadler (Eds.), *Ambiguity in Mind and Nature SE - 9* (Vol. 64, pp. 159–184).: Berlin, Heidelberg: Springer.

Keogh, D. O. and, DeOreo, K., & Keogh, J. (1980). Performance of fundamental motor tasks. In C. B. Corbin (Ed.), *A Textbook of Motor Development* (2nd ed., pp. 76–91). Dubuque, IA: Brown

Kiphard, E. J., & Schilling, F. (1974). *Körperkoordinationstest für Kinder*. Weinheim: Beltz Test GmbH.

Kiphard, E. J., & Schilling, F. (2007). *Körperkoordinationstest für Kinder: KTK*. Weinheim: Beltz-Test.

Kirk, D. (2012). *Defining Physical Education (Routledge Revivals): The Social Construction of a School Subject in Postwar Britain* (Vol. 12). Guilford, London. Routledge.

Kirk, D., & Macdonald, D. (1998). Situated learning in physical education. *Journal of Teaching in Physical Education*, *17*, 376–387.

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. London: Guilford press.

Lai, S. K., Costigan, S. A., Morgan, P. J., Lubans, D. R., Stodden, D. F., Salmon, J., & Barnett, L. M. (2014). Do school-based interventions focusing on physical activity, fitness, or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents? A systematic review of follow-up studies. *Sports Medicine (Auckland, N.Z.)*, *44*(1), 67–79. http://doi.org/10.1007/s40279-013-0099-9

Lander, N. J., Barnett, L. M., Brown, H., & Telford, A. (2015). Physical Education Teacher Training in Fundamental Movement Skills Makes a Difference to Instruction and Assessment Practices. *Journal of Teacher Physical Education*, *34*(3).

Langendorfer, S. J., & Roberton, M. A. (2002). Individual pathways in the development of forceful throwing. *Research Quarterly for Exercise and Sport*, *73*(3), 245–256. http://doi.org/10.1080/02701367.2002.10609018

Langendorfer, S., Roberton, M. A., & Stodden, D. (2013). Biomechanical Aspects of the Development of Object Projection Skills. In D. S. C. Korff (Ed.), *Peaediatric Biomechanics and Motor Control: Theory and Application* (pp. 181– 201). Oxford: Routledge.

Lattimore, D. L. (2000). Motivational perspectives of female gymnasts and their coaches. Master's Thesis, University of Memphis.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. London: Cambridge university press.

Lavin, J., Swindlehurst, G., & Foster, V. (2008). The use of coaches, adults supporting learning and teaching assistants in the teaching of physical education in the primary school. *Primary Physical Education Matters*, *3*(1), 9–11.

Law, M., Finkelman, S., Hurley, P., Rosenbaum, P., King, S., King, G., & Hanna, S. (2004). Participation of children with physical disabilities: relationships with diagnosis, physical function, and demographic variables. *Scandinavian Journal of Occupational Therapy*, *11*(4), 156–162.

Lecanuet, J. P., & Schaal, B. (1996). Fetal sensory competencies. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, *68*(1-2), 1–23.

Lecanuet, J. P., & Schaal, B. (2002). Sensory performances in the human foetus: A brief summary of research. *Intellectica*, *34*(1), 29–56.

Lee, D. N., & Thomson, J. A. (1982). Vision in action: the control of locomotion. *Analysis of Visual Behavior*, 411–433.

LeGear, M., Greyling, L., Sloan, E., Bell, R. I., Williams, B.-L., Naylor, P.-J., & Temple, V. A. (2012). A window of opportunity? Motor skills and perceptions of competence of children in Kindergarten. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 29.

Lenoir, M., Bardid, F., Huyben, F., Deconinck, F., Seghers, J., & De Martelaer, K. (2014). The effectiveness of "Multimove": A fundamental motor skill intervention for typically developing young children. *Science & Sports*, *29,* , S49. http://doi.org/http://dx.doi.org/10.1016/j.scispo.2014.08.097

Logan, S. W., Robinson, L. E., & Getchell, N. (2011). The comparison of performances of preschool children on 2 motor assessments. *Perceptual and Motor Skills*, *113*(3), 715–723.

Logan, S. W., Robinson, L. E., Wilson, A. E., & Lucas, W. A. (2012). Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. *Child: Care, Health and Development*, *38*(3), 305–315.

Lopes, V. P., Rodrigues, L. P., Maia, J. a R., & Malina, R. M. (2011). Motor coordination as predictor of physical activity in childhood. *Scandinavian Journal of Medicine & Science in Sports*, *21*(5), 663–9. http://doi.org/10.1111/j.1600-0838.2009.01027.x

Lopes, V. P., Stodden, D. F., Bianchi, M. M., Maia, J. a R., & Rodrigues, L. P. (2012). Correlation between BMI and motor coordination in children. *Journal of Science and Medicine in Sport / Sports Medicine Australia*, *15*(1), 38–43. http://doi.org/10.1016/j.jsams.2011.07.005

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010a). Fundamental movement skills in children and adolescents. *Sports Medicine*, *40*(12), 1019–1035.

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010b). Fundamental movement skills in children and adolescents: review of associated health benefits. *Sports Medicine (Auckland, N.Z.)*, *40*(12), 1019–35. http://doi.org/10.2165/11536850-000000000

Macdonald, Doune, and Eimar Enright. 2013. "Physical Literacy and the Australian Health and Physical Education Curriculum." *Journal of Sport Science and Physical Education* 65: 351–59.

Magill, R. A. (2011). *Motor Learning and Control: Concepts and Applications* (9th ed.). New York: McGraw-Hill.

Mandigo, J., Francis, N., Lodewyk, K., & Lopez, R. (2009). Physical literacy for educators. *Phys Act Health Education Journal*, *75*, 27–30.

Mardia, K. V. (1970). Measures of multivariate skewness and kurtosis with applications. *Biometrika*, *57*(3), 519–530.

Marsh, H. W. (1997). The measurement of physical self-concept: A construct validation approach. In B.A Bracken (Ed.), *Handbook of self- concept* (pp 38-90). New York: Wiley.

Marsh, H. W., & Peart, N. D. (1988). Competitive and cooperative physical fitness training

   programs for girls: Effects on physical fitness and multidimensional self-concepts. *Journal of

   Sport and Exercise Psychology*, *10*(4), 390–407.

Martin, E. H., Rudisill, M. E., & Hastie, P. A. (2009). Motivational climate and fundamental

   motor skill performance in a naturalistic physical education setting. *Physical Education and

   Sport Pedagogy*, *14*(3), 227–240.

McDaid, D. (2011). Making the long-term economic case for investing in mental health to

   contribute to sustainability. Retrieved from

   http://ec.europa.eu/health/mental_health/docs/long_term_sustainability_en.pdf

McKenzie, T. L., Alcaraz, J. E., Sallis, J. F., & Faucette, E. N. (1998). Effects of a physical

   education program on children's manipulative skills. *Journal of Teaching in Physical

   Education*, *17*, 327–341.

Miller, J., Vine, K., & Larkin, D. (2007). The relationship of process and product performance of

   the two-handed sidearm strike. *Physical Education and Sport Pedagogy*, *12*(1), 61–76.

Mitchell, B., McLennan, S., Latimer, K., Graham, D., Gilmore, J., & Rush, E. (2013).

   Improvement of fundamental movement skills through support and mentorship of class room

   teachers. *Obesity Research & Clinical Practice*, *7*(3), e230–e234.

Mogilner, A., Grossman, J. A., Ribary, U., Joliot, M., Volkmann, J., Rapaport, D., … Llinas, R. R.

   (1993). Somatosensory cortical plasticity in adult humans revealed by

   magnetoencephalography. *Proceedings of the National Academy of Sciences*, *90*(8), 3593–

   3597.

Moneghetti, S. (1993). *Physical and Sport Education for Victorian Schools*. Melbourne:

Directorate of Sport Education

Morgan, P. J., Barnett, L. M., Cliff, D. P., Okely, A. D., Scott, H. A., Cohen, K. E., & Lubans, D.

R. (2013). Fundamental movement skill interventions in youth: A systematic review and meta-

analysis. *Pediatrics*, peds. 2013–1167.

Morgan, P. J., & Bourke, S. (2005). An investigation of pre-service and primary school teachers`

perspectives of PE teaching confidence and PE teacher education. *The ACHPER Healthy

Lifestyle Journal*, *52*(1), 7–13.

Morgan, P. J., & Bourke, S. (2008). Non-specialist teachers' confidence to teach PE: the nature

and influence of personal school experiences in PE. *Physical Education and Sport Pedagogy*,

*13*(1), 1–29. http://doi.org/10.1080/17408980701345550

Morgan, P. J., & Hansen, V. (2008). Classroom teachers' perceptions of the impact of barriers to

teaching physical education on the quality of physical education programs. *Research Quarterly

for Exercise and Sport*, *79*(February 2015), 506–516.

http://doi.org/10.1080/02701367.2008.10559517

Morley, D., Till, K., Ogilvie, P., & Turner, G. (2015). Influences of gender and socioeconomic

status on the motor proficiency of children in the UK. *Human Movement Science*, *44*, 150–156.

http://doi.org/10.1016/j.humov.2015.08.022

Nevill, A. (1996). Validity and measurement agreement in sports performance. *Journal Of Sports

Sciences*, *14*(3), 199.

Newell, K. M. (1986). Constraints on the development of coordination. *Motor Development in

Children: Aspects of Coordination and Control*, *34*, 341–360.

Novak, D., Kovač, M., Čuk, I., Bučar, T., Makovec, U., Bertoncelj, J., … Bolkovič, T. (2008). *Gimnastična abeceda*. Fakulteta za šport, Inštitut za šport.

Ntoumanis, N., & Biddle, S. J. H. (1999). A review of motivational climate in physical activity. *Journal of Sports Sciences*, *17*(8), 643–665. http://doi.org/10.1080/026404199365678

Okely, A. D., & Booth, M. L. (2004). Mastery of fundamental movement skills among children in New South Wales: prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, *7*(3), 358–372. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15518301

Papaioannou, A. (1998). Students' perceptions of the physical education class environment for boys and girls and the perceived motivational climate. *Research Quarterly for Exercise and Sport*, *69*(3), 267–275. http://doi.org/10.1080/02701367.1998.10607693

Peart, N. D., Marsh, H. W., & Richards, G. E. (2005). The physical self-description questionnaire: Furthering research linking physical self-concept, physical activity and physical education. *Educational Psychology Review*, *2*(1), 71–77.

Pot, N., & van Hilvoorde, I. (2014). Fundamental movement skills do not lead necessarily to sport participation. *Science & Sports*, *29*, S60–S61.

Project Play. (2015). *Physical literacy in the United States*. Aspen Institute.  Retrieved from http://aspenprojectplay.org/sites/default/files/PhysicalLiteracy_AspenInstitute.pdf.

Rasbash, J., Charlton, C., Browne, W.J., Healy, M. and Cameron, B. (2009). MLwiN Version. Bristol: Centre for Multilevel Modelling University of Bristol.

Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy*, *15*(2), 117–137.

Riemann, B. L., Myers, J. B., & Lephart, S. M. (2002). Sensorimotor system measurement techniques. *Journal of Athletic Training*, *37*(1), 85.

Riethmuller, A. M., Jones, R. A., & Okely, A. D. (2009). Efficacy of interventions to improve motor development in young children: a systematic review. *Pediatrics*, *124*(4), e782–e792.

Roberton, M. A., & Konczak, J. (2001). Predicting children's overarm throw ball velocities from their developmental levels in throwing. *Research Quarterly for Exercise and Sport*, *72*(2), 91–103. http://doi.org/10.1080/02701367.2001.10608939

Robertson, S. J., Burnett, A. F., & Cochrane, J. (2014). Tests examining skill outcomes in sport: a systematic review of measurement properties and feasibility. *Sports Medicine (Auckland, N.Z.)*, *44*(4), 501–518. http://doi.org/10.1007/s40279-013-0131-0

Robinson, L. E., & Goodway, J. D. (2009). Instructional climates in preschool children who are at-risk. Part I: Object-control skill development. *Research Quarterly for Exercise and Sport*, *80*(3), 533–542.

Robinson, L. E., Rudisill, M. E., & Goodway, J. D. (2009). Instructional climates in preschool children who are at-risk. Part II: Perceived physical competence. *Research Quarterly for Exercise and Sport*, *80*(3), 543–551.

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, P. L., & D'Hondt, E. (2015). Motor Competence and its Effect on Positive Developmental Trajectories of Health. *Sports Medicine*.

Rudd, J. R., Barnett, L. M., Butson, M. L., Farrow, D., Berry, J., & Polman, R. C. J. (2015).

Fundamental Movement Skills Are More than Run, Throw and Catch: The Role of Stability

Skills. *PloS One*, *10*(10), e0140224. http://doi.org/10.1371/journal.pone.0140224

Rudd, J. R., Butson, M. L., Barnett, L. M., Farrow, D., Berry, J., Borkoles, E., & Polman, R.

(2015). A holistic measurement model of movement competency in children. *Journal of Sports

Sciences*, (ahead-of-print), 1–9. http://doi.org/10.1080/02640414.2015.1061202

Rudisill, M. E., Mahar, M. T., & Meaney, K. S. (1993). The relationship between children's

perceived and actual motor competence. *Perceptual and Motor Skills*, *76*(3 Pt 1), 895–906.

http://doi.org/10.2466/pms.1993.76.3.895

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new

directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Sallis, J. F., McKenzie, T. L., Beets, M. W., Beighle, A., Erwin, H., & Lee, S. (2012). Physical

education's role in public health: Steps forward and backward over 20 years and HOPE for the

future. *Research Quarterly for Exercise and Sport*, *83*(2), 125–135.

Salmon, J. O., Ball, K., Crawford, D., Booth, M., Telford, A., Hume, C., … Worsley, A. (2005).

Reducing sedentary behaviour and increasing physical activity among 10-year-old children:

overview and process evaluation of the "Switch-Play" intervention. *Health Promotion

International*, *20*(1), 7–17.

Seefeldt, V. (1980). Developmental motor patterns: Implications for elementary school physical

education. In W. Nadeau, K. M. Newell, & G. Roberts (Eds.), *Psychology of Motor Behavior

and Sport* (pp. 314–323). Human Kinetics Champaign, IL.

Seefeldt, V., & Haubenstricker, J. (1982). Patterns, phases, or stages: An analytical model for the study of developmental movement. *The Development of Movement Control and Coordination*, 309–318.

SHAPE America. (2013). Grade-level outcomes for K-12 physical education. Reston, VA

Shapiro, D. R., Yun, J. K., & Ulrich, D. A. (2002). Measuring perceived gross motor skill competence in children. *International Journal of Sport Psychology*, *33*(4), 391–409.

Shaw, R. E., & Alley, T. R. (1985). How to draw learning curves: Their use and justification. *Issues in the Ecological Study of Learning*, 275–304.

Shirley, M. M. (1931). The first two years: A study of twenty-five babies, Vol. I. Postural and locomotor development.-Inst. *Child Welfare Monograph Series*, (6).

Simons, J., Uitgevers, G. (2014). Introduction to the psychomotor – 7th ed. Antwerpe: Belguim

Slykerman, S., Ridgers, N. D., Stevenson, C., & Barnett, L. M. (2015). How important is young children's actual and perceived movement skill competence to their physical activity? *Journal of Science and Medicine in Sport*.

Smith, B. (1989). Curriculum developments in gymnastics. In L. Almond (Ed.), *The Place of Physical Education in Schools* (p. 7281). London: Kogan Page.

Smits-Engelsman BCM., Henderson SE., & Michels CGJ. (1998) The assessment of children with developmental coordination disorders in the Netherlands: the relationship between the Movement Assessment Battery for Children and the Körperkoordinationstest für Kinder. *Human Movement Science*;17:699–709.

Sparto, P. J., Redfern, M. S., Jasko, J. G., Casselbrant, M. L., Mandel, E. M., & Furman, J. M. (2006). The influence of dynamic visual cues for postural control in children aged 7-12 years. *Experimental Brain Research*, *168*(4), 505–516. http://doi.org/10.1007/s00221-005-0109-8

Standage, M., Treasure, D. C., Hooper, K., & Kuczka, K. (2007). Self-handicapping in school physical education: The influence of the motivational climate. *British Journal of Educational Psychology*, *77*(1), 81–99. http://doi.org/10.1348/000709906X103636

Stein, J. F., Riddell, P. M., & Fowler, S. (1988). Disordered vergence control in dyslexic children. *British Journal of Ophthalmology*, *72*(3), 162–166.

Stodden, D. F., Gao, Z., Goodway, J. D., & Langendorfer, S. J. (2014). Dynamic relationships between motor skill competence and health-related fitness in youth. *Pediatric Exercise Science*, *26*(3).

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, *60*(2), 290–306.

Stodden, D. F., Langendorfer, S. J., Fleisig, G. S., & Andrews, J. R. (2006). Kinematic constraints associated with the acquisition of overarm throwing part II: upper extremity actions. *Research Quarterly for Exercise and Sport*, *77*(4), 428–436. http://doi.org/10.1080/02701367.2006.10559378

Talbot, M. (2008). Ways forward for primary physical education. *Physical Education Matters*, *3*(1), 6–8.

Telford, R. D., Cunningham, R. B., Fitzgerald, R., Olive, L. S., Prosser, L., Jiang, X., &

Telford, R. M. (2012). Physical Education, Obesity, and Academic Achievement: A 2-Year

  Longitudinal Investigation of Australian Elementary School Children. *American Journal of*

  *Public Health*, *102*(2), 368–374. http://doi.org/10.2105/AJPH.2011.300220

Telford, R. D., Cunningham, R. B., Waring, P., Telford, R. M., Olive, L. S., & Abhayaratna, W. P.

  (2013). Physical education and blood lipid concentrations in children: the LOOK randomized

  cluster trial. *PloS One*, *8*(10), e76124. http://doi.org/10.1371/journal.pone.0076124

Tester, G., Ackland, T. R. T. R., & Houghton, L. (2014). A 30-Year Journey of Monitoring Fitness

  and Skill Outcomes in Physical Education: Lessons Learned and a Focus on the Future.

  *Advances in Physical Education*. 127– 137. http://doi.org/10.4236/ape.2014.43017

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist*, *50*(2), 79.

Thelen, E., Ulrich, B. D., & Wolff, P. H. (1991). Hidden Skills: A Dynamic Systems Analysis of

  Treadmill Stepping during the First Year. *Monographs of the Society for Research in Child*

  *Development*, *56*(1), i–103. http://doi.org/10.2307/1166099

Thorndike, E. (1914). The measurement of ability in reading: Preliminary scales and tests:

  Introduction. *The Teachers College Record*, *15*(4), 1–2.

Tremblay, M., & Lloyd, M. (2010). Physical literacy measurement–the missing piece. *Physical*

  *and Health Education Journal*, *76*(1), 26–30.

Turvey, M. T. (1990). Coordination. *The American Psychologist*, *45*(8), 938–953.

Ullman, J. B. (2006). Structural equation modeling: Reviewing the basics and moving forward.

  *Journal of Personality Assessment*, *87*(1), 35–50. http://doi.org/10.1207/s15327752jpa8701_03

Ulrich, B. D., & Ulrich, D. A. (1985). The role of balancing ability in performance of fundamental motor skills in 3-, 4-, 5-year-old children. *Motor Development: Current Selected Research*, *1*, 87–97.

Ulrich, D. A. (2000). *Test of Gross Motor Development* (2nd ed.). Austin, TX: PRO-ED.

Van Beurden, E., Zask, A., Barnett, L. M., & Dietrich, U. C. (2002). Fundamental movement skills—how do primary school children perform? The "Move it Groove it"program in rural Australia. *Journal of Science and Medicine in Sport*, *5*(3), 244–252.

Van Waelvelde, H., De Weerdt, W., De Cock, P., & Smits-Engelsman, B. C. M. (2004). Aspects of the validity of the Movement Assessment Battery for Children. *Human Movement Science*, *23*(1), 49–60.

Van Waelvelde, H., Peersman, W., Lenoir, M., & Smits-Engelsman, B. C. M. (2007). Convergent Validity Between Two Motor Tests: Movement-ABC and PDMS-2. *Adapted Physical Activity Quarterly*, *24*, 59–69.

Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods*, *3*(1), 4–70.

Vandorpe, B., Vandendriessche, J., Lefèvre, J., Pion, J., Vaeyens, R., Matthys, S., … Lenoir, M. (2011). The KörperkoordinationsTest für Kinder: reference values and suitability for 6–12-year-old children in Flanders. *Scandinavian Journal of Medicine & Science in Sports*, *21*(3), 378–388. http://doi.org/10.1111/j.1600-0838.2009.01067.x

Vereijken, B., Emmerik, R. E. A. van, Whiting, H. T. A., & Newell, K. M. (1992). Free (z) ing degrees of freedom in skill acquisition. *Journal of Motor Behavior*, *24*(1), 133–142.

Vilar, L., Araújo, D., Davids, K., & Renshaw, I. (2012). The need for "representative task design"in evaluating efficacy of skills tests in sport: A comment on Russell, Benton and Kingsley (2010). *Journal of Sports Sciences*, *30*(16), 1727–1730.

Vlahov, E., Baghurst, T. M., & Mwavita, M. (2014). Preschool Motor Development Predicting High School Health-Related Physical Fitness: a Prospective Study. *Perceptual and Motor Skills*, *119*, 279–291. http://doi.org/10.2466/10.25.PMS.119c16z8

Walkley, J., Holland, B., Treloar, R., & Probyn-Smith, H. (1993). Fundamental motor skill proficiency of children. *ACHPER National Journal*, (141), 11–14.

Wallace, S. A., Stevenson, E., Spear, A., & Weeks, D. L. (1994). Scanning the dynamics of reaching and grasping movements. *Human Movement Science*, *13*(2), 255–289.

Wenger, E., McDermott, R. A., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business Press.

Whitehead, M. (2001). The concept of physical literacy. *European Journal of Physical Education*, *6*(2), 127–138.

Whitehead, M. (2007). Physical literacy: Philosophical considerations in relation to developing a sense of self, universality and propositional knowledge. *Sports Ethics and Philosophy*, *1*(3), 281–298.

Whitehead, M. (2010). *Physical literacy: Throughout the lifecourse*. London, Routledge.

Whiting, H. T. A., & Vereijken, B. (1993). The acquisiton of coordination in skill learning. *International Journal of Sport Psychology*.

Wiart, L., & Darrah, J. (2001). Review of four tests of gross motor development. *Developmental Medicine and Child Neurology*, *43*(4), 279–85.

Wickstrom, R. L. (1977). Fundamental motor patterns.  Philadelphia: Lea & Febiger

Wikström, P.-O. H. (2005). The social origins of pathways in crime: Towards a developmental
ecological action theory of crime involvement and its changes. *Integrated Developmental and
Life-Course Theories of Offending*, *14*, 211–245.

Wilson, P. H. (2005). Practitioner review: approaches to assessment and treatment of children with
DCD: an evaluative review. *Journal of Child Psychology and Psychiatry, and Allied
Disciplines*, *46*(8), 806–823. http://doi.org/10.1111/j.1469-7610.2005.01409.x

Wright, J. (2006). Mapping the discourses of physical education: articulating a female tradition.
*Journal of Curriculum Studies*, *28*(3), 331–351. http://doi.org/10.1080/0022027980280306

Wright, J. (2011). Educacion corporal en Australia: 1870-1910. In P. Scharagrodsky (Eds.), *La
invencion del "homo gymnasticus": Fragmentos historicos sobre la educacion de los cuerpos
en movimento en Occidente* (pp. 321-346). Buenos Aires: Prometeo Libros.

# CHAPTER - 10  APPENDICES

# Appendix A: Information Statement (Chapter 3 &5)

# INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

**You are invited to participate**

Validation of a Movement competence test battery to measure the efficacy of Gymnastics Australia's

Note: The 'Launch Pad' initiative has been developed by Gymnastics Australia (GA) to increase performance of Movement skill competence within primary school aged children.

This project is being conducted by Professor Remco Polman from Institute of Exercise and Active Living at Victoria University.

**Project explanation**

Children are invited to participate in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad program. This is a national initiative which aims to teach children aged between 6 – 12 years the critical movement skills to give them the competence to participate in sport for life.

**What will I be asked to do?**

The testing will involve children taking part in a circuit of fifteen fundamental movement skills and four general coordination tasks they will complete gross motor tasks similar to that of a normal physical education lesson, completing tasks such as bouncing a basketball, kicking a soccer ball, jumping, running, rolling, hand grip test, walking along a beam and hopping.

**What will I gain from participating?**

The whole experience will be designed to be an enjoyable activity for individual participants and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out for their participation.

**How will the information I give be used?**

The information will be used to assess the validity of the Launch pad fundamentals movement skills battery.

**What are the potential risks of participating in this project?**

There are no potential risks within the study beyond the risk which children would take within the classroom or in a PE lesson

**How will this project be conducted?**

The study will of two hours of being physically active completing different l movement skills.

**Who is conducting the study?**

Victoria University, Gymnastics Australia and Sports Commission
Professor Remco Polman
Institute of Sport Exercise and Active Living
Wk:   99199574
remco.polman@vu.edu.au

# **Appendix B: Consent Form**

# **(Chapter 3 & 5)**

**VICTORIA UNIVERSITY**
M E L B O U R N E   A U S T R A L I A

# CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

**INFORMATION TO PARTICIPANTS:**

We would like to invite you to be a part of a study into 'Validation of a Fundamental Movement skill (FMS) test battery to measure the efficacy of Gymnastics Australia's 'Launch Pad Movement Skill Intervention' (LPMSI)

Children are invited to participate in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad program. This is a national initiative which aims to teach children aged between 6 – 12 years the critical movement skills to give them the competence to participate in sport for life. There are no potential risks within the study beyond the risk which children would take within the classroom or in a PE lesson.

The whole experience will be designed to be an enjoyable activity for individual participants and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out for their participation.

**CERTIFICATION BY PARENT/ GUARDIAN**

I certify that my son/ daughter (name).......................................................................................................

I certify that I am at least 18 years old* and that I am voluntarily giving consent for my son/ daughter to participate in the study:
Examine the effectiveness of the 'Launch Pad Movement Skill Intervention' for children 6- 12 years.'
 being conducted at Victoria University by: Professor Remco Polman

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

Dr Jason Berry

and that I freely consent to participation involving the below mentioned procedures:

Launch Pad test battery to assess Fundamental Movement Skills (Children will complete a circuit completing different fundamental movement task such as- run, hop, jump, throw etc..)
.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.
I have been informed that the information I provide will be kept confidential.

Signed:
Date:
Any queries about your participation in this project may be directed to the researcher
Professor Remco Polman
99199574

# Appendix C: Information Statement (Chapter 4)

**VICTORIA UNIVERSITY**
M E L B O U R N E  A U S T R A L I A

# INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

**You are invited to participate**

You are invited to participate in a research project to examine the effectiveness of the 'Launch Pad Movement Skill Intervention' for children 5- 12 years.'

Note: The 'Launch Pad' initiative has been developed by Gymnastics Australia (GA) to increase performance of fundamental movement skills (FMS) within primary school aged children.

This project is being lead by Professor Remco Polman from Institute of Exercise and Active Living at Victoria University.

**Project explanation**

Children are invited to participate in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad program. This is a national initiative which aims to teach children critical movement skills which will give them the competence to participate in sport for life.

**What will I be asked to do?**

The intervention will take place over eight weeks and children will be asked to take part in two one hour Launch Pad Movement Skills lessons each week . Tests using the Launch Pad test battery will be taken by the children before and after the eight week period to assess any improvement in these skills. Testing will take no longer than 60 minute to complete per child, and will involve children completing two questionnaires which are suitable for this age group: one on athletic competency and the other on physical activity enjoyment .Once the children have completed the questionnaires they will go to the sports hall where they will rotate around seven fundamental movement skill stations completing the following tasks: bouncing a basketball, kicking a soccer ball, jumping, running, hand grip test, walking along a beam and hopping.

**What will I gain from participating?**

The whole experience is designed to be an enjoyable activity for individual participants and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out for their participation.

**How will the information I give be used?**

The information will be used to assess the impact of the Launch pad movement skills intervention had on development of children's Fundamental Movement Skills.

**What are the potential risks of participating in this project?**

There are no potential risks within the study beyond the everyday risks which children would encounter within the classroom or in a PE lesson

**How will this project be conducted?**

The testing and evaluation will be carried out by Victoria University research team. The eight week intervention will be led by class teacher and Gymnastics Australia coaches.

**Who is conducting the study?**

Victoria University, Gymnastics Australia and Australian Sports Commission

Professor Remco Polman

# Appendix D: Consent Form

# (Chapter 4)

# CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

**INFORMATION TO PARTICIPANTS:**.'
Children are invited to take part in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad Movement Skill Intervention' program. This is a national initiative which aims to teach children under 12 years important movement skills which can help to improve their health and enhance their performance and enjoyment of sport. There are no potential risks within the study beyond the everyday risks which children would encounter within the classroom or in a normal PE lesson

The whole experience is designed to be an enjoyable activity for individual students and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out to recognise their participation in this study.

**CERTIFICATION BY PARENT/ GUARDIAN**

I, certify that my son/ daughter (name).......................................................................................................

I certify that I am at least 18 years old* and that I am voluntarily giving consent for my son/ daughter to participate in the study:
Examine the effectiveness of the 'Launch Pad Movement Skill Intervention' for children 5- 12 years.' being conducted at Victoria University by: Professor Remco Polman

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

Dr Jason Berry

and that I freely consent to participation involving the below mentioned procedures:

Launch Pad test battery to assess Fundamental Movement Skills
Athletic competency Questionnaire
Enjoyment of physical activity Questionnaire
Intervention lasting eight weeks, consisting of two one hour lessons of Launch Pad Movement Skill lessons per week.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw my child from this study at any time and that this withdrawal will not jeopardise meor my child in any way.
I have been informed that the information provided will be kept confidentia

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher
Professor Remco Polman

# Appendix E: Information Statement (Chapter 6)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

# INFORMATION TO PARENTS OF CHILD PARTICIPANTS INVOLVED IN RESEARCH

### You are invited to participate

You are invited to participate in a research project to examine the effectiveness of the 'Launch Pad Movement Skill Intervention' for children 5- 12 years.'

Note: The 'Launch Pad' initiative has been developed by Gymnastics Australia (GA) to increase performance of fundamental movement skills (FMS) within primary school aged children.

This project is being lead by Professor Remco Polman from Institute of Exercise and Active Living at Victoria University.

### Project explanation

Children are invited to participate in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad program. This is a national initiative which aims to teach children critical movement skills which will give them the competence to participate in sport for life.

### What will I be asked to do?

The intervention will take place over sixteen weeks and children will be asked to take part in two, one hour Launch Pad Movement Skills lessons each week.  Tests using the Launch Pad test battery will be taken by the children before and after the sixteen week period to assess any improvement in these skills. The tests will take no longer than 60 minutes to complete, and will involve children answering  the Physical Self-Description Questionnaire short form. This questionnaire has been designed and is suitable for this age group.

Once the children have completed the questionnaires they will go to the sports hall where they will rotate around seven fundamental movement skill stations completing the following tasks: bouncing a basketball, kicking a soccer ball, jumping, running, hand grip test, walking along a beam and hopping.

### What will I gain from participating?

The whole experience is designed to be an enjoyable activity for individual participants and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out for their participation.

### How will the information I give be used?

The information will be used to assess the impact of the Launch pad movement skills intervention had on development of children's Fundamental Movement Skills. These findings will be written up within a report for Gymnastics Australia and journal articles to further advance our understanding of how children develop Fundamental Movement Skills. This information will be unidentifiable and will not be able to be traced back to individual participants.

**What are the potential risks of participating in this project?**

There are minimal physical and social risks associated with this study. This is due to it being practical in nature and the children taking part in small groups when rotating around the fundamental movement skill stations. These risk range from physical injuries such as cuts, bruises, twisted ankle to social risk of feeling they have under achieved or peer pressure from their peers.

The following preventions will be put into place to eliminate or minimise these risks:
Trained staff will be present at every FMS station
Safety checks will be carried out on the sports hall and all equipment used
All participants will be supported throughout the testing process and will receive positive feedback on their performance

**How will this project be conducted?**

The testing and evaluation will be carried out by Victoria University research team. The eight week intervention will be led by class teacher and Gymnastics Australia coaches.

**Who is conducting the study?**

Victoria University, Gymnastics Australia and  Australian Sports Commission
Alongside chief supervisor there will be a trained research assistant supporting James Rudd. Supporting the project will be Professor Damian Farrow and Dr Jason Berry.

If you do not feel comfortable with your child partaking in this research there is no obligation and your child can withdraw at any time.

Professor Remco Polman
Institute of Sport Exercise and Active Living
Wk:   99199574
remco.polman@vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above.
If you have any queries or complaints about the way you have been treated, you may contact the Research Ethics and Biosafety Manager, Victoria University Human Research Ethics Committee, Victoria University, PO Box 14428, Melbourne, VIC, 8001 or phone (03) 9919 4148.

# Appendix F: Consent Form

# (Chapter 6)

**VICTORIA UNIVERSITY**
MELBOURNE AUSTRALIA

# CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

**INFORMATION TO PARTICIPANTS:.'**
Children are invited to take part in a research program being conducted by Victoria University to support the development of Gymnastics Australia's new Gymnastics Launch Pad Movement Skill Intervention' program. This is a national initiative which aims to teach children under 12 years important movement skills which can help to improve their health and enhance their performance and enjoyment of sport. There are no potential risks within the study beyond the everyday risks which children would encounter within the classroom or in a normal PE lesson.

The whole experience is designed to be an enjoyable activity for individual students and the wider school. The children will be given positive feedback for their efforts and certificates will be handed out to recognise their participation in this study.

**CERTIFICATION BY PARENT/ GUARDIAN**

I certify that I am voluntarily giving consent for my son/ daughter ………………..(insert name) to participate in the study:
Examine the effectiveness of the 'Launch Pad Movement Skill Intervention' for children 5- 12 years.' being conducted at Victoria University by: Professor Remco Polman, Professor Damien Farrow, Dr Jason Berry and James Rudd.

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

Dr Jason Berry

and that I freely consent to participation involving the below mentioned procedures:

Launch Pad test battery to assess Fundamental Movement Skills
Physical Self perception Questionnaire
Intervention lasting sixteen weeks, consisting of two one hour lessons of Launch Pad Movement Skill lessons per week.
Video recording of two Physical Education lessons

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.
I have been informed that the information I provide will be kept confidential.

Signed:

Date:

# Appendix G: Physical Self- Description Questionnaire

# (Chapter 4)

| Please circle the number that best describes what you think. | False | | | | | True |
|---|---|---|---|---|---|---|
| 1. I feel confident when doing cordinated movements. | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. I am a physically strong person. | 1 | 2 | 3 | 4 | 5 | 6 |
| 3. I am quite good at bending, twisting and turning my body. | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. I can run a long way without stopping. | 1 | 2 | 3 | 4 | 5 | 6 |
| 5. Overall, most things I do turn out well. | 1 | 2 | 3 | 4 | 5 | 6 |
| 6. I usually catch whatever illness (flu, virus, cold etc) is going around. | 1 | 2 | 3 | 4 | 5 | 6 |
| 7. Controlling movements of my body comes easily to me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 8. I often do exercise or activities that make me breathe hard. | 1 | 2 | 3 | 4 | 5 | 6 |
| 9. My waist is too large. | 1 | 2 | 3 | 4 | 5 | 6 |
| 10. I am good at most sports. | 1 | 2 | 3 | 4 | 5 | 6 |
| 11. Physically, I am happy with myself. | 1 | 2 | 3 | 4 | 5 | 6 |
| 12. I have a nice looking face. | 1 | 2 | 3 | 4 | 5 | 6 |
| 13. I have a lot of power in my body | 1 | 2 | 3 | 4 | 5 | 6 |
| 14. My body is flexible. | 1 | 2 | 3 | 4 | 5 | 6 |
| 15. I am sick so often that I cannot do all the things I want to do. | 1 | 2 | 3 | 4 | 5 | 6 |
| 16. I am good at coordinated movements. | 1 | 2 | 3 | 4 | 5 | 6 |
| 17. I have too much fat on my body. | 1 | 2 | 3 | 4 | 5 | 6 |
| 18. I am better looking than most of my friends. | 1 | 2 | 3 | 4 | 5 | 6 |
| 19. I can perform movements smoothly in most physical activities. | 1 | 2 | 3 | 4 | 5 | 6 |
| 20. I do physically active things (e.g., jog, dance, bicycle, aerobics, gym, swim) at least three times a week. | 1 | 2 | 3 | 4 | 5 | 6 |
| 21. I am overweight. | 1 | 2 | 3 | 4 | 5 | 6 |
| 22. I have good sports skills. | 1 | 2 | 3 | 4 | 5 | 6 |
| 23. Physically, I feel good about myself. | 1 | 2 | 3 | 4 | 5 | 6 |
| 24. Overall, I am no good. | 1 | 2 | 3 | 4 | 5 | 6 |
| 25. I get sick a lot. | 1 | 2 | 3 | 4 | 5 | 6 |
| 26. I find my body handles coordinated movements with ease. | 1 | 2 | 3 | 4 | 5 | 6 |
| 27. I do lots of sports, dance, gym, or other physical activities. | 1 | 2 | 3 | 4 | 5 | 6 |
| 28. I am good looking. | 1 | 2 | 3 | 4 | 5 | 6 |
| 29. I could do well in a test of strength. | 1 | 2 | 3 | 4 | 5 | 6 |
| 30. I can be physically active for a long period of time without getting | 1 | 2 | 3 | 4 | 5 | 6 |
| 31. Most things I do, I do well. | 1 | 2 | 3 | 4 | 5 | 6 |
| 32. When I get sick, it takes me a long time to get better. | 1 | 2 | 3 | 4 | 5 | 6 |
| 33. I do sports, exercise, dance or other physical activities almost every | 1 | 2 | 3 | 4 | 5 | 6 |
| 34. I play sports well. | 1 | 2 | 3 | 4 | 5 | 6 |
| 35. I feel good about who I am physically. | 1 | 2 | 3 | 4 | 5 | 6 |
| 36. I think I would perform well on a test measuring flexibility. | 1 | 2 | 3 | 4 | 5 | 6 |
| 37. I am good at endurance activities like distance running, aerobics, bicycling, swimming or cross-country, skiing. | 1 | 2 | 3 | 4 | 5 | 6 |
| 38. Overall, I have a lot to be proud of. | 1 | 2 | 3 | 4 | 5 | 6 |
| 39. I have to go to the doctor because of illness more than most people my | 1 | 2 | 3 | 4 | 5 | 6 |
| 40. Nothing I ever do seems to turn out right. | 1 | 2 | 3 | 4 | 5 | 6 |

**Appendix H: One page of the TGMD-2 score sheet (Chapter 3, 4, 5, 6)**

## Section VI. Subtest Performance Record

Preferred Hand: Right □ Left □ Not Established □
Preferred Foot: Right □ Left □ Not Established □

### Locomotor Subtest

| Skill | Materials | Directions | Performance Criteria | Trial 1 | Trial 2 | Score |
|---|---|---|---|---|---|---|
| 1. Run | 60 feet of clear space, and two cones | Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial. | 1. Arms move in opposition to legs, elbows bent<br>2. Brief period where both feet are off the ground<br>3. Narrow foot placement landing on heel or toe (i.e., not flat footed)<br>4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks) | | | |
| | | | Skill Score | | | |
| 2. Gallop | 25 feet of clear space, and tape or two cones | Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone. | 1. Arms bent and lifted to waist level at takeoff<br>2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot<br>3. Brief period when both feet are off the floor<br>4. Maintains a rhythmic pattern for four consecutive gallops | | | |
| | | | Skill Score | | | |
| 3. Hop | A minimum of 15 feet of clear space | Tell the child to hop three times on his or her preferred foot (established before testing) and then three times on the other foot. Repeat a second trial. | 1. Nonsupport leg swings forward in pendular fashion to produce force<br>2. Foot of nonsupport leg remains behind body<br>3. Arms flexed and swing forward to produce force<br>4. Takes off and lands three consecutive times on preferred foot<br>5. Takes off and lands three consecutive times on nonpreferred foot | | | |
| | | | Skill Score | | | |
| 4. Leap | A minimum of 20 feet of clear space, a beanbag, and tape | Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10 feet away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial. | 1. Take off on one foot and land on the opposite foot<br>2. A period where both feet are off the ground longer than running<br>3. Forward reach with the arm opposite the lead foot | | | |
| | | | Skill Score | | | |

# Appendix I: Body coordination and Anthropometric score

# sheet (Chapter 3, 4, 5, 6)

Name                           Date

Bib Colour          Bib No.          Gender

| Height | | |
|---|---|---|
| Weight | | |
| Grip Strength | 1 | 2 |

Please make sure all details are filled in

**Backward Balance (No. of backward steps)**

| Beam width | 1 | 2 | 3 |
|---|---|---|---|
| Wide | | | |
| Medium | | | |
| Skinny | | | |

**Sideways Jumping (in 15 seconds)**

| 1 | 2 | Total |
|---|---|---|
| | | |

**Moving Platforms Sideways (in 20 seconds)**

| 1 | 2 | Total |
|---|---|---|
| | | |

**Hopping for Height (Foam)**

| Blocks | Left Foot | Right Foot |
|---|---|---|
| 0 | | |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |