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A longitudinal examination of the contribution of perceived motor competence and actual motor competence to physical activity in 6 to 9 year old children

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A LONGITUDINAL EXAMINATION OF THE CONTRIBUTION OF PERCEIVED MOTOR COMPETENCE AND ACTUAL MOTOR COMPETENCE TO PHYSICAL ACTIVITY IN 6 TO 9 YEAR OLD CHILDREN

Submitted by

Fleur McIntyre

This thesis is submitted for the degree of Doctor of Philosophy of the University of Notre Dame Australia, School of Health Science.

2009
Declaration of Authorship

This thesis is the candidate’s own work and contains no material which has been accepted for the award of any degree or diploma in any other institution.

To the best of the candidate’s knowledge, the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

_________________________ ___________________
Candidate’s Name   Date
ABSTRACT

This study examined the relationship between perceived motor competence, actual motor competence and physical activity. In particular, it aimed to identify the impact of perceived motor competence (PMC), actual motor competence (AMC), and age and gender on the physical activity levels of young children. A number of factors have been identified as key contributors to children’s physical activity levels. However, there had been little investigation into their developing impact and subsequent relationship with emergent physical activity levels, particularly in the younger primary age groups.

Physical activity, AMC and PMC measures were collected from 6-, 7-, 8-, and 9-year-old boys and girls (N=201) on four occasions across 18 months. For physical activity, participants wore pedometers for 7 days and completed physical activity diaries to record daily step counts. Actual motor competence was assessed by videoing four motor skills (50m run, overhand throw, standing broad jump, and line walk), and creating a score based on mastery of skill criteria. Perceived motor competence was measured through the Self Description Questionnaire-I (Marsh, 1988). Participants answered closed questions in the form of scaled responses based on a scoring system of 1 (No, always) to 5 (Yes, always) with a total possible score of 120.

Independent t-tests detected significant gender differences in physical activity with boys having higher mean daily step counts than girls at every age. Similarly, boys had significantly higher AMC scores than girls at every age. There were no significant differences between boys and girls for PMC scores. AMC and PMC were moderately correlated in older boys (7-, 8-, and 9-year-olds) and strongly correlated in older girls (9-year-olds), with the relationship evident at an earlier age in boys than girls.

Cross sectional multiple regression analysis investigated the contribution of PMC and AMC to physical activity levels at each age, and in this sample of young children AMC made a greater contribution (9% – 30%) to physical activity than PMC (0% -
5%). Again, this significant input was evident at an earlier age in boys (7 years) than girls (9 years). Longitudinal analysis examined the influences on physical activity over time. Using linear mixed model analysis across the four data collection cycles (DC) identified Actual Motor Competence level, Gender and School significantly impacting physical activity levels over time in these young children.

This study provides evidence of the emerging relationship between perceived and actual motor competence and their differing impact on physical activity levels in young primary school children. Previous research has predominantly focused on children older than 9 years and identified that independently, perceived and actual motor competence both influence physical activity levels. The current results for children younger than 9 years suggest that AMC is more important to physical activity than PMC. Another major finding is that the pattern of development is different between boys and girls, with boys being more advanced in actual motor competency and its subsequent contribution to physical activity. These results have important implications for early childhood learning environments and the need to acknowledge these developmental distinctions.
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CHAPTER ONE

THE PROBLEM

Background and Context
Physical activity contributes to the optimal development of many physical, physiological, educational, social and psychological functions in children and youth (Bauman, Bellew, Vita, Brown & Owen, 2002). There is also growing evidence that regular physical activity participation in childhood and adolescence facilitates a physically active lifestyle in future years and is important for health, physical wellbeing and lifestyle disease prevention (Hands, Parker & Larkin, 2001; Trost, 2003). For example, sufficient physical activity limits unhealthy weight gain, strengthens bones and muscles, improves some types of cholesterol, and enhances psychosocial health (Strong, Malina, Blimkie, Daniels, Dishman & Gutin, 2005).

In early childhood a number of factors have been identified, proposed or hypothesised as key contributors to children’s physical activity levels. As physical activity is a learned behaviour and can be changed or modified (Sallis, Berry, Broyles, McKenzie & Nader, 1995), what key factors contribute to physical activity behaviour in a developing child?

Physical activity is determined or influenced by a variety of factors (Sallis et al., 1992). No one variable or category of variables was expected to account for most of the variance in children’s physical activity. However, these factors may have varying degrees of influence at different times in a child’s development (Sallis et al., 1992; Hands, Parker & Larkin, 2001). The application of the dynamic systems theory to cognitive and motor development views behaviours as emergent from the complex and changing interactions of factors and are not solely pre determined through maturation (Thelen & Smith, 1994). The interaction of these factors at different stages of development may support and “enable” physical activity behaviours, whilst some will limit or “constrain” physical activity levels.
Several theoretical models have been proposed to explain the factors that influence physical activity behavior, however few have been developed specifically for children (Welk, 1999). Lindquist, Reynolds and Goran (1999) provided a hierarchal framework that identified “determinants” or factors that affect children’s physical activity behaviour at four levels - physiological factors such as age, gender and actual motor competence (AMC), psychological factors such as motivation and perceived motor competence (PMC), sociocultural factors such as parents and family structure and ecological factors such as the physical environment. The focus of the current study is to investigate the influence of a physiological determinant, AMC, and a psychological determinant, PMC, on physical activity in young children.

Actual motor competence is the mastery of physical skills and movement patterns that enable enjoyable participation in physical activities (Castelli & Valley, 2007). In movement development, the acquisition of proficient fundamental motor skills in early childhood serves as a foundation for building complex motor skills later in life. Early development of competence in motor skills has the potential to establish a healthy habit of physical activity participation (Garcia, Garcia, Lloyd & Lawson, 2002). Perceived motor competence is an individual’s awareness and belief of their capability to perform both gross and fine motor tasks (Rudisill, Mahar & Meaney, 1993). Feelings of perceived competence are experienced when performance outcomes are positive and an individual’s perception of their own competence towards a task or activity serves to motivate the individual and increase persistence (White, 1959; Harter, 1978, 1982; Ulrich, 1987).

Previous research has examined the relationship between PMC and AMC (Biddle, Page, Ashford, Jennings, Brooke & Fox, 1993; Boucher, Doescher & Sugawara, 1993; Rudisill, Mahar & Meaney, 1993; Raudsepp & Liblik, 2002), however the focus was on boys and girls 9 years old and above. Findings from these studies reveal a moderate yet significant, relationship between PMC and AMC for boys and girls which strengthen as children become older (Roberts, 1984).

Older children and adolescents ranging from 10 to 16 years old who have higher perceived competence participate in more physical activity, than those with lower perceived competence (Telama, 1998; Carroll & Loumidis, 2001). For both children
and adolescents, a strong and positive belief about one’s competence leads to greater enjoyment and commitment to continue the activity than those with lower perceived competence (Weiss & Ferrer-Caja, 2002).

Children with movement difficulties or low motor competence tend to be vigorously active less often (Li & Dunham, 1993; Bouffard, Watkinson, Thompson, Dunn & Romanow 1996). However, these studies have primarily examined children with Developmental Coordination Disorder (DCD) and children with disabilities rather than typically developing children.

Past research has highlighted the important role that, separately, PMC, AMC and physical activity play in a child’s development. However, whilst some researchers have examined the relationship between perceived and actual motor competence, and others have investigated the relationship between motor competence and physical activity in children with DCD, little research has investigated the evolving relationship between PMC, AMC and physical activity levels in typically developing young children.

Welk (1999) and Stodden et al. (2008) have both proposed models conceptualising determinants influencing physical activity in youth. Both agreed on a lack of knowledge and of understanding the changing influence of these factors with development and their subsequent relationships with physical activity. However separately, they purported the importance of different types of competence in influencing physical activity behavior.

Welk’s (1999) Youth Physical Activity Promotion model (YPAP) categorised the five most commonly reported determinants/correlates of physical activity into a) personal, b) biological, c) psychological, d) social and e) environmental. Determinants were then classified into factors that predispose, enable and reinforce physical activity behavior, with the intention to emphasise those that are most likely to be causally related to activity and those that are more yielding to change. The YPAP model suggested biological factors such as physical skills and competence act as enabling factors. This means youth who are physically fit and skilled are more likely to seek out opportunities to be active, whereas children who are less skilled
and fit are less likely to achieve the same level of activity. Predisposing variables, including self-efficacy and perceived competence, collectively increase the likelihood that a person will be physically active on a regular basis. Reinforcing factors included family, peer, and coach influence. Welk (1999) proposed that while direct effects of biological factors (such as skill competence) on activity behavior are possible, indirect effects through the child’s perception of competence are perhaps more likely. He stated “with respect to competence, evidence shows that children’s perceptions of competence may be [italics added] more important than actual ability” (p. 14).

On the other hand, Stodden et al. (2008) argued that the development of actual motor skill competence is important in its own right. Their conceptual model focused on the developmental and dynamic nature of motor skill competence and its role in promoting physical activity over time. Young children’s early physical activity might drive their development of motor skill competence. As young children demonstrate variable levels of physical activity and motor competence, they proposed the relationship between the two will be weak at this point in time. However, in the transition from middle to late childhood, environmental and individual factors operating in early childhood will compound over time, resulting in a stronger relationship between physical activity and motor competence. In addition, this emergent relationship is mediated by a variety of other factors, including perceived motor competence.

Clearly, there is no consensus on the influence of AMC or PMC in the development of children and youth’s physical activity behavior. Therefore, the intention of this study was to assess a new conceptual model which is based on Welk (1999) and Stodden et al.’s (2008) models, to identify what has the greater influence on emerging levels of physical activity in young children, actual or perceived motor competence? Neither Welk’s (1999) or Stodden et al.’s (2008) models had specified age or considered possible gender differences in the development of competencies and resultant relationships with physical activity. Additionally, one aim of the current study is to specifically concentrate on 6- to 9-year-old children in order to examine more closely age and gender changes in actual and perceived motor competence and physical activity in young children.
**Purpose of this Study**

The purpose of this study was to examine the relationship between PMC, AMC and physical activity in young children, aged 6 to 9 years old. Specifically, the focus is the contribution of PMC and AMC on the emergence of physical activity levels in young boys and girls.

The underlying assumption of this study is that behaviours emerge from complex and changing interactions of factors, an application of the dynamic systems theory. Through the mixed-longitudinal design of the research, a single cohort of 6- to 9-year-olds (N = 201) were recruited and tracked across four data collections in 18 months, the objective was to identify the developmental changes in this relationship and how this contributed to physical activity in the early primary years.

**Significance of the Study**

Given the current focus on physical activity and building evidence of its importance to health, the significance of the current study seeks to provide information on the influences of self perceptions and skill competence on physical activity in young children. At present, the link between PMC, AMC and physical activity in typically developing children is not widely understood. With respect to young children, there are few studies on those younger than 9 years old investigating the influences of these variables on emerging physical activity behaviour. Very few studies have used a longitudinal study design to examine the influences on physical activity on young children. As a result, the current study will test our own model based on the models proposed by Welk (1999) and Stodden et al. (2008) to determine the contributions of perceived and actual competence to young children’s physical activity levels over time.

The findings from this research may guide educational initiatives, interventions, and health promotion initiatives in primary schools to focus on factors that are most important to physical activity in these early years. Ultimately, effective interventions taking into account these factors will support children to adopt a more physically active and healthier lifestyle.
**Major Research Question:**
What are the relative contributions of PMC and AMC to the development of young children’s physical activity levels across time?

In addressing the major research question the following questions were considered.

- Was there a relationship between AMC and PMC in young children?
- How does the relationship between AMC and PMC change with age and gender?
- How do levels of AMC and PMC relate to levels of physical activity for boys and girls?
- Were there differences for age and gender for physical activity, PMC and AMC?
- Were there specific ages for boys and girls in the early primary years which can be identified as significant for changes in the relationship between PMC, AMC and physical activity?

**Major Hypotheses:**
In addressing the main research questions, the following hypotheses were proposed.

1. Boys will record higher physical activity levels than girls across all age groups.

2. Boys will record higher PMC scores than girls across all age groups.

3. Boys will record higher AMC scores than girls across all age groups.

4. AMC will be significantly related to PMC in boys and girls.
5. Boys and girls with higher PMC and higher AMC will have higher physical activity levels.

6. AMC, PMC, age and gender will be predictors of physical activity behaviour in young children.

**Delimitations**

1. This research project was delimited to 6-, 7- and 8-year-old boys and girls. This is because the principal focus is on the physical activity behaviours of young primary school children.

2. Medically unfit children who were unable to regularly participate in physical education classes and activities at school were excluded from the study.

3. The location of primary schools invited to participate in the study were representative of a geographic spread of the Perth metropolitan region.

**Limitations**

1. The sample for this study was limited to children from middle socio-economic primary school areas and therefore results may not be generalisable to broader socio demographic areas.

2. Although young children are often inconsistent when performing motor skills and performance can be affected by such factors as level of motivation, feeling tired or unwell and attention span. It was anticipated the size of the sample and global motor skill score would lessen the effect of fluctuating performance.

3. A limitation of the mixed-longitudinal study design is greater probability of missing or incomplete data due to multiple data collection cycles.
Definition of terms

**Actual Motor Competence (AMC)**
Motor competence has been defined as an individual’s capability to master physical skills and movement patterns that enable enjoyable participation in physical activities (Castelli & Valley, 2007).

**Fine Motor Skills**
The ability to perform movements with smaller muscles, usually involving manipulation of small objects with hands and fingers (Payne & Isaacs, 2002).

**Fundamental Movement Skills**
Fundamental movement skills are the basic movement patterns involving different body parts and are the foundation movements to the more specialised, complex skills used in play games, sports, dance, gymnastics, outdoor education and physical recreation activities. Fundamental movement skills can be separated into locomotor skills such as running and jumping, object control skills such as throwing and catching, and balance skills such as line or beam walking (Payne & Isaacs, 2002).

**Gross Motor Skills**
The ability to perform movements with larger muscles, usually involving movement of the body through space or manipulation of larger objects (Payne & Isaacs, 2002).

**Motor Development**
Motor development has been defined as the changes in movement behaviour over the lifespan and the processes that underlie these changes (Payne & Isaacs, 2002).

**Perceived Motor Competence (PMC)**
Perceived competence is an individual’s belief of how capable they are in various achievement domains (Weiss & Amorose, 2005). Perceived motor competence is an individual’s awareness of their ability to perform both gross and fine motor tasks (Rudisill, Mahar & Meaney, 1993).


**Physical Activity**

Any bodily movement produced by skeletal muscle that results in energy expenditure (Casperan, Powell & Christensohn, 1985). Physical activity is the observable feature in different aspects of play, the explicit expression of the developing child (Hands, Parker & Larkin, 2001).

**Self concept**

Self concept is an individual’s self description which is based on his/her self-perceptions. These perceptions are formed through experience with and interpretations of one’s environment (White, 1959).
CHAPTER TWO

LITERATURE REVIEW

Physical activity plays an important role in children’s healthy development (Bauman et al., 2002). Participation in regular physical activity in childhood and adolescence can contribute to a healthier lifestyle as an adult and help reduce the onset of Type II diabetes, cardiovascular disease and other chronic ailments (Bauman et al., 2002; Trost, 2003). Identifying the contributions of key determinants of physical activity in early childhood is essential to optimise activity levels in young children and maximise the possibility of a physically active lifestyle in future years.

This chapter will firstly review the developmental theories and previous research on trends, determinants and conceptual models of young children’s physical activity, as this is essential to the development of the conceptual framework for the current study. This is followed by an appraisal of previous research for perceived motor competence and actual motor competence. The final section comprises a review of measurement instruments for perceived motor competence, motor competence and physical activity, particularly in young children.

Developmental Theory

When describing development, the most global description is that an organism goes from being small and simple to bigger and complex. On one hand development is linear and quantitative, as growth is always incremental, yet at the same time development is also non-linear and qualitative, since complexity invokes new forms and abilities (Thelen & Smith, 1994).

Developmentalists have devoted considerable time and effort in the quest to understand the primary driver of development; the classic “nature-nurture” debate. At one end, the developmental ground plan is seen as residing entirely within the organism, a set of genetic plans which contain all the information needed for final adult form, and which need only to be “read” over time. At the other end, the organism is viewed as containing none of the information for its final destiny, but as an absorbing configuration which adjusts and changes through experience with the
environment (Thelen & Smith, 1994). Most developmentalists agree that
development is most likely the result of both genetically determined processes and
input from the environment and their interaction.

One of the key tasks of human development is the coordination of movement at both
a simple and complex level. In their daily physical activity children demonstrate
many different patterns of coordinated movement and throughout childhood develop
a repertoire of skills to perform a variety of tasks.

The examination of how these behaviours emerge through a child’s growth has been
predominantly approached over the years through five different perspectives, the
neural-maturation, information-processing, the ecological psychological, the
constraint and dynamic systems perspectives.

**Neural maturation perspective**
The neural maturation process is one of the original theories of motor development,
with primary interest towards this approach emerging in the 1930s and 1940s. Motor
development is seen as a universal sequence of development and unfolding of
postures and movements that are mainly attributed to the general process of
maturation of the central nervous system (Savelsbergh, Davids, van der Kamp &
Bennett, 2003). The major contribution to the understanding of the development of
movement was the establishment of ‘milestones’ of development by Gesell (1939),
McGraw (1932; 1940; 1945) and Shirley (1931). Both Gesell and McGraw invoked
maturational process as the primary driver of these developmental milestones and
change.

However, McGraw eventually acknowledged that her effort to relate development to
maturation of the neural tissues and brain was largely unsuccessful, in part due to
methodological limitations, but more fundamentally as a result of unwarranted belief
that complex functioning could be understood by histological changes in the brain or
by assuming simple localisation of function (Savelsbergh, Davids, van der Kamp &
Bennett, 2003). Gesell (1945) also developed a sophisticated theory that
acknowledged both the dynamic and non linear nature of the developmental process.
which led to renewed efforts to explain development taking these concepts into account.

**Information processing perspective**

There was a shift in motor development theories in the 1960s and 70s towards cognitive approaches in the form of Piagetian theory and information processing theory. Both have been described as cognitive theories because there is an emphasis on formation of plans for behaviour (Ulrich, 1997).

The aspect of Piaget’s work that received most attention from students of motor development was his concept of stages. According to Piaget (1952), each stage involves qualitatively different ways of thinking or behaving and reflects underlying structural changes. They occur in a fixed order and none can be skipped. Furthermore, shifts in behaviour arise from the interaction of the organism with its environment.

Similarly, the information processing perspective divides the cognitive system into components and determines the way in which these process and transmit information. This approach focuses on the concept of memory and theorises the diversity between novices and experts is attributed to differences in stored knowledge with respect to the task at hand and the associated processing activities. Children, as novices, learn a skill and store knowledge regarding that skill. As a child develops and ‘moves’ to expert (adult) status they acquire a variety of problem solving strategies and store increasingly complex knowledge about that skill. Thus, development involves improving the strategies for encoding and manipulating information (Savelsbergh, Davids, van der Kamp & Bennett, 2003).

There are two types of models that influenced and dominated the development of movement coordination in this period: the open and closed loop models. In these models, feedback loops for error corrections were invoked for explaining the control and coordination of motor behaviour. During this time developmental researchers were primarily concerned with constructing motor tests and gathering normative data (Cratty, 1970; Wickstrom, 1983; Williams, 1983). As a result most studies were
descriptive and a theoretical framework to explain the origin of new motor behaviours was missing.

The information processing approach focused on the question “what develops?” and research from this perspective provided answers rich in details but lacking in illumination of the big picture. Thelen and Smith (1994) suggest the big picture is “how does it develop?”. Whilst research in maturationist and cognitive approaches added to our information base, it did not explain the richness, diversity and dynamic nature of motor skill acquisition, particularly the how and why (Ulrich, 1997).

Ecological psychology perspective
The ecological psychology approach was first proposed by Gibson (1966; 1979) in the 1960s and 1970s but it was only adopted by those studying movement in the late 1980s and 1990s. Ecological psychology stresses the interrelationship between the individual and the environment. There are two branches of enquiry in ecological psychology - one concerned with perception and the other with motor control and coordination (Payne & Isaacs, 2002). Gibson (1966; 1979) proposed that a close interrelationship exists between the perceptual and motor system. The ecological perspective theorises that information in the environment is not static in time and space, but specifies events, places and objects. According to Savelsbergh et al. (2003) the child must learn to pick up and select appropriate information, rather than try to construct meaningful perception from stimuli.

Gibson (1966; 1979) used the term ‘affordance’ to describe the functions environmental objects provide to an individual of a certain shape and size within a particular setting. For example, a baseball bat affords an adult, but not an infant, the opportunity to swing. Hence, the interrelationship between individual and environment is so intertwined that one’s characteristics define an object’s meanings. The movement capabilities of a child may improve through multiple developmental changes with the maturation of the central nervous system, the sensitivity to information sources, the growth of body dimensions and the ability to combine information and movement (Savelsbergh et al., 2003). The child then learns to detect affordances, pick up relevant information and then couple the information to movements.
As in previous theories of motor development, the focus of the ecological approach was on “here and now” and little attention was given to motor learning (how the skills are learned). Theoretical interest then shifted to behaviours which emerge as a result of the organism-environment interaction.

**Constraints model perspective**

The constraints model was initially derived from the organism-environmental theory (developed from the ecological approach) and explains the behavioural patterns that are produced through the interaction and dynamics of constraints categories. The key issue is how a system learns to regulate the ‘degrees of freedom’ embodied in a movement (Bernstein, 1967). The degrees of freedom refer to the possible movements of all components of the motor apparatus of the human body, for example, the neuro muscular connections, the innervated muscle fibres, the joint actions, the force effect of muscle contraction, and so on. Bernstein (1967) highlighted that the non-linear nature of these interacting components created a very complex control problem which could best be solved by reducing the degrees of freedom. In the early phases of motor development, these degrees of freedom are superfluous and action is rudimentary and relatively uncoordinated. This coordination problem at the beginning of motor skill acquisition is often solved by an initial ‘freezing out’ of the excess degrees of freedom, which often keeps the body rather rigid. As a task or skill is practiced and greater mastery occurs, there is a gradual release of these degrees of freedom on the motor apparatus. Greater coordination and smoothly timed segmental action is the result.

Kugler and Turvey (1980) further developed Bernstein’s constraints theory suggesting that the development of movement skill and coordination is brought about by changes in constraints imposed upon the organism-environment system, guided by movement produced information. Newell (1986) developed a framework which identified three potential sources of enablers to action - the organism, the task and the environment. Newell (1986) proposed that these enablers interact with each other leading to a task-specific organisation of the movement coordination pattern and that this pattern is emergent rather than prescribed.
However, whilst Newell’s constraints model established a framework which identified an emergent behaviour from three sources of enablers, researchers sought to investigate the interacting effect of maturation, progression of behaviour and directional trends of movement. It was essential to understand these non linear interactions in the progression of skill and behaviour that led to the increasing interest in the dynamic systems theory.

*Dynamic systems perspective*

The dynamic systems theory portrays movement development and coordination as a process that confines the free variables of a system into a behavioural unit (Savelsbergh et al., 2003). Bernstein’s (1967) early work, regarding the degrees of freedom problem and explanation of movement coordination through the interaction of complex systems, provided a cornerstone in the theoretical foundation and concepts of dynamic systems theory. The basic criterion or principles for a dynamic system is that it changes over time and that systems undergoing change are complex, coordinated and somewhat self-organising (Ulrich, 1997). Thus, a movement pattern or an observable behaviour, such as physical activity, would emerge from component parts interacting both together and with the environment (Payne & Isaacs, 2002).

The three fundamental concepts of the dynamic systems theory are the existence of a self-organising complex system, behavioural patterns are determined by attractor states and the impact of control parameters on the system. The first principle of the dynamic systems theory, that of self-organising complex systems, is that patterns of behaviour can emerge spontaneously from the cooperation and self-organisation of multiple subsystems or components (Ulrich, 1997). The cooperation of subsystems is termed a coordinative structure and, as Newell (1986) had described, behaviour emerges from the self-organisation of body systems, the nature of the performer’s environment and the demands of the task.

The second principle in the dynamic systems theory is the notion of attractor states, both stable and unstable, which refers to preferred patterns of behaviour which a system ‘wants’ to perform under certain circumstances (Ulrich, 1997). A stable attractor has a high probability of occurring and when disturbed, the system quickly returns to that stable pattern and the interruption is minimal. Furthermore, new
behaviours or movements can emerge when the stable attractor weakens to the point at which a different attractor state influences the behaviour (Schoner & Kelso, 1988).

The third principle stated that changes in attractor states and emergence of new behaviours occur over time as a complex system gradually changes. As the system changes as a result of transition in attractor states, there is a relatively abrupt reorganisation of the system into a new pattern and this reorganisation is referred to as a non linear phase shift (Ulrich, 1997). The components of a system that produces phase shifts in movement patterns are called control parameters. Control parameters, by their own gradual change, cause the system to reach a point where the current ‘pattern’ fails to work as well as it did. Behaviour becomes unstable for a period of time, and the system examines new possibilities before eventually discovering a new, more efficient pattern (Ulrich, 1997). These control parameters may be internal or external to the system.

The dynamic systems perspective portrays the observed behaviour as a process that reduces the potentially free variables of a system. A collective variable captures the observed behaviour, while a control parameter leads the system through different behavioural patterns.

In applying the dynamic systems theory to the present study, the emergent behaviour is considered to be physical activity and levels of physical activity surface as a result of the interaction with key control parameters, hypothesised in this case, to be actual and perceived motor competence and the individual’s personal demographics (age and gender). By tracking the impact and nature of this relationship over time, a greater understanding of the dynamic changes in this relationship that influence developing physical activity levels in young children is expected.
Physical Activity in Children and Youth

Over the last decade there has been a building body of evidence that an active lifestyle is one of the best investments for individual and community health (Bauman et al., 2002). Engaging in regular physical activity, even of moderate intensity, reduces the risk of diseases such as cardiovascular disease, osteoporosis, obesity and injury. Regular physical activity facilitates better stress management, alleviates depression and anxiety, strengthens self esteem and provides social benefits through increased social interaction and integration (Bauman et al., 2002).

With regards to children and adolescents, physical activity is also related to the optimal functioning of various physical, psychological, and social processes. Previous research reports that participation and involvement in physical activity during childhood and adolescence may contribute to a continuing commitment to a physically active lifestyle in adulthood. For a full review see Hands, Parker and Larkin (2001) and Trost (2003).

Australian and international guidelines currently recommend participation in at least 60 minutes (and up to several hours) of moderate to vigorous activity per day for children and adolescents (Cavill, Biddle & Sallis, 2001; National Association for Sport and Physical Education, 2004; Commonwealth Department of Health and Ageing, 2004). However, children are being exposed to a growing range of sedentary recreation opportunities, such as the internet, television, videos and computer games, homework and additional tutoring (McMurray et al. 1993; Shilton & Naughton, 2001). Children are becoming less active as they become older, and participation and activity levels are lower in female children (Armstrong et al., 1990; Welsman & Armstrong, 1997; Trost et al. 2000; Thompson, Baxter-Jones, Mirwald & Bailey, 2003; Hands et al., 2004).

There are no agreed guidelines for how many steps children should take each day, however two common recommendations are that: a) boys get at least 13,000 steps per day and girls 11,000 steps (President Council on Fitness & Sport, 2002), or boys average at least 15,000 steps per day and girls 12,000 steps (Tudor-Locke et al., 2004). In a recent national survey on Australian children, more than 4,000 males and females 5 to 16 years old wore pedometers for up to seven consecutive days and
completed a computerised 24-hour physical activity recall (Commonwealth Department of Health and Ageing, 2007). It was found 5- to 8-year old boys averaged 13,815 steps per day, and girls averaged 12,086 steps per day. Overall, 55% of boys and 66% of girls met the recommended steps per day. The percentage meeting the recommendations decreased with age, with only 26% of 14- to 16-year-olds meeting the recommendations, and this was also true for moderate-vigorous physical activity (MVPA) among both males and females aged 9 to 16 years. The overall amount decreased by about 10 minutes per day with each year of age.

In 2003, a study of Western Australian children 7 to 16 years old, found that more secondary than primary school students reported participating in no vigorous intensity sport, exercise or dance (Hands et al., 2004). Higher mean daily step counts for 7-year-old (10,337), 8-year-old (11,578) and 9-year-old (12,039) boys were recorded compared to 7-year-old (10,116), 8-year-old (9,989) and 9-year-old (10,461) girls.

Armstrong, Balding, Gentle and Kirby (1990) examined patterns of physical activity in British children 11 to 16 years old. They reported that only 6.2% of boys and 4.3% of girls were spending time with their heart rate > 139 beats/per min. The relationship between age and percentage of time with heart rate > 139 beats/per min was not significant for boys but a negative correlation was found for girls, indicating that as girls became older percentage of time with heart rate above 139 beats/per min decreased. In comparison, Welsman and Armstrong (1998) investigated the percentage of time 5- to 7-year-olds spent with heart rates exceeding moderate and vigorous activity thresholds. They concluded that younger boys (13.6%) and girls (8.5%) spent a greater percentage of time with heart rates exceeding 139 beats/per min in comparison to older children and adolescents and sustained this activity over longer periods of time.

Trost et al. (2002) measured physical activity levels in children from grades 1 - 12 with accelerometers for seven consecutive days. Children were grouped into four grade groups: grades 1 - 3 (mean age 7.0 years), grades 4 - 6 (mean age 10.1 years), grades 7 - 9 (mean age 12.9 years) and grades 10 - 12 (mean age 15.6 years) and minutes spent in moderate-to-vigorous physical activity (MVPA) and vigorous
physical activity (VPA) were examined. They found that physical activity declines rapidly during childhood and adolescence with the greatest age related decline during the younger primary years.

Thompson et al. (2003) administered a physical activity questionnaire biannually or triannually to 9- to 18-year-old Canadian children for seven years. They reported that physical activity levels were decreasing with increasing chronological age in both boys and girls. Similarly, Hands et al. (2004) modelled pedometer step counts of Western Australian children showed that they peaked at 14.3 years for males and 12.8 years for females before gradually reducing with age. Riddoch et al. (2004) investigated physical activity in European children aged 9 and 15 years. Participants wore accelerometers for 3 to 4 days, which included at least 1 weekend day. Boys were more active than girls at 9 years and 15 years. At age 9, the great majority of boys (97.4%) and girls (97.6%) achieved the recommended guidelines of 60 minutes of daily moderate-intensity physical activity however by age 15, fewer children achieved these guidelines, particularly girls (62%).

**Gender differences in physical activity**

With previous research supporting the decrease in physical activity levels as children get older, particularly during adolescence, there is also evidence that this decline is greater for girls than boys (Sallis, Prochaska & Taylor, 2000). It has been commonly reported that boys are more physically active than girls, even from an early age (Garcia, Broda, Frenn, Covik, Pender, & Ronis, 1995; Sarkin, MacKenzie & Sallis, 1997; Ernst & Pangrazi, 1999; Hovell, Sallis, Kolody & McKenzie 1999). There have also been reported gender differences, favouring boys, in engagement of moderate - vigorous intensity physical activity (Trost et al., 1996; Trost et al., 2002; Finn, Johansen & Specker, 2002; Riddoch et al., 2004).

In younger children, a meta-analysis of 127 studies revealed that boys are more active than girls at every age level (Eaton & Enns, 1986). Finn, Johansen and Specker (2002) used accelerometers to measure percentage of time spent in vigorous activity and mean activity levels for children 3 to 5 years old. Boys spent a significantly higher percentage of time in vigorous physical activity (5.2%) compared to girls (4.5%), and boys also had significantly higher average daily
activity levels than girls. In a preschool study involving 3- to 5-year-olds, Pate, McIver, Dowda, Brown and Addy (2008) observed that boys were more likely than girls to engage in MVPA and 3-year-old boys were more active than 4- and 5-year-old boys but there was no difference across age amongst the girls.

In a group of fifth grade students, Trost et al. (1996) reported that girls had significantly less participation in moderate and vigorous physical activities (MVPA). Using accelerometers with Australian children, Telford et al. (2005) found that, in particular for VPA, there were significant gender differences apparent even at 5 and 6 years old. Trost et al. (2002) compared the gender gap for moderate physical activity (MPA) versus vigorous physical activity (VPA) and found that for daily VPA, the average gender gap was substantial. Girls had low levels of participation in VPA, in comparison with MPA where the gender differences in participation were quite modest.

These gender differences have also been observed in older children and adolescents as well. From the Australian national survey, for children 9 to 16 years old there were clear gender trends for physical activity. Girls reported lower levels of MVPA than boys at every age and boys spent more time playing organised sport which could be a reason for their higher levels of MVPA (Commonwealth Department of Health and Ageing, 2007). In a school-based physical activity intervention to help children lead active lifestyles, Ernst and Pangrazi (1999) also found that 9-, 10- and 11-year-old boys reported higher levels of physical activity than girls. Riddoch et al. (2004) found boys were more active at both 9 and 15 years old in time spent in moderate intensity activity and in a study of 11 to 18 years old in Northern Ireland, boys reported significantly more minutes of physical activity at all ages (Riddoch et al., 1991).

Both Thompson et al. (2003) and Sherar, Eslinger, Baxter-Jones and Tremblay (2007) reported boys recorded significantly greater physical activity levels than similarly aged girls. However when physical activity was aligned on maturity, gender differences disappeared, suggesting physical maturity may be linked to adolescent decline in physical activity. They speculated that because on average girls mature earlier than boys and reach every maturity milestone earlier, this may explain why
the decline in adolescent physical activity occurs earlier in girls than boys. Kohl and Hobbs (1998) also suggested gender differences in participation may be related to differential development of motor skills, differences in body composition during growth and maturation, and greater socialisation toward certain sports and physical activities.

Determinants of Physical Activity
With evidence showing that physical activity level declines with age and gender differences are apparent, Sallis, Berry, Broyles, McKenzie and Nader (1995) questioned what factors in early childhood would optimise activity levels in young children and lead them to have a physically active lifestyle in future years. From this question, the underlying conclusion was that physical activity is shaped by a variety of factors and no one variable or category of variables was expected to account for most of the variance in children’s physical activity (Sallis et al., 1992). However, the level of contribution these factors had on physical activity behaviour probably differs at various stages of a child’s development and the interaction of these factors support and enable, or limit, physical activity levels (Sallis, et al., 1992; Hands, Parker & Larkin, 2001).

Whilst there has been much cross sectional exploration into identifying influences on physical activity, there have been several attempts to classify these influences. Sallis et al. (1992) identified four types of factors, biological and developmental factors (such as motor skills and physical fitness), psychological factors (such as self efficacy and attitudes), social and cultural factors (such as race and ethnicity, peer and parental influences), and physical environmental factors (such as geographic locations, access to facilities and programs).

Kohl and Hobbs (1998) then reviewed potential determinants of physical activity but classified them into three different areas: physiological/developmental factors, environmental factors, and psychological, social and demographic factors. Next, Lindquist, Goran and Reynolds (1999) modified Kohl and Hobbs (1998) classification to consider determinants at four levels: the physiological level (factors such as maturation and growth), the psychological level (including motivation, perceived competence), the sociocultural level (including family characteristics and
role models) and the ecological level (including availability of facilities, climate and physical safety). They found that the majority of previous empirical research on child physical activity determinants have focused on psychological influences, whilst sociocultural and ecological determinants had received little attention. They suggested that an understanding of children’s activity patterns would be best accomplished by a hierarchical approach, in which all the determinants are considered at the four levels, resulting in a complete profile of determinants of physical activity among children. Sallis et al. (1992) had also previously suggested variables should be considered “correlates” of physical activity, rather than causal factors.

However, due to difficulty in measuring physical activity in young children, few studies have to date, examined the influences on physical activity behaviour in children younger than 10 years (Ziviani, Macdonald, Jenkins, Rodger, Batch & Cerin, 2005) and most of the studies investigating determinants of physical activity have been cross-sectional.

Therefore, previous models proposed to conceptualise the determinants and factors influencing physical activity have focused predominantly on adults, only a few have been developed for children (Welk, 1999). Welk’s (1999) YPAP model and Stodden et al.’s (2008) conceptual model are two models that focused on children and youth.

**Conceptual Framework**

Youth Physical Activity Promotion model (Welk, 1999)

The predominant framework guiding research on determinants has been social cognitive theory (Bandura, 1986), socialisation behaviour models (Eccles & Harold, 1991), and competence motivation theory (Harter, 1978). Bandura’s (1986) social cognitive theory, suggested that behaviour is influenced by reciprocal relationships between an individual, the social and the physical environments. Social behaviour models are helpful in understanding the mechanisms through which parents influence their children. Competence motivation theory is related to how children develop perceptions of competence and how this relates to motivation and physical activity. Research has expanded to even broader social-ecological approaches to understand activity behaviour (Sallis & Owen, 1997), suggesting that multiple levels of
environmental influence (social, cultural, physical, and institutional) can directly and indirectly influence behaviour. Welk (1999) summarised previous research on determinants on physical activity and developed a simple conceptual framework to facilitate promotion of physical activity in youth (school-age children and adolescents) using a single model. As multiple theoretical approaches had been included as the basis for the construction of the YPAP model, Welk (1999) proposed that this allowed the structures and links among variables to be compared across different, and even competing, theoretical frameworks.

Welk (1999) drew a number of conclusions from his summary of determinant research in children. Firstly, determinants in youth are multifactorial. Secondly, differences in instruments and theoretical orientations influence how various determinants are operationalised and discrepancies in findings may be explained by differences in the way constructs are measured. Overall, the most commonly identified determinants were perceived competence, self efficacy, enjoyment, parental influence and access to programs and equipment.

Welk (1999) then classified the determinants into predisposing, reinforcing and enabling factors of physical activity in youth and proposed links between some of the factors to facilitate subsequent research and promotional endeavours. Predisposing variables included those that collectively increase the likelihood that a person will be physically active on a regular basis, uniting themes of decision making processes and self evaluation. The YPAP model reduced these themes into two fundamental questions: Is it worth it? and Am I able? The first component (Is it worth it?) included both cognitive (attitudes, perceived benefits of physical activity) and affective (enjoyment of physical activity, interest in physical activity) variables. The second component (Am I able?) included variables such as perceived competence, self efficacy, and physical self worth (Welk, 1999). Within the model, he linked these two components together, suggesting children usually value what they are good at doing and pursue things they value.

Reinforcing factors included variables that reinforce children’s physical activity behaviour. This domain included determinants primarily from the social/family categories such as peer, family, and coach influences. These factors are linked to the
two predisposing components of Am I able? and Is it worth it? Enabling factors were variables that allow youth to be physically active. This included determinants from the biological category, including physical skills, fitness and body fat, and environmental category, such as access to parks and community programs. Welk (1999) linked the enabling factors to the predisposed component of Am I able? suggesting that fitness, skills, access and environment effect perceptions of competence and self efficacy.

Demographic factors are at the foundation of the YPAP model, because they directly affect how a particular individual will incorporate various influences within the enabling, predisposing and reinforcing factors. Demographic factors included age, gender, ethnicity/culture and socio-economic status.

One of the key propositions in Welk’s (1999) conceptual model is that whilst direct effects of factors such as AMC and skills on activity behaviour are possible, indirect effects through children’s perceived competence are perhaps more likely. Previous literature suggests that children’s perceptions may be more important than actual competence (Welk, 1999). It is important to note however, that Welk (1999) does not attempt to specify age within his model.

*Developmental Mechanisms influencing Physical Activity Trajectories of Children (Stodden et al., 2008)*

Stodden et al. (2008) conceptualised the underlying determinants of physical activity in children in a different manner to Welk (1999). They proposed that the development of actual motor competence is the primary underlying mechanism that promotes engagement in physical activity. Their model is offered within the confines of limited research on the development of physical activity behaviour which they believe is from a lack of

a) interdisciplinary and developmental approaches, b) consideration that motor skill competence plays a significant and varying role in supporting physical activity behaviours, c) understanding of how perceived motor competence, physical fitness and obesity, act as mediating variables, and have different associations to physical activity across developmental time, and
d) appropriate measures of motor skill competence in previous studies (p. 290).

In contrast to Welk (1999) who focused on the importance of PMC, Stodden et al. (2008) see AMC as the primary underlying determinant in encouraging or discouraging children’s physical activity engagement. They also contend that the relationship between AMC and physical activity strengthens over time, but is mediated by other factors, including PMC. Of interest, Welk (1999) also noted that children need to master a variety of physical skills to participate in different activities. Welk’s (1999) model, as well as previous research findings that motor skill competence is foundational to engagement in physical activity (Seefeldt, 1980; Clarke & Metcalfe, 2002), forms the basis of Stodden et al.’s (2008) conceptual model. The Stodden et al. (2008) model also included the role of health-related fitness and the risk of obesity as an outcome, however the focus for the current study is their proposed development of relationships between PMC, AMC and physical activity.

Stodden et al. (2008) suggested that in early childhood, physical activity might drive development of motor competence. As young children display variable levels of physical activity due to different experiences and the influences of many environmental influences, they hypothesised that AMC and physical activity will be weakly related. As children transition into middle and late childhood, the relationship between AMC and physical activity will strengthen from individual and environmental constraints compounding over time.

Perceived motor competence is the mediating variable that differentially influences the developing relationship between AMC and physical activity (Stodden et al., 2008). PMC is not strongly correlated to AMC or physical activity during early childhood, however from early to middle childhood, children shift to higher levels of cognitive development and can compare themselves more accurately to their peers. This shift will mean children who have lower AMC will demonstrate lower PMC and will therefore be less physically active. Children with higher PMC and AMC will be more likely to persist in physical activities.
In summary, both Welk (1999) and Stodden et al. (2008) identified a lack of understanding of developmental changes in determinants and subsequent relationships with physical activity, however they independently stressed the importance of PMC and AMC in influencing physical activity behaviour. Stodden et al. (2008) also contended that the shift from early to middle childhood is an important transition for the development of the relationship between AMC, PMC and physical activity. The ages of the key transition phases between early to middle childhood suggested by Stodden et al. (2008) are not specified, so the focus on the 6-to 9-year-old groups in this study will test this component of the model. Of importance, neither conceptual model addressed the potentially different developmental trends of young boys and girls.

Conceptual Framework for the Present Study
The conceptual framework for the current study (Figure 1) has evolved from concepts and ideas regarding the influence of PMC from Welk’s (1999) model, and the influence of AMC from Stodden et al.’s (2008) model. It also incorporates two of the levels of determinants, the physiological (AMC) and psychological (PMC) levels, proposed by Linquist, Goran and Reynolds (1999). The current study will test our own conceptual model to determine the impact and interactions of age and gender, perceived and actual motor competence on physical activity in young children.

As part of the focus on these specific determinants, the current study also recognises that these interacting relationships are embedded in and influenced by other contextual factors (for example, environment, family, peers, culture, and nutrition) (Stodden et al., 2008). Information about children’s choices of play will be gathered to provide contextual information that may help explain or expand on the findings (Refer to Figure 1).
Figure 1. Conceptual framework for the current study, adapted from Welk’s (1999) and Stodden et al.’s (2008) models and physiological and psychological levels of physical activity determinants (Lindquist, Goran & Reynolds, 1999).

The present study analyses the interaction between PMC and AMC and their dynamic and developmental relationship with physical activity and each other, through the longitudinal research design. In the proposed conceptual framework (Refer to Figure 1), the personal demographics of age and gender impact the separate development of AMC, PMC and physical activity and their relationships with each other across time. These variables need to be considered within a number of contextual factors (such as type of play choices), that may influence the development
of competencies and activity levels differently for boys and girls in the early years. The following review of the relevant literature identifies key findings that relate to the overall conceptual framework of the study and the importance and rationale for selecting these two factors.

_Perceived Motor Competence_
Perceived competence is an individual’s awareness of their level of ability to perform a task or activity (Rudisill & Mahar, 1993). Perceived competence has been theorised as having an effect on achievement motivation. Specifically, the motive to participate or continue participation may be mediated by an individual’s perception of competence towards a task or activity (Ulrich, 1987). White (1959) introduced the concept of competence and its potential effect on motivation by suggesting that feelings of competence, efficacy, pleasure and joy are experienced when performance outcomes are positive. The extent that these experiences generate such feelings, then serve to motivate the individual and increase persistence.

Harter (1978; 1982) expanded White’s motivational theory, proposing a motivational framework in which perceived motor competence and actual competence were emphasised. Rather than being a global construct, Harter (1978; 1982) viewed perceived competence as specific to the cognitive, physical and social domains. She proposed that individuals who perceive themselves to have high competence in a particular domain, combined with internal control, will be more intrinsically motivated in that domain. These perceptions of competence will encourage effort, persistence and high achievement. Other motivational theorists such as Bandura (1977; 1986), Nicholls (1976; 1984) and Weiner (1985) also supported this notion of the importance of persistence and self efficacy in performing and maintaining performance.

With regards to perceptions of motor competence in the physical domain, Harter (1978) predicted that those who perceive themselves highly competent at an activity or skill will persist longer and continue to attempt to master the skill. In contrast, children with low competence, will have lower perceived motor competence, and will not persist and therefore lose interest in the activity or skill. Harter’s (1982) competence motivation theory has been confirmed by research investigating children
and adolescents’ experiences in the physical domain. The theory is receptive to developmental change by considering individual differences within stages of development (Raudsepp & Liblik, 2002).

Harter (1978; 1982) also highlighted that actual competence plays an important role in a child’s motivation although she believed that its influence was not as strong as perceived competence in these early years. She argued that if a child is unaware of actual competence, abilities may be over or under estimated, meaning perceived competence does not accurately match actual competence. Over-estimation may lead to unrealistic expectations of success despite a difficult task and unsuccessful outcomes. According to her theory, experiencing failure when a task is not perceived as difficult will result in lower perceived competence. A child who underestimates actual competence may have lower expectations for future competence, thus negatively influencing performance outcomes and motivation (Harter, 1978; 1982).

This framework provided the basis for the Perceived Motor Competence Scale (Harter, 1982) which measures children’s self perceptions of their own ability in three domains; cognitive, social and physical. The physical domain focused on the sports and outdoor games. Harter (1982), Harter and Connell (1984), Harter and Pike (1984), and Ulrich (1987), all used the Perceived Motor Competence Scale to assess children’s ability to predict their own physical competence. The findings from these studies will be reviewed later in the chapter when looking at the relationship between PMC and AMC.

In assessing such measurement tools, Ulrich (1987) argued that for greater accuracy in assessing children’s perceived and actual competence for physical abilities, the motor competence tasks and perceived competence items should match. Further, to enhance validity, the chosen motor tasks should relate to motor activities which are familiar and that children frequently undertake.
Relationship between perceived motor competence and physical activity.

There has been an increased interest in determining the influence of different self perceptions on health-related behaviour in children and adolescents. To date, research has primarily examined the predictive capability of self perceptions on physical activity in children 9 to 14 years old. Little is known about younger children.

Raudsepp, Liblik and Hannus (2002) used the Children’s Physical Self Perception Profile (CPSPP) to examine the relationship between self perceptions, physical activity and fitness in Estonian children 11 to 14 years old. All the scales in the CPSPP (sport competence, body attractiveness, physical conditioning, physical strength) were significantly but moderately related with physical activity and fitness in boys and girls. Using multiple regression analysis, the best predictors of higher levels of MVPA and physical fitness in boys and girls were higher perceptions of competence in sport/athletic, strength and self worth. Crocker, Ecklund and Kowalski (2000) also used the Physical Self Perception Profile (PSPP), to develop physical self perception models based on the four profile domains and general self worth to predict physical activity in children 10 to 14 years old. All physical self perceptions domains were weakly correlated with physical activity in girls ($r = .026 - .047$) and boys ($r = .028 - .048$). Using structural equation modelling, the physical self perception models were able to predict 27 - 29% of the variance of physical activity in both boys and girls across ages. Carroll and Loumis (2001) studied the relationship between perceived competence in physical education and levels of physical activity in 10- and 11-year-old boys and girls. They found that those children who perceived themselves as more competent in physical education would participate in more physical activity than those who perceived themselves to be less competent.

Davison, Symons and Birch (2006) examined perceived athletic competence, parental support and physical activity in girls 9 to 11 years old. At each age, girls who were more physically active reported higher levels of perceived competence and parental support. In longitudinal associations, higher perceived competence at 9 years of age, predicted higher levels of perceived competence and physical activity levels at 11 years of age.
Barnett, Morgan, van Beurden and Beard (2008) investigated whether perceived sports competence acted as a mediator between motor proficiency developed in early childhood and subsequent physical activity and fitness in adolescence. Motor proficiency was determined in a sample of 8- to 12-year-old school children. In a follow up study 6 years later, the participants completed the Adolescent Physical Activity Recall Questionnaire (APARQ) and PSPP for perceived sports competence. Results revealed that for both teenage males and females, proficiency in object control motor skills (kicking, throwing, striking) as a child was important in developing high self perceptions in the sports domain, and combined to increase physical activity levels as an adolescent. Childhood locomotor proficiency did not predict perceived sports competence, or physical activity and fitness.

Given the building evidence that few studies have examined the relationship between perceived competence and physical activity, particularly in younger children, further investigation into the development of this relationship is warranted. Researching the earlier years would appear critical in establishing pathways for physical activity across the lifespan.

**Actual Motor Competence**

Actual motor competence is defined as an individual’s capability to master physical skills and movement patterns that enable enjoyable participation in physical activities (Castelli & Valley, 2007). In the early childhood years, children develop competency in basic skills known as fundamental motor skills (FMS). Early competence in these skills is an important indicator of typically developing childhood and has the potential to create a healthy habit of physical activity participation as they mature (Garcia, Garcia, Floyd & Lawson 2002; Mandich & Polatajko 2003).

Two models of motor development have emphasised the importance of motor skills in later physical activity (Seefeldt, 1980; Clark & Metcalfe, 2002). Seefeldt (1980) suggested that competency in motor skills was critical to break through a hypothetical “proficiency barrier” that would assist children applying these motor skills to sports and games. He proposed a “critical threshold” of motor skill development, above which children will be active and successfully engage in lifetime physical activities. Those children below the threshold would be less successful and
ultimately drop out of physical activities. Clarke and Metcalfe (2002) proposed that the phase when children developing mastery in FMS represented the “base camp from which children would climb up the mountain of motor development to achieve context-specific motor skills and participate in subsequent activities” (p.176). Children may follow different developmental pathways of skill competence and physical activity based on environmental opportunities and individual constraints. Based on these models, important research has investigated the association between fundamental motor skills and activity levels in young children.

Relationship between actual motor competence and physical activity
With fundamental motor skill competence shown to be essential for the development of more complex combinations of skills and physical activities, researchers have sought to determine the influence of motor competence on physical activity behaviour and if it might predict physical activity choices in later life, particularly during adolescence.

Firstly examining younger children, the relationship between physical activity and motor competence appears tenuous. Saakslahati et al. (1999) found that physical activity was significantly linked to fundamental motor skills (running and walking speed, standing broad jump, throwing and catching) in 3- to 4- year-old children. Although significantly related, the correlation coefficients for these skills and relationship to high level of physical activities and very active outdoor play were low ($r = .05 - .21$). Fisher et al. (2005) also reported a weak but significant relationship ($r = .10$) between objectively measured physical activity and fundamental motor skills in preschool children. Specifically, children who spent more time in moderate-vigorous physical activity had higher fundamental motor skills ($r = .18$).

Similarly, Butcher and Eaton (1989) examined the relationship between motor skill proficiency and free play and activity behaviour in 5-year-old preschool children. They found that free play behaviour and motor activity levels were significantly related to aspects of motor proficiency such that children who engaged in more active play also had more proficient motor skills, particularly running. Ulrich (1987) also reported a significant relationship between movement competence and physical activity, mainly organised sports participation in children from 5 to 10 years old.
Wrotniak, Epstein, Dorn, Jones & Kondilis (2006) investigated children’s level of motor proficiency. The results of the study revealed that motor proficiency was positively associated with physical activity. Children in the highest quartile of motor proficiency were the most physically active and spent more time in MVPA than children in the lower quartiles. For motor proficiency tasks, 8- to 10-year-old boys ran faster, threw a ball at a target more successfully and had greater response speed than girls of the same age. Castelli and Valley (2007) examined the relationship of physical fitness and motor competence to physical activity in children 7 to 12 years old. Motor competence was assessed by performance on 13 criteria across three modified sport activities: basketball skill which involved dribbling and passing, striking a ball with a hand paddle, and throwing a baseball overarm. Physical activity was significantly predicted ($p < .01$) by total motor competence score in the sample, indicating that those who had higher levels of motor competency had higher levels of physical activity.

Raudsepp and Pall (2006) studied the time spent in outside-school physical activity and fundamental motor skills in primary school children with a mean age of 8 years. Through qualitative assessment they examined the developmental level of overhand throw and standing long jump and the correlation with two categories of physical activity - skill specific activity and overall physical activity. Results revealed that levels of throwing and jumping were related with skill-specific physical activity but not with general levels of physical activity.

In exploring the link between childhood motor competence and teenage activity levels, Barnett, van Beurden, Morgan, Brooks and Beard (2008) looked at locomotor and object control motor skills in children and considered whether this was related to physical activity participation in adolescence. As adolescents, they completed a physical activity questionnaire (APARQ) to record type, duration, frequency and context of activities. Adolescent time spent in MVPA and organised activity was positively associated with childhood object control proficiency. Similarly, McKenzie et al. (2002) also examined childhood movement skills and physical activity levels in adolescence. Balance, agility, eye-hand coordination in a bi-ethnic cohort were measured at ages 4, 5 and 6 years. Habitual physical activity was assessed through 7
day recalls when the children were 12 years old. Results revealed that the measures of these three movement skills did not predict physical activity at the age of 12 years.

Okely et al. (2001b), in a study of adolescents with a mean age of 13 years (Grade 8) and 15 years (Grade 10), examined the relationship between fundamental movement skills and time spent in organised and non-organised physical activity. They found fundamental movement skills significantly predicted time in organised physical activity although it only explained a small percentage (3%) of the variance. This prediction was stronger for girls than boys although it was not statistically significant. There was also no relationship between fundamental movement skills and time in non-organised physical activity.

Further information can also be found in the literature reporting studies involving children with low competence. Children with diagnosed severe movement difficulties and coordination problems, mainly Developmental Coordination Disorder (DCD), find performing and learning motor skills difficult. Their level of motor skill is very low therefore they cannot successfully participate in sports and activities with their peers. Another key issue surrounding movement dysfunction is that children are unable to perform the required actions of daily living in a culturally accepted way (Savelsburgh, Davids, Vander Kaup & Bennett, 2003).

Children with DCD tend to be vigorously active less often, play less on large playground equipment and spend less time interacting socially with their peers (Butcher & Eaton, 1989; Bouffard, Watkinson, Thompson, Dunn & Romanow, 1996; Smyth & Anderson, 2000). Bouffard et al. (1996) found that children with movement difficulties were significantly less active than their peers. They were vigorously active 15.1% of recess time at school compared to 23.7% for children without movement difficulties.

Individuals with movement difficulties more often have negative experiences and are therefore less likely to participate in movement opportunities. Ultimately low motor competence, minimal enjoyment in physical activity settings, and social difficulties within movement situations lowers interest in physical activity and lowers participation levels (Bouffard et al. 1996).
It is evident both AMC and PMC influence physical activity in children and adolescents, however it appears age is a factor in the strength of these relationships. The following section will review the literature on the relationship between AMC and PMC and any developmental trends for boys and girls.

*Gender differences, Age trends and the Relationship between Actual Motor Competence and Perceived Motor Competence*

In one of the few studies involving younger children, Goodway and Rudisill (1997) assessed 4-year-old African American children who were at risk of school failure and/or developmental delay. They used Harter and Pike’s (1984) Pictorial Scale of Perceived Competence and Social Acceptance (PSPCSA) to measure perceived physical competence, and Ulrich’s (1985) Test of Gross Motor Development (TGMD) to assess total AMC, locomotor competence and object control competence. Low correlations were found between perceived physical competence and locomotor ($r = .03$), object control ($r = .18$) and total motor competence ($r = .12$). It was concluded that this sample of young children were poor at perceiving their motor skill competence as they recorded high perceived competence scores and low actual motor competence scores. There were also no gender differences for perceived physical competence scores but when assessing motor competence, boys had significantly higher object-control skills than girls ($p < .00$).

In older children, Rudisill, Mahar and Meaney (1993) used the Motor Skill Perceived Competence Scale to examine age and gender trends within PMC, and the relationship with AMC in 9-, 10- and 11-year-olds. Actual motor competence was measured on a series of gross motor tests which focused on lower body (50 metre run, shuttle run and standing broad jump) and upper body skill (over arm throw). They found that while boys recorded higher PMC scores than girls there was no difference in PMC scores between age groups. Boys had significantly higher overall total AMC scores and also higher upper body AMC scores compared to girls. Overall, both lower body and upper body AMC had a significant relationship with PMC and when all ages were included in the analysis, the correlation coefficient increased.
Raudsepp and Liblik (2002) also assessed the relationship between perceived and actual motor competence in 10- to 13-year-old boys and girls. The Children’s Physical Self Perception Profile (CPSPP) was used to assess PMC, whilst they assessed AMC through fitness measures which included the shuttle run, sit-ups completed in 1 minute, and the sum of five skinfolds. Boys recorded significantly higher actual motor scores compared to girls. They found that boys had significantly higher perceived competence scores than girls and that relationships between PMC and the three actual motor competence factors whilst significant, were only moderately related.

Harter (1982; 1984) used the Perceived Competence Scale for Children and examined the relationship between perceived and actual competence in 4- to 12-year-old children. Correlations were low and increasing from ages 4 to 7, but plateaued with a consistent, moderate correlation ($r = .60$) from ages 8 to 12. Ulrich (1987) also looked at perceptions of physical competence and actual motor competence. Girls and boys were given the Pictorial Scale for Perceived Competence (for 5-, 6- and 7-year-old children) or the Perceived Competence Scale for Children (for 8- and 9-year-old children) to measure perceived competence. Motor competence was assessed via 9-items that sample motor abilities (broad jump, flexed arm hang, sit-ups, side-steps, shuttle run) and motor skills (soccer ball dribble, basketball dribble, softball throw and soccer ball throw). Scores for perceived competence were used to classify children into the top, middle and bottom third for their age group. Results revealed that children had relatively accurate perceptions of their motor competence, at least when grouped into the top, middle, or bottom third for self perception scores ($p < .00$). Therefore, children with lower actual competence had lower perceived competence in comparison to their peers with higher actual and perceived competence. No interaction between age, perceptions of competence and motor competence was found.

Rose, Larkin and Berger (1997) investigated how level of coordination influenced the perceptions of competence of 8- to 12-year-old children. They compared perceived competence, using Harter’s (1985) Self Perception Profile for Children, and global self worth between children who were poorly coordinated and children who were well coordinated. They found children with poor coordination had lower
self perceptions of competence and global self worth than their well coordinated peers. Success and failure in the motor domain not only linked to perceptions of competence in the athletic domain but pervaded self perceptions in many aspects of children’s lives.

Whilst there is evidence that AMC and PMC are linked, there is no consensus with regards to age trends, specifically in the development of perceived competence and accuracy of these perceptions. Harter (1982) reported that from about 8 years of age, the accuracy of children’s perceptions of competence improved until around 12 years of age. In contrast, Rudisill, Mahar and Meaney (1993) found that 11-year-olds were no more accurate at perceiving their motor ability than those aged 9 years.

Therefore, when considering why there is a lack of congruency between AMC and PMC in 8-to 11-year-old children, Harter (1978) proposed that competence motivation is based on past experiences, difficulty of the outcome, reinforcement and interaction with significant others and intrinsic motivation. Piaget (1955) believed that by the age of 12 years, children will possess the necessary cognitive ability to combine information such as past experience and challenges of the task, and be capable of an accurate appraisal of their ability to perform a task.

Other researchers have also reported age-related differences for the level of perceived competence. Some studies have shown that children’s level of self-perceptions decreased across the primary school years (Marsh, Barnes, Cairns & Tidman, 1984), with a more rapid decline noted in the upper primary and high school years (Jacobs et al., 2002). Other studies have reported stable perceptions from 8 to 14 years old (Feltz & Brown, 1984), or found increases in levels of perceived competence from primary to high school (Wigfield et al., 1991). Although results are varied, collectively these studies indicated there are age related trends in children and adolescents levels of perceived competence. However, there is a lack of agreement on whether children are becoming more or less confident as they get older and at what age these changes in perceived competence occur (Weiss & Amorose, 2005).

To summarise, previous studies examining the relationship between perceived and actual motor competence have focused on 8- to 12-year-old children and have
reported that within this age group children are only moderately accurate at perceiving motor competence. There is evidence that suggests congruency between AMC and PMC increases with age (Harter & Connell, 1984; Harter & Pike, 1984; Rudisill, Mahar & Meaney, 1993; Raudsepp & Liblik, 2002). However, the developmental trends of the relationship between PMC and AMC for children younger than 9 years old have been largely ignored.

Where reported, gender differences are also an important issue. Boys have significantly higher levels of PMC and AMC compared to girls, however the focus of studies again has been on children 9 years of age and older (Rudisill, Mahar & Meaney, 1993; Raudsepp & Liblik, 2002). Whilst the influences of AMC and PMC on physical activity have been established in this review of the literature, again little is known about what happens for children in the early primary years in 5- to 9-year-olds and there is a lack of developmental knowledge about the trends of these relationships. Therefore, as it is apparent that this is a crucial time in the development of actual and perceived competence and physical activity behaviours, the current study seeks to provide empirical evidence about the younger age groups for boys and girls regarding the development of physical activity and influences of AMC and PMC.

The final section of the review is related to measurement of AMC, PMC and physical activity, an important issue as there is an extensive range of assessment tools for these key variables and protocol varies in the assessment of AMC, PMC and physical activity across the literature.

Assessment of Physical Activity
Accurate and valid measures of physical activity are important to fully understand young children’s true activity levels (Hands, Parker & Larkin, 2006). Young children’s movement patterns are highly variable, non-structured and generally comprise of short frequent bursts of moderate to vigorous activity (Sallo & Silla, 1997).

Many methods for measuring physical activity in children have been trialled, however, debate continues as to the most appropriate. These include direct
observation, motion sensors, heart rate monitors, doubly labelled water, indirect calorimetry, proxy measures such as teacher and parent ratings, and self report measures (Baranowski, Simons-Morton, Wilson & Parcel, 1989; Noland, Danner, Dewalt, McFadden & Kotchen, 1990; Trost & Brown, 2000; Trost et al., 2000).

**Direct observation**

Direct observation methods usually involve time sampling and are most appropriate for relatively short observation periods and with small sample sizes (Freedson & Melanson, 1996). Direct observation is able to provide contextually rich data about the environment and is often used to validate other methods of assessment (Freedson & Melanson, 1996). Due to its convenient and inclusive nature, it is often considered a ‘criterion’ measure of physical activity in young children (Sirard & Pate, 2001).

Bailey, Olson, Pepper, Parszasz, Barstow and Cooper (1995) used the Fargo Activity Timesampling Survey (FATS) to assess the duration, intensity and frequency of physical activity in children. The child’s behaviour is coded across a number of categories of children playing freely and observations were recorded every 3 seconds over a 4 hour period. They found that the direct observation method was able to capture the social and physical context of the activity and also provide measures of the duration, intensity and frequency of a specific activity. Oliver, Schofield and Kolt (2007) listed two of the strengths of direct observation as it is relative unobtrusive to children and non-reliant on parents’ or teachers’ ability to recall physical activities of the children involved in the study. There is also limited response burden on the child and direct observation can also be used in a variety of settings (Hands, Parker & Larkin, 2006).

However, the direct observation method can also be time consuming for the observer, labour intensive, expensive and impractical for repeated monitoring of large numbers (Hands et al., 2006; Oliver et al., 2007). DuRant, Baranowski, Davis, Thompson, Puhl, Greaves and Thompson (1993) used the Children’s Activity Rating Scale (CARS) as a partial time sampling approach to code child behaviour and they also noted the importance of observer training as diligence and accuracy is essential.
**Self report**

The most widely used assessment technique with older children and adults is self reporting of physical activity through questionnaires or activity diaries (Freedson & Melanson, 1996). Ease of administration, convenience, the ability to characterise the activity and low costs are primary advantages of this method (Freedson & Melanson, 1996).

It is generally not appropriate to use this method for children under 10-years-old as their ability to reliably recall activity is limited (Baranowski, 1988; Manios, Kafatas & Makakis, 1998; Welk, Corbin & Dale, 2000). Young children have difficulty remembering what they have done and have problems with estimating the duration and intensity of the activity (Cale, 1994; Crocker et al. 1997; Curtis-Ellison et al., 1992).

**Proxy report**

As children under 10 years old are not able to provide reliable information about their physical activity, an alternative strategy is to use proxy reports from parents or teachers. The advantages of the proxy report method is that it is relatively inexpensive and quick to administer (Hands, Parker & Larkin, 2001).

Manios, Kafatos and Markakis (1998) validated two forms, 5 day teacher report and 3 day parent report, against heart rate in 6-year-old children. Significant correlations were reported between proxy measures and corresponding heart rate data for school and home. However, Manios et al. (1998) noted that it cannot be assumed that the parents or teachers will provide appropriate or reliable information. Fulton et al. (2001) also suggested that interpretation of questions may vary between parents and teachers and this method is not usually appropriate for measuring unplanned or unstructured physical activity.

**Heart rate monitors**

The use of heart rate monitors to quantify physical activity is based on the understanding that heart rate is linearly related to energy expenditure (Freedson & Melanson, 1996). Heart rate monitors are accurate in assessing the duration and intensity of exercise, provide a continuous record of physical activity for extended
periods of time and permit almost total freedom of movement (Hands, Parker & Larkin, 2006).

However, other factors such as type of exercise, movement efficiency, fitness level and stress can affect heart rate. It is often assumed that children who spend longer time with a high heart rate are more active than those children with a lower heart rate but this assumption is not correct with less efficient movers may record a higher heart rate when performing the same task as an efficient mover (O’Beirne, Larkin & Cable, 1994).

Accelerometers

Accelerometers measure motion in a 3-D axis based on the deflection of a piezoelectric plate inside a watch sized monitor and can be secured to the hip (Oliver et al., 2007).

Ott, Pate, Trost, Ward and Saunders (2000) assessed the CSA uniaxial accelerometer and the Tric Trac triaxial accelerometer using heart rate telemetry as the criterion measure. Validation of the accelerometers was determined with respect to their ability to measure free-play activities of different intensities in children 9 to 11 years old. High correlation coefficients were found between the Tri Trac accelerometer and heart rate monitor ($r = .073$) during physical activity of different intensities. Correlations between CSA accelerometer and heart rate were also significant but slightly lower ($r = .64$). They reported that accelerometers were an appropriate assessment tool for measuring children’s free-play activity. However, it has been reported that whilst the uniaxial accelerometer is small and lightweight, the triaxial is larger, heavier and may be less suitable for studies with children (Hands et al., 2006).

Some of the disadvantages of the accelerometer that have been suggested also include the cost of using the accelerometer in larger research studies, and data produced is difficult to interpret because all movement is captured and information is provided on the intensity of the activity but not the duration of bouts of physical activity against incidental movement (Curtis-Ellison et al., 1992; Bailey et al., 1995; Hands et al., 2001; Oliver et al., 2007).
Pedometers

Pedometers are another form of motion sensor that also provide valid assessments of total volume of physical activity. These simple, electronic devices measure each vertical movement or step as a count. The quantity of physical activity, therefore, is determined by the number of steps or count taken over a period of time (Hands et al., 2006).

Disadvantages of the pedometer include the inability to measure the intensity of the activity or record activity while cycling, swinging or hanging (all common activities in young children). However, recent advances in the design have significantly improved the accuracy (Bassett et al., 1996), validity (Eston, Rowlands & Ingledew, 1998; Kilanowski, Consalvi & Epstein, 1999; Bassett et al., 2000), and reliability (Gretebeck & Montoye, 1992).

Hands et al. (2006) compared measures of physical activity derived from accelerometry, pedometry and direct observation in 5- and 6-year-old children. High correlations were reported between all measures indicating that the simplest method, pedometry, can be validly used to measure physical activity with this age group.

Other advantages of the pedometer include low cost, ease of interpretation, social acceptability and comfort when worn, therefore they are suitable for measuring daily or weekly physical activity patterns (Bassett et al., 1996; Rowlands, Eston & Ingledew, 1997; Welk et al., 2000; Hand et al., 2001; Tudor-Locke & Myers, 2001).

Doubly labelled water

The doubly labelled water method is the most valid and reliable method for measuring energy expenditure (Hands et al., 2001). The method involves monitoring the production of carbon dioxide through the analysis of urine samples, usually over 12 to 21 days. Total energy expenditure can be calculated from standard respiratory gas exchange equations.

Freedson and Melanson (1996) noted that an advantage of this method is its accuracy in producing information on the total daily energy expenditure. However, they also report that this technique is unable to determine the proportion of energy expenditure
required for an activity. The doubly labelled water method is also very expensive and cannot give information on the duration and frequency of specific activities (Bailey et al., 1995; Hands et al., 2001). It has also been noted that energy expenditure is a physiological consequence of physical activity and the two are separate forms. This may limit attempts to use doubly labelled water to validate measures of physical activity as physical activity may cause an elevation in metabolic rate that persists long after the end of obvious movement (Armstrong & Welsman, 2006).

**Assessment of Perceived Motor Competence**

A comprehensive review of instruments used to measure self concept in young children found few assessment tools focused on children’s perceived self efficacy in the motor domain. Only those instruments that included items designed to measure physical abilities have been included in this review. It should be stated, a key issue within the measurement of perceived motor competence is the diversity of measurement tools and definitions by researchers of what perceived competence is. Within different studies measures of self-efficacy, self concept, perceived physical competence and perceived motor competence have all been used to describe self perceptions of samples.

The Piers and Harris Children’s Self Concept Scale (Piers & Harris, 1969) is a widely recognised measurement tool with solid psychometric properties for children 8 years and older. The scale contains 80-test items with a number of items addressing the child’s perception of competence in physical activities. However, the majority of items ask the child to comment more on their role rather than on their perceived efficacy.

The Self Administered Student Profile (Rappaport, Levine, Aufseeser & Incerto, 1983) measures self efficacy in fine and gross motor tasks for children aged 9 years and older. However, the printed items in the test may be read aloud to accommodate the younger child.

The Perceived Competence Scale for Children (Harter, 1982) is a self report instrument designed to assess a child’s sense of competence across the cognitive, social, and physical domains. A fourth sub scale of general self worth, independent
of any particular skill domain, was also included. However, the scale was developed for children and adolescents 8 to 15 years old.

Harter’s (1984) Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984) was designed as an extension of the Perceived Competence Scale for Children (Harter, 1982) and appropriate for children 4 to 7 years old. The pictorial format was devised instead of a written questionnaire, to engage a young child’s interest, sustain a child’s attention, and lead to more meaningful responses. Factor analyses for this scale indicate that cognitive and physical items tend to combine into a single competence factor, which suggest that young children may not be able to clearly distinguish between some of the cognitive and physical aspects of tasks (Missuina, 1998).

Rudisill, Mahar and Meaney (1993) designed the Perceived Motor Competence Scale, valid for children 7 to 12 years old to measure their perceptions when performing motor tasks. Items were designed so the participant circled the number on a 5-point Likert scale of agreement. For example, the first statement is ‘I can...’ and participants must circle either ‘not run fast’ (1) through to ‘run fast’ (5) to indicate what best represents their personal feelings about the statement.

Marsh (1989; 1990; 1991) developed a set of three Self Description Questionnaire (SDQ) instruments (SDQ-I, SDQ-II, SDQ-III) validated on Australian children of differing ages. The SDQ-I was originally designed to measure self concept in 6- to 11-year-old children. Eight sub scales were identified within the questionnaire; physical abilities, physical appearance, relationship with peers, relationship with parents, reading, maths, all school subjects and general self concept. Responses are made on a 5-point true to false Likert scale. Numerous factor analyses established that the SDQ-I factor structure is stable across ages and across gender. Marsh (1991) then evaluated a new, adaptive procedure for using the SDQ-I with children younger than 8 years old. He adjusted procedures for the standard SDQ-I to enable the modified SDQ-I to be administered as an individual interview and found that appropriately measured self concepts are better differentiated by young children than previously assumed.
Prior to Marsh et al.’s (1991) revision, Harter and Pike’s (1984) instrument was the best available instrument for measuring multiple dimensions of self concepts for young children. Marsh et al.’s (1991) results however, suggest that the psychometric properties of the individually administered SDQ-I are stronger, although the length of his SDQ-I is considerably longer (64 items) compared to Harter and Pike’s (1984) instrument (24 items). However, it is generally better to use a shorter instrument with young children given their attention span, but Marsh et al. (1991) found that the items at the start of the questionnaire were least effective. They interpreted this to mean that younger children took longer to discover how to respond appropriately to the questions asked. They labelled this a practice effect, and concluded that a longer instrument for assessing younger children may be appropriate giving them practice and time to express their cognitive structures that already exist.

Furthermore, Harter and Pike’s (1984) instrument had not been previously validated with children at any age which means comparison of responses to their instrument and comparison of responses to different instruments by older children may differ because of the age of the children or differences in the instrument. As the SDQ-I has been well validated with young Australian children 5 to 8 years old, and the availability of Marsh’s (1988; 1989) previous research, future comparisons of perceived competence scores of Australian children are possible.

Assessment of Motor Competence

One of the key issues within the measurement of motor competence is that again there are a number of proxy measures to assess motor development, motor competency and motor proficiency. Often it is the researcher’s definition of motor competence that identifies which measure they will use for their study. Another important issue is that many of the motor skill tests used with Australian children have been developed overseas.

The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978), McCarron Assessment of Neuromuscular Development (MAND) (McCarron, 1982) and the Test of Gross Motor Development (TGMD) (Ulrich, 1985; 1999) are examples of American tests designed to assess motor development. The Movement Assessment
Battery for Children (Movement ABC) (Henderson & Sugden, 1992) is an English test designed as a means of identifying those with (and at risk of) motor impairment.

The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) assesses the motor functioning of children 4.5 to 14.5 years-old. The test consists of eight sub tests (running speed and agility, balance, bilateral coordination, strength, upper limb coordination, response speed, visual motor speed, upper limb speed and dexterity), with a total of 46 separate items that provide a comprehensive index of motor proficiency as well as separate measures of both gross and fine motor skills.

The McCarron Assessment of Neuromuscular Development (McCarron, 1982) is intended to be a standardized and quantitative method of assessing psychomotor skills and is also useful for the identification of DCD in children. The MAND consists of 5 gross and 5 fine motor tasks and the scaled scores for the 10 tasks are summed and converted to a Neuromuscular Development Index (NDI). The NDI is based on a distribution mean of 100 and a standard deviation of 15, NDI values of 70-85 may constitute a mild disability; 55-70, a moderate disability; and values below 55 may represent a severe disability. One of the disadvantages of the MAND is that it does not assess ball skills within the motor tasks.

The Test of Gross Motor Development (TGMD) (Ulrich, 1985; 1999) provides norm and criterion-referenced interpretations of 12 gross motor skills. Ulrich (1985; 1999) placed great emphasis and priority on the gross motor skill sequence rather than the product of performance. Two sub tests assess locomotor (run, gallop, hop, leap, horizontal jump, skip and slide) and object control (strike, stationary bounce, catch, kick and overhand throw) skills. Each skill is assessed against performance criteria and the child is scored with 1 if the criterion is present and 0 if the criterion is not present during performance of the skill. The raw score for each skill is calculated by the sum of the performance criteria achieved during performance of the skill. The sub test (locomotor and object control) scores are summed and these raw scores are converted to percentiles and standard scores. Finally, the gross motor skill score is determined by combining the standardised sub test scores and transformed into the Gross Motor Development Quotient which provides a guide of how the child has performed based on descriptions from very poor to very superior.
The Movement Assessment Battery for Children (ABC) comprises a teacher’s checklist, a standardised test and a set of guidelines for intervention (Smits-Engelmen, Henderson & Michels, 1998). The 32 items included in the test battery are divided into four sets of eight tasks, with each intended for use with children of specific ages. The first set is designed for children aged 4 to 6 years, the second with children aged 7 to 8 years, the third for children aged 9 to 10 years and the fourth for children 11 years and older. Within each band the structure of the test is identical, all children complete three items involving manipulative skills, two items requiring the child to catch and throw a bean bag or small ball and three items which assess static and dynamic balance (Smits-Engelmen, Henderson & Michels, 1998). The raw scores for each task are converted to scaled scores to ascertain the child’s performance in relation to the standardisation sample. Total scores falling below the fifth percentile are considered indicative of a definite motor problem, while scores between the fifth and fifteenth percentile suggest a degree of motor difficulty that needs further monitoring.

Significant differences between results for the same motor skill test have been reported between Australian and English children (Erhardt, McKinlay & Bradley, 1987) and American children (Larkin & Parker, 1995). The standardisation sample needs to reflect the same characteristics of the population being tested and whilst the contribution of factors to observed differences remains unclear, tests developed from another culture may be irrelevant for another (Hands & Larkin, 1998). There is a lack of comprehensive tests of motor proficiency and motor skills suitable for Australian children. While most of the earlier tests developed were quantitative, there has been a more recent trend towards assessing movement qualitatively using criterion-referenced approaches (Hands & Larkin, 2001). Some of the advantages of quantitative tests that have been listed are that they are more objective may be less time consuming, more reliable, and easier to transform into a score than qualitative assessments. Quantitative measures, while providing a score that represents the child’s motor skill status, do not, however, provide direct information as to the level of proficiency of the skill (Branta, Haubenstricker & Seefeldt, 1984). The few quantitative tests that were developed for Australian older children (Calder, 1979; Jeanes, 1988) are now out of print and generally not available.
Qualitative tests provide information as to how the child performs a particular motor skill often via observation checklists and were recently developed by the Victorian (1996), Tasmanian (1997), New South Wales (2000) and Western Australian (1997; 2001) Education Departments. The Tasmanian checklists are more general than the Victorian and Western Australian assessments. Important skill components are identified but the child is simply graded on a three point scale; ranging from attempting the skill to developing to proficiency (Hands & Larkin, 2001).

The Victorian Education Department’s (1996) protocol is based on scoring six skill components and then classifying the performance as mastery or near mastery. Near mastery of the skill is achieved if five of the six components are present and mastery is achieved if all six of the components are present. The VICED (1996) tool presented tabulated data for each skill, indicating the age at which each component could be expected to be mastered. The New South Wales Education Department’s (2000) resource “Get Skilled Get Active” was derived from the earlier NSW Schools and Fitness and Physical Activity surveys protocol (Booth et al., 1997) and VICED (1996) assessment tool. The NSW resource again specifies a battery of fundamental movement skills, eight of which were validated against the VICED manual, with a similar scoring system based on mastery and near mastery of skills.

The Education Department of Western Australia’s (EDWA) (1997; 2001) assessment tool is primarily used for assisting teaching of skills and planning for lessons in the school environment. Similar to the VICED, NSW and TGMD assessment tool, components of skills (body management skills, locomotor skills and object control skills) are listed and the participant is assessed based on the presence of different components within the skill. However, at present there are no Western Australian normative data by which to compare performance.

In conclusion, motor skill assessment tools can vary in complexity and qualitative and quantitative protocol. However in most instances, Hands and Larkin (2001) suggested FMS assessment of young children is best undertaken using the checklist qualitative approaches and to maximise reliability and validity of these qualitative tests, extensive tester training and a thorough understanding of motor development is required.
The current research study’s definition and subsequent measurement of AMC was based on qualitative observation of key fundamental movement skills. A pilot project for the development of a Fundamental Movement Skills Quotient was undertaken during the current study in an attempt to validate and quantify movement observations of motor competence assessment for future research. An FMS quotient score was derived from Z-scores of the run, throw and jump skill scores collected from this research and then normed around a mean of 100 and SD of 15 to equate to the NDI from the MAND (McCarron Assessment of Neuromuscular Development). Balance was not included as scores did not discriminate between children this age. For the 10 boys and girls, a mean FMS Quotient for the three skills was 106.54 in comparison to a mean NDI of 105.43. Further expansion on this pilot work will seek to validate the measurement of motor competence through observation of fundamental movement skill criteria. Therefore, the final selection of the EDWA (2001) resource to assess AMC is based on this pilot work, and the number of components available within each skill for assessment, leading to an increased range of possible motor competence scores, and more importantly the potential for greater discrimination between AMC scores between children in this study.

**Conclusion**

Past research has highlighted the important role that, separately, perceived motor competence, actual motor competence and physical activity play in a child’s development. However, whilst some research acknowledges the relationship between perceived and actual motor competence and others acknowledge the separate influence of actual and perceived competence on physical activity in children and adolescence, there is a little known about the developing relationship between perceived motor competence, actual motor competence and physical activity in younger children. Research is needed to identify the importance of motor competence and perceived ability which together create strong foundations for the child who is attracted and motivated towards physically active play and ultimately a healthier lifestyle. The framework for this study has initially drawn on both Welk (1999) and Stodden et al.’s (2008) models, to ultimately test our own conceptual model to explain the developmental nature of the relationship between AMC, PMC and physical activity in children 6 to 9 years old.
CHAPTER THREE

METHODOLOGY

The investigation was a mixed-longitudinal study, designed to track patterns and identify critical periods regarding the contribution of actual and perceived motor competence to physical activity levels in the early primary years between 6 and 9 years of age. For the current study, a single-cohort, multiple age design was employed. A sample of 6-, 7- and 8-year-olds were recruited, and followed forwards for 18 months across four data collection periods at approximately 6 month intervals.

Single-cohort, multiple age studies are complex and challenging to execute. According to Nicholson, Sanson, Rempel, Smart and Patton (2000), recruitment methods and assessment instrumentation for each age groups need to be developed and administered simultaneously, and measurement approaches need to remain consistent across all data collection periods in order to retain comparability across the sample.

This design allows for separate assessments of age effects, time of measurement effects and cohort effects. Measurement of time and cohort effects are minimal, the data from multiple cohorts collected at the same age can be combined to increase sample size and analytic power (Nicholson et al., 2000). The design has the further advantage of providing data on later developmental periods without waiting for a single cohort to mature across the full period of interest. As results are produced more quickly, there is also less concern that theories and instruments will be out of date before the results are available. Importantly, follow up of more than one age group increases the confidence in the generalisability of results (Nicholson et al., 2000). A single sample of 6-, 7- and 8-year-olds were recruited, and followed forwards for 18 months across four data collection periods, approximately 6 months apart.
Sample
The sample for this study comprised children aged 6 to 8 years old from middle socio-economic primary schools located across a geographic spread of the Perth metropolitan area. Based on Socio Economic Indices for Areas (SEIFA) (part of the Australian Bureau of Statistics), twenty schools from middle socio economic areas were invited to participate in the study. Eleven schools agreed to take part in the study.

Both boys and girls from these schools were invited to be part of the study if they were aged 6, 7 or 8 years between January and June 2005, and were of good health status. Children were ineligible if they were medically unfit or suffered from any ill health that prohibited them from participating in physical education classes at school. No specific response rate was obtained as the schools were responsible for the distribution of the research information and invitations to eligible children.

Two hundred and one participants (89 females and 112 males) were initially recruited for the study in November and December 2004. The study was planned based on a continuous response (physical activity step count) dependent variable from an independent group of subjects. In a previous study (Hands & Parker, 2008), the response within each subject group was normally distributed with standard deviation of 2,500 steps. If the true difference in males and females is 2,000 steps, the current study needs 26 male subjects and 26 female subjects in each age group to be able to reject the null hypothesis that the population means of males compared to female groups are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05.

Four data collection periods (February to March 2005 and 2006, and October to November 2005 and 2006) assessed the children across 18 months, with approximately 6 months between each data collection. Attrition was low (2.5%) with one participant withdrawing from the study and four other participants moving schools after the first data collection. Sample size for each data collection cycle varied depending on school attendance on the testing day and complete data set for each participant depended on diligence in returning pedometer diaries for the physical activity measure.
Figures 2 and 3 present the sample breakdown for male and female participants across all four data collection cycles. The figures represent the number of children tested at each data collection cycle. If participants were absent in data collection one (DC1), they were still included in the study for subsequent data collections. Hence, attendance for 8-year-old boys and girls increased from DC1 to DC2 (Refer to Figure 2 and 3). Data collected from the sample at the same age were combined to increase sample size and analytic power during data analysis and reporting of results. For example, when the findings for 7-year-old boys and girls are reported, this refers to 7-year-olds from data collection cycles one and two (DC1 and DC2), and 6-year-olds who turned 7-years-old during data collections three and four (DC3 and DC4). The same applies to the 8-year-olds boys and girls (8-year-olds from DC1 and DC2, and 7-year-olds turning 8 years old in DC 3 and DC4) (Refer to Figure 2 and 3).

<table>
<thead>
<tr>
<th>Age</th>
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<th>DC2</th>
<th>DC3</th>
<th>DC4</th>
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<tr>
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<td>102</td>
<td>99</td>
<td>101</td>
<td>403</td>
</tr>
</tbody>
</table>

*Figure 2. Breakdown of male sample attendance across age and data collection cycles.*


<table>
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<tr>
<th>Age</th>
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<th>DC2</th>
<th>DC3</th>
<th>DC4</th>
<th>Total</th>
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<td>-</td>
<td>-</td>
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<td>77</td>
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</tr>
</tbody>
</table>

Figure 3. Breakdown of female sample attendance across age and data collection cycles.

Measures
The primary instruments for gathering data for this study were pedometers and diaries for physical activity, the Self Description Questionnaire - I (SDQ-I, Marsh, 1988; 1990) for PMC and the Fundamental Movement Skills Teacher Resource Manual (EDWA, 2001) for AMC.

Physical activity
Pedometers (Yamax SW-200) were used to record daily step counts over a 7 day period. Previous research has found the pedometer to be a reliable measure of physical activity in young children (Bassett et al., 1996; Hands, Parker & Larkin, 2006). Schneider, Crouter and Bassett (2004) compared step values of multiple brands of pedometers over a 24 hour period in measuring free living physical activity. They concluded that five pedometers, including the Yamax SW 200, appeared to give similar values for step counts per day and were suitable for applied physical activity research.

Tudor-Locke, Williams, Reis and Pluto (2002) examined convergent validity through correlation between pedometers and self-report physical activity as low to moderate ($r = .0.33$). However, they state that an opportunity exists to study combinations of
objective and subjective measures of physical activity. In a follow up paper, Tudor-Locke, Williams, Reis and Pluto (2004) also provided evidence for construct validity of pedometers to measure physical activity. In a review of previous work, they reported a small inverse relationship between pedometer-determined physical activity and age, and pedometers and body mass index (BMI). The combined evidence of construct and convergent validity provide support for using the simple and inexpensive pedometers in both research and practice. Self-report measures can provide important contextual information not provided by motion sensors and physical activity data may be better interpreted from multiple perspectives (Tudor-Locke, et al., 2002; Hands, et al., 2004). Therefore, whilst the pedometer records number of steps as a measure of physical activity, the diaries asked parents and children to record both type and frequency of activities over a 7 day period (Refer to Appendix A for example of records from a weekday and weekend).

Participants were required to wear a pedometer for 7 days. The step counter was expected to be worn during waking hours and only taken off when swimming, bathing or sleeping. Participants, with assistance from parents, were required to fill out a diary at the end of every day over the 7 day period. Activities for the day were listed in the diary for time spent before school, recess, lunch, after school, and any physical education or fitness classes and the number of steps recorded that day noted by parents in the diary. Each day the children and parents reported the amount of time they did not wear the pedometer and why. In cases where the child was involved in an activity where a pedometer was not possible or advisable (such as swimming), the responses were converted into steps and added to the daily step count. All conversions were based on ‘activity duration’ (min) x 120 steps (Tudor-Locke, Kasse, Williams & Reiss, 2002). This physical activity diary and conversion method has been used in other studies (Hands et al., 2004).

Perceived motor competence

The Self Description Questionnaire-I (Marsh, 1988; 1990) is designed to measure multiple dimensions of self concept and was used to measure perceived motor competence. The SDQ-I assesses three areas of academic self concept (Reading, Mathematics, and General School self concept), four areas of non-academic self concept (Physical Ability, Physical Appearance, Peer Relationships, and Parent
Relationships) and General Self Concept scale. Research with the SDQ-I strongly supports the multidimensionality of self-concept (Marsh, 1987; 1988; Marsh & Shavelson, 1985). Numerous factor analyses of responses by boys and girls of different ages have shown the SDQ-I factor structure to be stable across ages and across sex (Marsh, 1988).

The SDQ-I was selected for the current study as it is one of the few assessment items that has been proven reliable and validated for use with Australian children aged 5 to 8 years old (Marsh et al., 1991). Marsh et al.(1991) reported a central finding of support for the use of the individually administered SDQ-I with children younger than 8 years, with factors within the SDQ-I previously identified in responses by older children, also identified by younger children, indicating that self-concept factors are better defined in younger children than were previously assumed. Within the current study, three areas of non-academic self concept were measured, Physical Ability, Physical Appearance and Peer Relationships. The use of selected subscales, within the SDQ-I is acceptable (H. Marsh, personal communication, 19 December, 2004). Participants answered closed questions in the form of scaled responses based on a Likert-type scoring system of 1 to 5 and a total score out of 120 (Refer to Appendix B).

Perceived motor competence (Physical Ability, Physical Appearance and Peer Relationships subscales) was assessed after the AMC assessment, in one on one interviews with participants using the SDQ -I. The researcher recorded answers on the interview questionnaire.

**Actual motor competence**

Actual motor competence was assessed based on the quality of motor skill performance using criteria based on a proficiency model to analyse performance. Skill observation records from the Fundamental Movement Skills Teacher Resource Manual (Education Department of Western Australia, 2001) were used to assess the quality of motor skill performance (Refer to Appendix C).

The FMS Manual (2001) is a resource developed to assist teaching fundamental movement skills such as body management skills, locomotor skills and object control.
skill. For the present study, one explosive locomotor skill (standing broad jump), a continuous locomotor skill (50m run), an object control skill (overarm throw), and a body management skill (line walk) were assessed. Participants were videoed performing each skill for the analysis of performance quality and increased reliability of assessment. The researcher, having had extensive training and previous research experience in the qualitative assessment of motor skills, reviewed the video performance of each skill to avoid inter-rater unreliability. A score of 1 was recorded for each criterion successfully demonstrated and a 0 recorded if mastery of the criterion was not displayed. The run comprised six criteria, the overarm throw seven criteria, the standing broad jump eight criteria, and the line walk five criteria (Refer to Appendix C for examples of the skill criteria). A total AMC score of 26 was possible from the combination of all 4 skills criteria. This construction of a composite motor skill score has been used in previous Australian research in the assessment of motor skills (Okely et al., 2001a; 2001b; Harten, Olds & Dollman, 2008).

The process-oriented assessment of fundamental movement skills was used in preference to product-oriented because it more accurately identifies topographical aspects of the movement (Ulrich, 1999). This methodology was adapted from previous assessments of movement skills in Australian adolescents (Okely et al., 2001a; 2001b).

Type of play choices
Additionally, open ended questions were included at the end of the SDQ-I to gather information on the type of activities participants liked best (Active games vs. something else) (Refer to Appendix B). Those activities were coded as 1) Organised, competitive games or training such as basketball, netball, cricket, football, 2) informal play or games such as skipping, playground, shooting baskets, 3) sedentary play such as computer, x-box, watching television.

Data Collection and Procedures
Data were collected from the sample on four occasions over an 18 month period, with approximately a 6 month gap between each data collection. The first two data collection cycles occurred in 2005 and the final two took place in 2006.
A research assistant was employed to assist with collection for the AMC phase of the study. The research assistant signed a confidentiality agreement acknowledging training received and agreement to adhere to strict protocol regarding behaviour, language and techniques when videoing participants performance of skills (Refer to Appendix D).

Where possible, the order in which school visits occurred was replicated through each data collection period to ensure the time between each collection was around 6 months. However, at times it was unavoidable for the order to be interrupted as the testing days often had to accommodate such events as school carnivals and school holidays. Nevertheless, the time period between each collection at each school only varied by no more than 1 to 2 weeks either side of the 6 month mark.

Data collection took place between 9am and 3pm on school days. Actual motor competence was assessed first after the morning bell and was completed just before recess. This was primarily undertaken on the school oval as a large space was required for performing the motor skills. Depending on the number of participants within the school, 5 to 10 participants were brought out at a time and separated into two small groups. One group performed the 50m run and overarm throw, whilst the other group performed the standing broad jump and line walk. On completion of the first two skills, the groups swapped over, then returned to class once all four skills had been completed. The next group of participants was then collected and the procedure repeated. The largest number of participants recruited within any school was 30, with the smallest being seven.

The PMC questionnaire was completed during an interview between the researcher and the participant. The interviews were conducted in a quiet place, usually just outside the classroom and answers recorded on the interview questionnaire. Once the interview was completed, participants were handed a pedometer and physical activity diary and given instructions for the use of these instruments. Written instructions for parents were sent home with the child. The 7 day period for the pedometer usually commenced immediately following the data collection at the school. The researcher then returned to the school after 7 days and collected the pedometers and diaries. One or two follow up visits were required when children forgot to return these items.
These procedures were then repeated on three further occasions. Methods, assessment instrumentation and order of testing of AMC before PMC remained consistent across all four DC cycles.

_Treatment of Data_

Data screening for outliers was conducted by running frequencies on data following each DC. Outlying scores were identified and if it was possible to trace back and determine the error, scores were corrected. Where outlying scores were not due to error, they were removed, and subsequently treated as missing data. For the pedometer data, improbable records of step counts below 1,000 and above 40,000 steps were deleted (Hands, et al., 2004), only two cases of outliers (0.3%) across the four data collection cycles were removed.

Combining all four collection cycles resulted in a sample size of 718 cases in the main data file. When reviewing missing data within the variables, there were 3.3% of PMC scores missing, 1.8% of AMC scores missing and 33.2% of physical activity step counts missing. As reported earlier, pedometers and physical activity diaries given to children were occasionally not returned. The return rate of pedometer data decreased across the four data collection cycles and will be reported in the next chapter.

For longitudinal studies, missing cases and missing data present a difficult problem for analyses. If incomplete sets of data were omitted, three problems arose. The consequent waste of resources, decrease in statistical power, and the possibility that children with missing data may be systematically different from those who have complete data sets (e.g., may be less motivated or have different activity patterns). In contrast, the alternative method of replacing missing data using a group mean or group regression approach presents a different problem. If information on a group is used to determine the score attributed to an individual, then the appropriateness of using a child’s data for individual interpretation is questioned (Rowe et al., 2004).

According to Rowe et al. (2004), an individualised procedure could be used to replace data more accurately than traditional group-centred methods such as
replacement with group mean or regression. In this study, if a participant had recorded step counts in at least two of the four data collection cycles, that participant’s mean step count would replace the missing pedometer data. A participant case was deleted if none or if only one data collection cycle included pedometer data. Rowe et al. (2004) did not recommend replacing missing data based on only one data point.

In support of this procedure, Rowe et al. (2004) found that 79 out of 299 children (26%) had incomplete data over a 6 day data collection period. Two analyses were conducted to determine whether replacement of the missing data had altered the reliability or means of the data. First, the mean step count for children whose missing data were replaced was not significantly different from the mean for the children with complete data. Means and standard deviations of the combined data (replaced and originally complete data) were similar to those of the original complete data. In addition, reliability estimates for replaced data were only slightly higher than for complete data, which would be expected because replaced data points were estimated from the remaining data points. Combining the replaced data with the complete data also increased the reliability estimates slightly. Overall, Rowe et al. (2004) demonstrated that an individual data-replacement procedure resulted in more reliable data, and that when this method was applied, children who had missing data were similarly active to children who had complete data.

Therefore in the current study, participants who were missing more than two cycles of pedometer data were deleted and participants who were missing data in one or two collection cycles had their data individually replaced. Using these procedures the original data file of 718 cases reduced to 589 cases (82%) with complete data for analysis. For separate perceived and actual motor competence descriptive analysis, 711 cases remained with full data sets. Those original cases that were missing PMC scores (3.3%) and AMC scores (1.8%) were children who also had more than two cycles with incomplete pedometer data and hence were deleted.

Data Analysis
SPSS version 17.0 was employed for all data analysis conducted for the current study. For initial statistical tests, normality of the distribution of scores for key
variables was assessed separately for males and females within age groups. This strategy is recommended when analysing and comparing scores between groups (Pallant, 2005). Despite the overall high scores of PMC, when the distribution of males and female scores (for AMC and PMC) and step counts (for physical activity) within separate age groups was analysed, the distribution output was normal, therefore no transformation of variables was necessary and standard parametric tests were performed. Descriptive data, the means and standard deviations from each participant’s physical activity recordings, PMC and AMC assessment were determined. An independent samples t-test was conducted to compare mean scores for males and females at each age group for all variables and Cohen’s $d$ was calculated to indicate effect size (magnitude of difference between boys and girls). Cohen (1992) suggested that effect sizes of 0.2 are small, 0.5 are moderate, and above 0.8 are large.

Standard linear multiple regression analysis was used to assess the relationship between physical activity (dependent variable) and PMC and AMC (independent variables), determining how well variables (perceived and actual motor competence) predicted physical activity levels and which variable was the best predictor of physical activity. The data collection cycles (DC1, DC2, DC3, DC4) were combined to investigate the contribution of perceived and actual motor competence to boys’ and girls’ physical activity at different ages. The 6-, 7-, and 8-year-old boys and girls became 7-, 8- and 9-year-olds between DC2 and DC3, therefore the 7- and 8-year-old age groups are represented across all four data collections. In comparison, 6-year-olds are represented from DC1 and DC2, and the new age group of 9-year-olds are represented from DC3 to DC4 (Refer to Figure 2 and 3). According to Tabachnick and Fidell (2001), multiple regression makes a number of assumptions about the data and is not forgiving if these assumptions are violated. Tests for multicollinearity (relationships amongst independent variables), normality, linearity, homoscedacity (variance of residuals about predicted dependent variable) and independence of residuals were all conducted. Based on cut off points and recommendations from Tabachnick and Fidell (2001), results revealed there were no violations of assumptions.
For the longitudinal analysis a linear mixed model (LMM) was performed to model the trajectory of physical activity over time from the first to the fourth data collection cycle. LMM are statistical models for continuous outcome variables (e.g. physical activity) in which residuals are normally distributed but may not be independent or may have constant variance. They are well suited to longitudinal and repeated measure studies, where subjects are measured repeatedly over time, or under different conditions, and there is likely correlation. LMM provide for estimation of covariance parameters which capture this correlation, as well as allowing subjects to have missing time points. Model selection involves repetitive investigations, combining a balance of statistical and subject considerations, until the simplest model with the best fit to the data is found (West, Welch, & Galecki, 2007).

Fixed effects are the independent covariates in LMM, and may be either continuous such as age, or a factor (categorical) such as gender. Within the model it includes all levels or conditions of interest. The fixed effects describe the relationship (contrasts or differences) between the independent covariate(s) and the dependent variable (West et al., 2007). A covariate is a variable that is either of direct interest or a confounding or interacting variable that is possibly predictive of the dependent variable within the LMM.

Random effects are levels of a factor in LMM, where the level sampled is not of intrinsic interest (e.g. classroom samples from a school). “Random effects are represented by (unobserved) random variables” (West et al., 2007, p.1). This includes a random sample of the possible levels or conditions of interest. These effects are specific to ‘clusters’ or subjects within a population, and represent random deviations from the relationship of fixed effects.

According to West et al. (2007), there are a number of advantages of LMM in longitudinal analysis, particularly over traditional repeated-measures ANOVA. These include provision for estimation of covariance parameters, allows for subjects with missing time points (i.e. unequal measurements over time for individuals), capacity to include all observations available for all individuals in analysis, cope with missing data at random, and allows for inclusion of time-varying covariates (in addition to time covariate).
**Likelihood Estimation, Covariance Structure type and Comparing Models using Information Criteria**

The most common types of estimation used for fixed effect parameters are Maximum Likelihood Estimation (ML) and Residual Maximum Likelihood Estimation (REML). ML “obtains estimates of unknown parameters by optimising a likelihood function” (West et al., 2007, p. 25) that is, values of the parameters that make the observed dependent variable values most likely. However ML does not account for the loss of degrees of freedom, whereas REML produces unbiased estimates of covariance parameters so therefore is often preferred (West et al., 2007). For this research data, REML statistical output was used for estimation of fixed effects parameters.

The covariance structure informs the final mixed model the shape of the variance covariance matrix between the random parameters or repeated measures with subjects. The covariance structure type specifications in repeated measures are used to specify the assumptions about the repeated measures error covariance, with different assumptions affecting the calculation of estimates. Too simple assumptions will increase Type I errors, while over complex structures will increase Type II errors. The selection of the best model is via ‘goodness of fit’ statistics, which in SPSS involves the information criteria results. Information criteria is based on the optimum log-likelihood statistic. It allows you to select the subset of interrelated predictors that best capture the effect of a single underlying construct (Singer & Willet, 2003; West et al., 2007). Two ad hoc criteria, based on the log-likelihood statistic allow the comparison of ‘goodness of fit’, namely Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The AIC parameter is based on the number of model parameters, while the BIC includes the number of model parameters plus sample size (Singer & Willet, 2003). Within the current study, the AIC was used for comparison of ‘goodness of fit’ for each model (Singer & Willet, 2003; West et al., 2007).

For the LMM analysis of the data within the current study, the four data collection cycles were the repeated measures. The effects of age, gender, school, PMC and AMC on physical activity over time were investigated. Physical activity was treated as the dependent variable, with Gender, Age, School, PMC and AMC treated as
factors (fixed effects). School was also examined as a random effect. The final model is determined through various combinations of fixed and random effects and their interactions, until the model with the best fit to the data is found, with model diagnostics performed.

**Ethical Clearance**

Permission to conduct the study was granted by University of Notre Dame Australia Human Research Ethics committee. After gaining permission from school principals, voluntary informed consent was obtained from the parents or guardians of children willing to participate in this study and children were required to print their name or sign willingness to participate on the parent consent form. Assurances were made to parents and children that they were free to withdraw at any time (Refer to Appendix E).
CHAPTER FOUR

RESULTS

In this chapter the results will be presented in five sections: descriptive statistics for the four data collection cycles; gender differences for key variables and activity and play choices; the relationship between perceived and actual motor competence; the levels of physical activity with levels of perceived and actual motor competence, the contribution of perceived and actual motor competence to physical activity; and finally developmental changes in physical activity behaviour considering the interacting effects of gender, age, school, actual and perceived motor competence.

Physical Activity, Perceived Motor Competence and Actual Motor Competence for Data Collection Cycles 1 to 4

As would be expected, AMC scores increased over the four data collection cycles for both boys and girls, whilst physical activity mean daily step counts and PMC remained relatively stable. Table 1 displays mean scores for all boys and girls across the four data collection (DC) cycles.

With ages combined at each data collection point, Table 1 displayed the number (n) of children with complete data across all three variables, physical activity, AMC, and PMC. The sample size (n) with complete data for physical activity for boys and girls decreased across data collection cycles 1 to 4 (DC1, DC2, DC3, DC4), due to children not always returning pedometers and physical activity diaries. Complete data for AMC and PMC remained high across data collection cycles (Refer to Table 1) since the assessment of AMC and PMC was conducted by the researcher at school.
A one way ANOVA was conducted to explore any significant differences in physical activity, AMC and PMC mean scores across data collection cycles for girls and boys with all age groups combined. There were no significant differences in physical activity daily step counts or PMC scores for girls or boys across the four data collection cycles. There was a significant difference in AMC scores for the four data collection cycles for girls \([F(3, 306) = 7.89, p = .00]\) and boys \([F(3, 398) = 6.19, p = .00]\). Post-hoc comparisons using Tukey HSD indicated girls AMC scores at DC1 was significantly less compared to DC3 and DC4, but not DC2. Similarly for boys, AMC scores at DC1 were significantly less than AMC scores at DC 3 and DC4, but not DC2.

Table 1

*Mean scores for Physical Activity (step counts), Actual Motor Competence (AMC, max 26) and Perceived Motor Competence (PMC, max 120) for all boys and girls across data collection cycles (DC).*

<table>
<thead>
<tr>
<th></th>
<th>Girls</th>
<th></th>
<th></th>
<th></th>
<th>Boys</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DC 1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Mean age (yrs)</td>
<td>7.2</td>
<td>7.8</td>
<td>8.3</td>
<td>8.8</td>
<td>7.2</td>
<td>7.6</td>
<td>8.1</td>
<td>8.5</td>
</tr>
<tr>
<td>n PA mean daily step count</td>
<td>61</td>
<td>62</td>
<td>43</td>
<td>49</td>
<td>78</td>
<td>73</td>
<td>66</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>11,859</td>
<td>11,553</td>
<td>11,844</td>
<td>12,019</td>
<td>14,358</td>
<td>15,345</td>
<td>14,821</td>
<td>14,508</td>
</tr>
<tr>
<td>n</td>
<td>81</td>
<td>82</td>
<td>72</td>
<td>75</td>
<td>103</td>
<td>99</td>
<td>99</td>
<td>101</td>
</tr>
<tr>
<td>AMC</td>
<td>15.6**</td>
<td>16.5</td>
<td>17.0**</td>
<td>17.2**</td>
<td>17.7**</td>
<td>18.4</td>
<td>19.0**</td>
<td>19.2**</td>
</tr>
<tr>
<td>n</td>
<td>80</td>
<td>80</td>
<td>72</td>
<td>73</td>
<td>103</td>
<td>98</td>
<td>97</td>
<td>98</td>
</tr>
<tr>
<td>PMC</td>
<td>97.5</td>
<td>97.9</td>
<td>98.0</td>
<td>97.5</td>
<td>99.1</td>
<td>97.0</td>
<td>96.7</td>
<td>96.7</td>
</tr>
</tbody>
</table>

**p ≤ .00
Gender Differences for Physical Activity, Perceived Motor Competence and Actual Motor Competence

Combining all four data collection scores and step counts, an independent samples t-test was conducted to identify any significant differences in the mean scores between boys and girls at each age for physical activity, PMC and AMC. Effect size was also calculated using Cohen’s $d$ for magnitude of significant differences (0.2 are small, 0.5 are moderate, and above 0.8 are large).

For physical activity, there was a significant difference in mean step counts between boys and girls at every age. At 6 years, boys ($M = 13,837$, $SD = 4,222$) had a significantly higher step count than girls ($M = 11,592$, $SD = 2,746$; $t(93) = -3.14$, $p = .00$, $d = 0.7$). At age 7, the boys mean step count ($M = 13,915$, $SD = 3,539$) was significantly higher than the girls ($M = 11,657$, $SD = 3,039$; $t(205) = -4.70$, $p = .00$, $d = 0.7$). At age 8, boys again ($M = 14,924$, $SD = 3,388$) recorded a significantly higher mean step count than girls ($M = 11,816$, $SD = 3,099$; $t(204) = -6.84$, $p = .00$, $d = 1.0$). Finally at 9 years of age, boys ($M = 15,419$, $SD = 4,166$) recorded significantly higher step counts than girls ($M = 12,087$, $SD = 2,731$; $t(96) = -4.59$, $p = .00$, $d = 1.0$)

(Refer to Figure 4). The effect sizes in the younger age groups were moderate (0.7) and in the older age groups were large (1.0). Overall, boys’ mean daily step counts increased with age whilst girls’ step counts remained constant with only a slight increase evident at every age group.
When comparing PMC scores for boys and females, there were no significant differences in scores in any age groups. At 6 years of age, differences between girls and boys approached significance ($t(111) = 1.92$, $p = .06$), with girls ($M = 103$, $SD = 11.7$) recording higher perceived competence scores than boys ($M = 98$, $SD = 14.2$, $d = 0.3$). For the 7-year-olds though there was no significant difference, girls ($M = 99.8$, $SD = 12.1$) again recorded higher scores than boys ($M = 98.4$, $SD = 11.2$; $t(221) = .89$, $p = .38$, $d = 0.1$). This trend was reversed in the 8-year-olds, with girls having slightly lower perceived competence ($M = 95.5$, $SD = 12.9$) than boys ($M = 96.5$, $SD = 15$; $t(238) = -.55$, $p = .58$, $d = 0.1$). This pattern continued in 9-year-olds, with girls again recorded lower ($M = 93.8$, $SD = 15.9$) perceived competence scores than boys ($M = 96.8$, $SD = 16.7$; $t(116) = -.99$, $p = .33$, $d = 0.2$) (Refer to Figure 5). The effect sizes were small ($d = 0.1 – 0.3$) for boys and girls at every age. Overall, girls’ perceived competence scores decreased with age whilst boys’ scores remained stable.

**$p \leq .01$**

*Figure 4. Gender differences across age for physical activity mean step counts.*
For AMC, boys displayed significantly higher scores than girls at every age group. Among 6-year-olds, AMC was significantly higher in boys ($M = 17.5, SD = 2.8$), than girls ($M = 15.1, SD = 1.9; t(110) = -5.34, p = .00, d = 1.0$). In 7-year-olds, boys ($M = 18.2, SD = 2.5$) recorded significantly greater scores than girls ($M = 16.6, SD = 2.2; t(223) = -4.91, p = .00, d = 0.7$). Boys ($M = 19.0, SD = 2.5$) also had significantly higher actual motor competency than girls ($M = 16.8, SD = 2.2; t(246) = -7.34, p = .00, d = 0.9$) at 8 years. AMC for boys ($M = 20, SD = 2.9$) continued to be significantly higher than girls ($M = 17.4, SD = 2.4; t(117) = -5.53, p = .00, d = 1.0$) at 9 years of age (Refer to Figure 6). The magnitude of these differences between boys and girls in the youngest (6 years) and oldest ages (8 and 9 years) were large ($d = 0.9 - 1.0$), and in 7-year-olds, the magnitude of these differences were moderate ($d = 0.7$). Overall, increases in actual motor competency with age were evident in both boys and girls, although the girls’ scores leveled out in the older age groups.

*p ≤ .05  **p ≤ .01

Figure 5. Gender differences across age for perceived motor competence (maximum score = 120)
Gender Comparisons for Type of Play and Activities

A chi square test of independence explored the difference between choices of play and various activities for boys and girls at different ages. Of those who reported play preference it should be noted that: a) some children had no response to the open ended question; and b) children could also report more than one type of choice for play preference; therefore play choices were coded based on responses from each child. The Pearson Chi-Square value was significant for boys and girls at 6 years ($\chi^2=21.54$), 7 years ($\chi^2=10.77$), 8 years ($\chi^2=25.89$), and 9 years ($\chi^2=39.87$) of age. More boys preferred to be involved in competitive/organised sports, and girls preferred more informal games and play. The participation rates were similar for sedentary activities. Table 2 displays the percentages of girls and boys who selected competitive /organised sports, or informal play / games, or sedentary activities as their favourite type of play.

**$p \leq .01$**

*Figure 6. Gender differences across age for actual motor competence (maximum score = 26)*
Table 2

*Play Choices in Competitive/organised sport, Informal Games and Sedentary Activities for Boys and Girls across age.*

<table>
<thead>
<tr>
<th>Age</th>
<th>Competitive/organised and games</th>
<th>Informal play/games</th>
<th>Sedentary activities</th>
<th>p. value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-year-olds</td>
<td>Count</td>
<td>2</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>8%</td>
<td>67%</td>
<td>42%</td>
</tr>
<tr>
<td>Boys</td>
<td>Count</td>
<td>24</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>92%</td>
<td>33%</td>
<td>58%</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>Count</td>
<td>21</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>27%</td>
<td>52%</td>
<td>40%</td>
</tr>
<tr>
<td>Boys</td>
<td>Count</td>
<td>58</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>73%</td>
<td>48%</td>
<td>60%</td>
</tr>
<tr>
<td>8-year-olds</td>
<td>Count</td>
<td>42</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>32%</td>
<td>70%</td>
<td>46%</td>
</tr>
<tr>
<td>Boys</td>
<td>Count</td>
<td>90</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>68%</td>
<td>30%</td>
<td>54%</td>
</tr>
<tr>
<td>9-year-olds</td>
<td>Count</td>
<td>14</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>22%</td>
<td>85%</td>
<td>56%</td>
</tr>
<tr>
<td>Boys</td>
<td>Count</td>
<td>50</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>% within play</td>
<td>78%</td>
<td>15%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Perceived and Actual Motor Competence Relationship

The relationship between perceived and actual motor competence for boys and girls of each age group was investigated using Pearson product-moment correlation. The perceived and actual motor competence scores were standardised using Z-scores. Table 3 indicates an increasing strength of association between perceived and actual motor competence with age. No significant relationship is detected at 6 years for either gender, however a moderately positive and significant relationship emerges in the older age groups. For boys, this significant relationship is evident at an earlier age (7-year-olds) than girls (8-year-olds). However at 9 years of age, the girls...
showed an increasingly strong positive relationship whilst the boys remained relatively stable with a moderate significant relationship. To summarise, the correlations for boys level out over 7, 8 and 9 years of age, whilst correlations strengthen for girls between 8 and 9 years old (Refer to Table 3).

Table 3

<table>
<thead>
<tr>
<th></th>
<th>PMC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
</tr>
<tr>
<td></td>
<td>6yo 7yo 8yo 9yo</td>
</tr>
<tr>
<td>n</td>
<td>46 85 107 56</td>
</tr>
<tr>
<td>AMC( r)</td>
<td>.05 .01 .24* .52**</td>
</tr>
</tbody>
</table>

* p ≤ .05 ** p ≤ .00

Levels of Physical Activity, Perceived and Actual Motor Competence

The continuous scores recorded for physical activity, perceived and actual motor competence were grouped into low, middle and high categories based on tertiles. The middle tertile was removed to compare the percentage of males and females within low and high tertiles of physical activity to those in the low and high tertiles of perceived and actual motor competence.
### Table 4

*Percentage of girls and boys in lowest or highest tertile for both Actual Motor Competence (AMC) and Physical Activity (PA)*.

<table>
<thead>
<tr>
<th></th>
<th>GIRLS AMC</th>
<th></th>
<th>GIRLS PA</th>
<th></th>
<th>BOYS AMC</th>
<th></th>
<th>BOYS PA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>GIRLS AMC</td>
<td>Low</td>
<td>25%</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>6.4%</td>
<td>3.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOYS AMC</td>
<td>Low</td>
<td>8.8%</td>
<td>3.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>4.1%</td>
<td>26.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5

*Percentage of girls and boys in lowest or highest tertile for both Perceived Motor Competence (PMC) and Physical Activity (PA)*.

<table>
<thead>
<tr>
<th></th>
<th>GIRLS PMC</th>
<th></th>
<th>GIRLS PA</th>
<th></th>
<th>BOYS PMC</th>
<th></th>
<th>BOYS PA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>GIRLS PMC</td>
<td>Low</td>
<td>19.5%</td>
<td>17.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5.2%</td>
<td>4.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOYS PMC</td>
<td>Low</td>
<td>8.8%</td>
<td>4.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>14.2%</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For girls, 25% were in the lowest tertile for both physical activity step counts and AMC scores compared to 8.8% of boys. In contrast, 26.5% of boys were classified for both high levels of both physical activity step counts and AMC scores, compared to only 3.4% of girls (Refer Table 8). Similarly, a higher percentage of girls (19.5%) had both low PMC scores and low average daily step counts in comparison to boys (8.8%), and a greater percentage of boys (18%) than girls (4.5%) were in the high groups for both PMC and physical activity (Refer Table 9).

Overall, boys outnumbered girls in the high physical activity, high AMC tertiles and also the high PMC categories. In direct contrast, more girls than boys were represented in the low physical activity, AMC, and PMC groups.

*Contribution of Perceived Motor Competence and Actual Motor Competence to Physical Activity – A cross sectional analysis.*

A standard multiple regression was performed with physical activity as the dependent variable and PMC and AMC as the independent variables. The analyses combined the four data collection cycles and were conducted for boys and girls and grouped by age to investigate any changes in the contribution of perceived and actual motor competence to physical activity levels at that age. Tables 6 and 7 display the regression results for boys and girls at each age group. These included correlations ($r$) between variables (AMC, PMC and physical activity), and the $R$ value identified if the regression model is significantly different from zero. $R^2$ is the coefficient of multiple determination which was the percent of the variance explained by the independent variables, the standardised regression coefficients ($\beta$) were compared for AMC and PMC to judge their relative predictive power to physical activity. Finally, the squared semi partial correlations ($sr_r^2$) then reflected the unique contribution of each independent variable (AMC or PMC) in explaining the total variance of the dependent variable (physical activity).
Table 6

The Contribution of Perceived Motor Competence (PMC) and Actual Motor Competence (AMC) to Physical Activity for 6-, 7-, 8- and 9-year-old girls.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>n</th>
<th>Physical Activity</th>
<th>PMC</th>
<th>AMC</th>
<th>r</th>
<th>r</th>
<th>β</th>
<th>sri²</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td>-.24</td>
<td>-.25</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PMC</td>
<td>-.07</td>
<td>-.08</td>
<td>-.07</td>
<td>-.09</td>
<td>.00</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AMC</td>
<td>.05</td>
<td>.05</td>
<td>.07</td>
<td>.07</td>
<td>.00</td>
<td>.01</td>
</tr>
<tr>
<td>7</td>
<td>76</td>
<td></td>
<td></td>
<td></td>
<td>.07</td>
<td>.09</td>
<td>.07</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PMC</td>
<td>.16</td>
<td>.14</td>
<td>.12</td>
<td>.12</td>
<td>.01</td>
<td>.04</td>
</tr>
<tr>
<td>8</td>
<td>97</td>
<td></td>
<td></td>
<td></td>
<td>.14</td>
<td>.14</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PMC</td>
<td>.33</td>
<td>.49</td>
<td>.35</td>
<td>.35</td>
<td>.09</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AMC</td>
<td>.33</td>
<td>.49</td>
<td>.35</td>
<td>.35</td>
<td>.09</td>
<td>.11</td>
</tr>
</tbody>
</table>

*p ≤ .05  **p ≤ .01
Table 7

The Contribution of Perceived Motor Competence (PMC) and Actual Motor Competence (AMC) to Physical Activity for 6-, 7-, 8- and 9-year-old boys.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>n</th>
<th>Physical Activity</th>
<th>PMC</th>
<th>β</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>58</td>
<td>.08</td>
<td>.06</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>117</td>
<td>.12</td>
<td>.03</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>105</td>
<td>.11</td>
<td>.03</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>41</td>
<td>.26</td>
<td>.05</td>
<td>.00</td>
<td></td>
</tr>
</tbody>
</table>

For girls at 6 years, R coefficient was not significantly different from zero, [F(2, 39) = 1.340, p = .274]. The R² value of .06 indicated that only 6% of the variance of physical activity was accounted for by both PMC and AMC. From the standardised beta coefficient values (β = -.25) and squared semi partial correlation (.05), PMC uniquely explained 5% of the variance in physical activity within this model, compared to AMC (.00). However, neither AMC nor PMC made a significant unique contribution to the prediction of physical activity.
Neither AMC, nor PMC contributed significantly to the prediction of physical activity for girls at either 7 years of age or at 8 years of age. It was not until 9 years of age that the $R$ for regression become significantly different from zero, $[F(2, 50) = 3.12, p = .05]$. The $R^2$ value of .11 indicated that 11% of the variance in physical activity levels for these girls is explained by both PMC and AMC, with AMC ($\beta = .35$) making a significantly unique contribution to physical activity levels accounting for 9% of the variance in the model. The contribution of PMC ($\beta = -.03$) was not significant (Refer to Table 6).

For 6-year-old boys, $R$ for regression was not significantly different from zero, with 5% of the variance in physical activity levels predicted by PMC and AMC. Neither perceived nor actual motor competence contributed significantly to regression. The $R^2$ value increased at 7 years for boys with 12% of the variance in physical activity explained by AMC and PMC. At this age, AMC ($\beta = .34$) made the strongest significant contribution, explaining 10% of the variance within the model, whilst perceived competence ($\beta = .027$) made a far smaller insignificant contribution. For boys at 8 years of age, only 5% of the variance of physical activity was explained by both independent variables. However, AMC made a statistically significant unique contribution ($\beta = .21$), although explained only 4% of the variance in the model. Perceived motor competence did not significantly contribute to the model.

At 9 years of age, 37% of the variance in boys’ physical activity is explained by both PMC and AMC, the highest value for boys and girls at any age. Actual motor competence ($\beta = .59$) continued to make a greater, significant contribution to physical activity, explaining 30% of the variance within the model. Perceived competence was not significant, making a much smaller ($\beta = -.05$) contribution (Refer to Table 7). There was no significant interaction effect between AMC and PMC for boys and girls at any age.

Overall, apart from only a slight decrease in 8-year-olds, the contribution of AMC to physical activity increased as boys became older and this was evident at an earlier age than girls. In contrast, AMC did not significantly contribute to physical activity in girls until 9 years of age. One common trend in both boys and girls was that PMC did not make a unique significant contribution to physical activity at any age. There
were no significant interactions between AMC and PMC at any age in the models (Refer to Table 6 and 7).

*Physical Activity Levels Over Time – A linear mixed-model longitudinal analysis.*
A linear mixed model was performed to model the trajectory of physical activity over time. Fixed and random effects, interactions and covariance structures were investigated to determine the final model, along with model diagnostics. Physical activity was the dependent variable and the data collection cycles were the repeated measure. Age was tested as a repeated measure variable but the model failed. Age, Gender, School, Actual Motor Competence and Perceived Motor Competence were treated as factors (main effects). School was also investigated as a random effect. Akaike Information Criteria (AIC) were used to compare best model fit between significant main effects, with smaller AIC representing a better model fit (Singer & Willet, 2003). Twelve models were examined with significance of main effects and interaction effects summarised in Table 8.
Table 8

Summary of linear mixed models investigated for physical activity and main effects of AMC, PMC, Gender, Age and School.

<table>
<thead>
<tr>
<th>Model</th>
<th>AIC</th>
<th>Gender</th>
<th>AMC</th>
<th>PMC</th>
<th>School</th>
<th>Age</th>
<th>School (Random)</th>
<th>Gender* AMC</th>
<th>Gender* PMC</th>
<th>Gender* School</th>
<th>Age (Random)</th>
<th>AMC* School</th>
<th>PMC* School</th>
<th>AMC* Age</th>
<th>PMC* Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>11018.89</td>
<td>NS</td>
<td>.017</td>
<td>NS</td>
<td>.022</td>
<td>NS</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>11043.30</td>
<td>&lt;.0001</td>
<td>.022</td>
<td>NS</td>
<td>.022</td>
<td>NS</td>
<td></td>
<td>NS</td>
<td>NS</td>
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</tr>
<tr>
<td>Model 3</td>
<td>11252.56</td>
<td>NS</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>.028</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Model 4</td>
<td>10967.95</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>.0008</td>
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<td>.029</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<td></td>
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<tr>
<td>Model 5</td>
<td>10941.70</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>.030</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<td></td>
</tr>
<tr>
<td>Model 6</td>
<td>10961.81</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>NS</td>
<td>.028</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Model 7</td>
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<td>NS</td>
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<tr>
<td>Model 8*</td>
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<td>NS</td>
<td>.032</td>
<td>Error</td>
<td>NS</td>
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<td></td>
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<tr>
<td>Model 9*</td>
<td>10975.98</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>.024</td>
<td>NS</td>
<td>Error</td>
<td>NS</td>
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<td>Model 10</td>
<td>10937.20</td>
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<td>.024</td>
<td>NS</td>
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<tr>
<td>Model 11</td>
<td>10975.46</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>.006</td>
<td>NS</td>
<td>.023</td>
<td>NS</td>
<td>NS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Model 12</td>
<td>11017.70</td>
<td>&lt;.0001</td>
<td>NS</td>
<td>.02</td>
<td>NS</td>
<td>.019</td>
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</tr>
</tbody>
</table>

Interactions of significant main effects from Final Model (Model 12 – Significant effects of AMC, Gender, School)

| Model 12A| 10884.89| NS     | NS    | NS    | NS     | NS   | NS            | NS          | NS          |               |              |             |             |          |          |
| Model 12B| 10882.80| .000   | NS    | NS    | NS     | NS   | NS            |             |             |               |              |             |             |          |          |
| Model 12C| 10833.46| .001   | .005  | .026  | NS     |     |               |             |             |               |              |             |             |          |          |
| Model 12D| 11006.63| NS     | .006  | .021  | NS     |      |                |             |             |               |              |             |             |          |          |

NS – Not significant, *Error – model failed
Model 12 was determined as the final model based on best model fit (AIC = 11017.70) and significant main effects of Gender ($p < .00$), AMC ($p = .02$) and School ($p = .02$) (Refer to Table 8). PMC as a main effect was insignificant and removed from the final model. Age was not significant in any model tested and there was no significant difference in Physical Activity with Age over time, irrespective of Gender. School was also investigated as a random effect but this resulted in Model Errors (Models 8 and 9) and it was removed as a random effect but remained as a fixed effect. There were no significant interactions for the fixed effects of AMC*School (Model 12B), School*Gender (Model 12C), Gender*AMC (Model 12D) from the final model (Model 12) (Refer to Table 8).

Covariance structures are reported for Model 12 to determine the most appropriate covariance structure based on the most common ‘goodness of fit’ measures, AIC, Schwarz’s Bayesian Criteria (BIC) and 2 restricted Log likelihood with results displayed in Table 9. Once the covariance structure is defined, this enables the estimation of parameters for the significant fixed effects (AMC, school, gender). The unstructured covariance structure reported the best model fit overall (Refer to Table 9).
Table 9

*Covariance Structure Analysis and Goodness of Fit for Physical Activity basic model.*

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<tr>
<th>Covariance Structure Type</th>
<th>2 Restricted Log Likelihood</th>
<th>Akaike’s Information Criterion (AIC)</th>
<th>Schwarz’s Bayesian Criterion (BIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstructured UN*</td>
<td>10985.851</td>
<td>11005.851</td>
<td>11049.686</td>
</tr>
<tr>
<td>First-Order Autoregressive AR1</td>
<td>11076.269</td>
<td>11080.269</td>
<td>11089.036</td>
</tr>
<tr>
<td>Compound Symmetry CS</td>
<td>11035.233</td>
<td>11039.233</td>
<td>11048.000</td>
</tr>
<tr>
<td>Compound Symmetry Heterogenous CSH</td>
<td>11006.586</td>
<td>11016.586</td>
<td>11038.504</td>
</tr>
<tr>
<td>Compound Symmetry Correlation Metric CSR</td>
<td>11035.233</td>
<td>11039.233</td>
<td>11048.000</td>
</tr>
<tr>
<td>Unstructured correlation metric UNR</td>
<td>10985.851</td>
<td>11005.851</td>
<td>11049.686</td>
</tr>
<tr>
<td>First-Order Ante-dependence AD1</td>
<td>11027.942</td>
<td>11041.942</td>
<td>11072.626</td>
</tr>
<tr>
<td>Heterogeneous First-Order Autoregressive ARH1</td>
<td>11039.608</td>
<td>11049.608</td>
<td>11071.526</td>
</tr>
<tr>
<td>ARMA (1,1) (ERROR CONVERGENCE)</td>
<td>11035.233</td>
<td>11041.233</td>
<td>11054.384</td>
</tr>
<tr>
<td>Diagonal DIAG</td>
<td>11254.516</td>
<td>11262.516</td>
<td>11280.560</td>
</tr>
<tr>
<td>First-Order Factor Analytic FA1 (ERROR)</td>
<td>11271.369</td>
<td>11281.369</td>
<td>11303.286</td>
</tr>
<tr>
<td>Factor Analytic Heterogenous FAH1 (ERROR)</td>
<td>11254.528</td>
<td>11270.528</td>
<td>11305.596</td>
</tr>
<tr>
<td>Huynh-Feldt HF (ERROR)</td>
<td>11028.588</td>
<td>11038.588</td>
<td>11060.506</td>
</tr>
<tr>
<td>Scaled Identity ID</td>
<td>11271.369</td>
<td>11273.369</td>
<td>11277.752</td>
</tr>
<tr>
<td>Toeplitz TP</td>
<td>11027.859</td>
<td>11035.859</td>
<td>11053.393</td>
</tr>
<tr>
<td>TPH</td>
<td>11000.242</td>
<td>11014.242</td>
<td>11044.926</td>
</tr>
</tbody>
</table>

*Best model overall fit

![Normal Q-Q Plot of Residuals](image)

*Figure 7. Final linear model diagnostics.*
Figure 7 revealed residual diagnostics for the final linear model (Model 12), for assumptions of normality and constant variance for the residuals based on the fit of Model 12. The residuals, based on Model 12, followed an approximately normal distribution with the majority of the points being on a near straight line (Refer to Figure 7). There was deviation from this line at the tails of the distribution, which suggested a long-distribution of the residuals (only the points at the tail ends of the distribution deviate from normality), with a series of very small (negative) and very large (positive) data points at the end of the tail. This deviation may be a result of covariates of physical activity that were not part of the study but may be impacting physical activity level in young children. Nevertheless, the overall model fit was shown to be good.

Therefore, the final linear mixed model (unstructured covariance) identified that at the first data collection (model intercept) there was a significantly higher physical activity step counts for males than females (2,292, \( p = .000 \)) and that this was impacted by actual motor competence and the school attended. For an increase in one AMC score (one component of one skill), physical activity increased by 144 steps \( (p = .002) \). Schools one to nine all showed decreased physical activity, with only decreases over 2,253 average steps significant (Schools 1, 2, 5, 7, 8 and 9, \( p < .005 \)), when compared to School 11. Only School 10 had reported an increased physical activity step count (60, \( p = .956 \)) but this was not significantly different from School 11 (Refer Table 10).

The equation for the final linear model is:

\[
\text{Predicted PA} = \text{intercept} + \text{gender} + \text{school} + \text{AMC}.
\]

For example, using the estimates from Table 10, a female from School 1 would have a predicted average daily step count of 8,397 steps per day compared to males from the same school with a predicted average daily step count of 10,689.
### Table 10

**Final Physical Activity Linear Mixed Model (Model 12): Estimates of Fixed Effects for parameters.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Physical Activity Estimate</th>
<th>Standard Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>13,479.42</td>
<td>1,055.67</td>
<td>.000</td>
</tr>
<tr>
<td>AMC</td>
<td>143.9433</td>
<td>46.27</td>
<td>.002</td>
</tr>
<tr>
<td>Gender - female</td>
<td>-2,291.77</td>
<td>439.21</td>
<td>.000</td>
</tr>
<tr>
<td>Gender – male</td>
<td>0</td>
<td>0</td>
<td>.</td>
</tr>
<tr>
<td>School</td>
<td></td>
<td></td>
<td>.19</td>
</tr>
<tr>
<td>School 1</td>
<td>-2,933.81</td>
<td>1,045.26</td>
<td>.006</td>
</tr>
<tr>
<td>School 2</td>
<td>-2,253.44</td>
<td>772.72</td>
<td>.004</td>
</tr>
<tr>
<td>School 3</td>
<td>-1,249.64</td>
<td>765.89</td>
<td>.105</td>
</tr>
<tr>
<td>School 4</td>
<td>-1,590.43</td>
<td>824.61</td>
<td>.056</td>
</tr>
<tr>
<td>School 5</td>
<td>-2,477.16</td>
<td>753.87</td>
<td>.002</td>
</tr>
<tr>
<td>School 6</td>
<td>-1,889.62</td>
<td>1,128.91</td>
<td>.096</td>
</tr>
<tr>
<td>School 7</td>
<td>-2,465.91</td>
<td>1,186.33</td>
<td>.022</td>
</tr>
<tr>
<td>School 8</td>
<td>-2,430.88</td>
<td>834.71</td>
<td>.005</td>
</tr>
<tr>
<td>School 9</td>
<td>-2,649.75</td>
<td>1,060.47</td>
<td>.014</td>
</tr>
<tr>
<td>School 10</td>
<td>60.40</td>
<td>1,082.35</td>
<td>.956</td>
</tr>
<tr>
<td>School 11</td>
<td>0</td>
<td>0</td>
<td>.</td>
</tr>
</tbody>
</table>

Finally, predicted physical activity from Model 12 was plotted according to gender and separated into AMC tertiles of low, medium and high (Refer to Figure 8). Both boys and girls in the lowest tertile of AMC had consistently lower physical activity over the 18 months. Girls in both middle and lower AMC tertiles displayed greater variability in physical activity levels between DC 2 and DC 4, in comparison with girls in the highest AMC tertile whose physical activity level appeared relatively stable across the data collection cycles. For the boys in both the middle and lower tertiles, physical activity decreased slightly across the 18 months particularly in DC 3 and DC 4, in comparison to boys in the highest AMC tertiles who showed increased physical activity levels in DC 3 and DC 4.
Figure 8. Final linear mixed model of physical activity over time with significant effects of AMC, school and gender (DC = Data Collection).
Model 12 was determined as the final model based on best model fit (AIC = 11017.70) and significant main effects of Gender ($p < .00$), AMC ($p = .02$) and School ($p = .02$) (Refer to Table 8). PMC as a main effect was insignificant and removed from the final model. Age was not significant in any model tested and there was no significant difference in Physical Activity with Age over time, irrespective of Gender. School was also investigated as a random effect but this resulted in Model Errors (Models 8 and 9) and it was removed as a random effect but remained as a fixed effect. There were no significant interactions for the fixed effects of AMC*School (Model 12B), School*Gender (Model 12C), Gender*AMC (Model 12D) from the final model (Model 12) (Refer to Table 8).

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<tr>
<td>Gender – male</td>
<td>0</td>
<td>0</td>
<td>.0</td>
</tr>
<tr>
<td>School</td>
<td></td>
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<td>School 11</td>
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Finally, predicted physical activity from Model 12 was plotted according to gender and separated into AMC tertiles of low, medium and high (Refer to Figure 8). Both boys and girls in the lowest tertile of AMC had consistently lower physical activity over the 18 months. Girls in both middle and lower AMC tertiles displayed greater variability in physical activity levels between DC 2 and DC 4, in comparison with girls in the highest AMC tertile whose physical activity level appeared relatively stable across the data collection cycles. For the boys in both the middle and lower tertiles, physical activity decreased slightly across the 18 months particularly in DC 3 and DC4, in comparison to boys in the highest AMC tertiles who showed increased physical activity levels in DC 3 and DC4.
Figure 8. Final linear mixed model of physical activity over time with significant effects of AMC, school and gender (DC = Data Collection).
CHAPTER FIVE

DISCUSSION

In this chapter, the discussion of the key findings is structured by statements responding to the major research questions of the study. First, the changing contributions of AMC and PMC to physical activity will be discussed along with other possible influences on the development of young children’s physical activity levels. Further examination of gender differences within the key variables, the relationship between AMC and PMC, and levels of AMC and PMC in relation to level of physical activity, will follow. The final section will present a revision of the conceptual framework based on the research findings.

Contributions of Perceived Motor Competence and Actual Motor Competence to Physical Activity.

The significance of the current study lies in the examination of both perceived and actual motor competence and their roles with respect to young children’s physical activity levels. Previous researchers have studied the relationship between physical activity and AMC and PMC in children separately, but have not considered that the relationships might differ with age and between genders (Stodden et al., 2008).

It was initially hypothesised that AMC, PMC, age and gender would contribute to physical activity levels. The multiple regression models were conducted independently for boys and girls in each age group to investigate patterns in predictive strength of specific contribution of perceived and actual competence to physical activity. A linear mixed model then investigated covariates within the study design that influenced physical activity levels over time. From the regression models for boys and the oldest girls in the sample, results revealed that AMC, not PMC, is making a significant contribution to physical activity levels. The linear mixed model analysis revealed that Gender, AMC and School were significant predictors of physical activity over time and there were no significant Gender-Actual Motor Competence, Gender-School, School-Actual Motor Competence interactions (Refer to Table 9). The importance of gender and the significant contribution of AMC to physical activity will be firstly discussed.
The multiple regression results showed that in 6-, 7- and 8-year-old girls, neither AMC nor PMC made a significant contribution to physical activity levels (Refer Table 6). However in 9-year-old girls, AMC explained 9% of the variance in physical activity levels. In comparison, AMC made a statistically significant contribution to physical activity levels for boys from as young as 7 years to 9 years. Overall, the modest contribution of AMC to physical activity continued to increase with age.

Generally, results from previous cross sectional studies reported a significant relationship between motor competency and physical activity in children and adolescents (Saakslahati et al., 1999; Okely et al., 2001a; 2001b; McKenzie et al., 2002; Fisher et al., 2005). However, the strength of this relationship between movement skills and physical activity appears weaker in younger children, compared to older children. Saakslahati et al. (1999) reported that physical activity was significantly linked to fundamental motor skills in 3- to 4-year-old children, yet the correlation coefficients were low ($r = .05 - .21$). Similarly, in another group of preschool children, Fisher et al. (2005) found a significant but small relationship ($r = .18$) that revealed children who spent more time in moderate-vigorous physical activity had higher fundamental motor skills.

In older children, Raudsepp and Pall (2006) investigated the association between AMC development and various outside-school physical activities in 7-year-olds. Time spent in skill-specific physical activities accounted for 20% of the variance in overhand throwing and 17% of the variance in jumping performance. However, the overall physical activity of children, measured via accelerometers and direct observation during two school days, was not related to motor competence in the overhand throw or jumping proficiency. Castelli and Valley (2007) also explored the influence of physical fitness, AMC, gender, age and ethnicity on physical activity engagement and level in 7- to 12-year-olds. A two-step hierarchical regression revealed AMC influenced both the level of physical activity engagement (41% of the variance) and step counts (34%) during the children’s participation in a summer program. Both Castelli and Valley (2007) and Raudsepp and Pall’s (2006) findings lend support for the significant influence of AMC to physical activity from as young as 7 years old. Unfortunately neither study examined the influence of AMC on
physical activity for boys compared to girls, and whether the effect was evident earlier in boys than girls as the current study showed. As there is limited, previous research that considered determinants of physical activity for girls and boys separately, and neither AMC nor PMC influenced physical activity in 6- to 8-year-old girls in the current study, future research might examine what are some of the other influences that could be contributing to physical activity levels in young girls.

The multiple regression findings also revealed that in both boys and girls PMC does not make a significant contribution to physical activity at any age (Refer to Table 6 and 7). Although the current study found that PMC did not influence physical activity in young children, past cross sectional research has noted the contributions of particular physical self perceptions to physical activity in older children and adolescents 10 to 14 years old (Crocker et al., 2000; Raudsepp et al., 2002). Crocker et al. (2000) used structural equation modelling to test physical self perception models and they were able to predict 27% to 29% of the variance of the physical activity in both boys and girls. Raudsepp et al. (2002) found that perceived sport/athletic competence, physical self worth and perceived strength competence were the best predictors of moderate to vigorous physical activity and physical fitness (21% of the variance for boys physical activity, 14% of the variance for girls physical activity). In a longitudinal study, Davison, Symons-Downs and Birch (2006) used path analysis to determine that PMC explained 27% of the variance in physical activity among 9- and 11-year-old girls. From these findings, it appears that in older children perceived competence begins to play a more prominent and significant role. It is also important to note that in the regression models for the current study, AMC and PMC were placed in the models together, firstly to see if they were jointly contributing to physical activity levels and then to establish which variable was making a more significant independent contribution.

Wrotniak et al. (2006) has also examined the relationship between perceived motor competence, actual motor competence and physical activity in a cross sectional study. They used the Bruinik-Oseretsky Test of Motor Proficiency (BOTMP) to assess AMC and its relationship to children’s self-perceptions of adequacy and desire to participate in physical activity and actual physical activity level (using accelerometers) in 8-, 9- and 10-year-olds. Motor competence explained 8.7% of the
variance in physical activity while controlling for various variables, including perceived competence. However, there was no significant relationship present between physical activity and perceived competence.

The original conceptual framework for the study was proposed to determine the contribution of AMC and PMC to young children’s physical activity levels, as informed by the models of Welk (1999) and Stodden et al. (2008). Welk (1999) proposed that the most common determinants of physical activity were self efficacy, perceived competence, enjoyment, parental influence and access to appropriate environment. Physical skills and fitness acted as ‘enabling’ factors that were promoted by physical activity, leading to increased persistence in physical activity and enhancement of perceived competence. He found that evidence from cross sectional studies indicated that children’s PMC may be more important than AMC. On the other hand, Stodden et al. (2008) hypothesised that younger children would demonstrate variable levels of physical activity and motor skill competence that were weakly related. They proposed that as children transition into middle and late childhood, the relationship between physical activity and AMC would strengthen.

The results from this present study support some components of Stodden et al.’s (2008) developmental framework. AMC, not PMC, was shown to be a significant contributor to physical activity levels in young children. The strengthening relationship between AMC and physical activity with age, especially among boys, also supports their model. However, the significant contribution of AMC to physical activity is apparent much earlier for boys than for girls, an important gender difference that has yet to be accounted for in developmental literature and models involving motor competence and physical activity. These findings have resulted in a modification of the initial conceptual framework developed in this study which will be revisited at the end of this chapter.

*The role of physical literacy*

Although this research was not primarily involved with school physical education, concepts raised by Whitehead (2001) and Tinning (2007) on how young people learn about their bodies, health, physical activity and sport may assist in explaining why boys AMC impacts on physical activity two years earlier than girls. Whitehead’s
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(2001) notion of physical literacy includes dimensions of physical competence (to do certain movement tasks or skills), spatial awareness (reading our own physical space and/or in relation to others) and sport/movement literacy (enables a person to understand games and sports with regards to tactics, rules, values etc.). Expanding this view, Tinning (2007) argued that physical education provides an opportunity for young people to develop certain physical competencies that are valued by young people themselves, and the development of these physical competencies provides some understanding of what engages and sustains young people’s participation in physical activity.

Tinning (2007) considered how physical literacies impact on young people and consequently influence physical activity behaviour. He suggested that some of the experiences developed through the world of computers, x-box and playstations, television and DVDs, might be useful in indirectly developing spatial awareness and sport/movement literacy that can then influence participation and competencies in certain forms of physical activity. With respect to this study, the development of such literacies may be associated with gender and the social and cultural contexts in which we learn them. The influence of AMC at an earlier age in boys than girls might be linked to not only the development of physical competence, but also the other dimensions of physical literacy that may well be developed differently across gender as a result of diverse experiences and even culturally biased expectancies.

However, specifying certain skills as important may also privilege one gender, particularly as most of these skills form the basis of male competitive sports (Wright, 1997). Yet some secondary physical education teachers express frustration that a number of students come from primary schools without having developed what they consider the necessary physical competencies (Tinning, 2007). Whilst the assessment of AMC in this study through fundamental movement skills performance could possibly be seen to advantage certain competencies, such as throwing, valued by boys rather than girls, further investigation into physical competencies valued by girls may assist in explaining the developmental differences in contributions to physical activity behaviour. In the perceived competence questionnaire, the open ended questions asked of the children about the type of play and activities they valued most, and revealed that a significant percentage of boys favoured
competitive/organised sports over informal play and sedentary activities. In comparison, a greater percentage of girls preferred informal play and sedentary activities (Refer to Table 2). These differences in percentage of boys and girls for type of play choices were significant in 6-, 7-, 8- and 9-year-olds. The activities boys and girls choose or value may not only develop physical literacy, but also influence self perceptions in terms of the social comparisons, and contexts in which they are learning. With more girls preferring informal play in the current study, there may be less chance for them to develop accurate self perceptions of their competence through peer comparisons compared to a more competitive context of organised sports which the boys seem to favour. The difference in the activities valued by boys and girls might explain the earlier development of the relationship between actual and perceived competence, and the contribution of AMC to physical activity. This is certainly a starting point for future research.

The role of perceived motor competence

Although PMC did not make a statistically significant contribution to physical activity in the young children in this study, Stodden et al. (2008) considered PMC played a critical role in the developing relationship between motor skill competence and physical activity. They suggested that PMC will not be strongly correlated with AMC or physical activity in early childhood as a result of high and inaccurate levels of self perceptions. The high self perception scores and insignificant contribution of PMC to physical activity reported in this study adds weight to this idea.

Barnett et al. (2008) used a longitudinal design to investigate whether sports competence acted as a mediator between childhood motor proficiency and adolescent physical activity and fitness. They found that adolescent perceived sports competence explained 18% of the variance of adolescent physical activity. Importantly, a relationship between childhood object control proficiency and adolescent perceived sports competence was found, suggesting that early competency in object control skills may be critical in building positive self perceptions in sports, and thereby increasing physical activity engagement in adolescence. Similarly, a significant relationship between PMC and AMC in the older age groups of the current study’s sample, which will be discussed later in this chapter, may also point to the role perceived competence plays in the development of
physical activity levels in middle to late childhood. Stodden et al. (2008) also proposed that more highly skilled children will have higher perceived competence, and engage in more mastery attempts, thus a stronger relationship will emerge between PMC, AMC and physical activity. However, there is currently no evidence to suggest that these relationships will have an opportunity to grow merely from the development of motor competency. Now with a greater understanding of AMC’s role in young children’s development of physical activity, future research may explore if different pathways exist for highly skilled versus less skilled children.

The effect of school on physical activity.
The influences of gender and AMC, and the lack of involvement of PMC to physical activity, have been discussed previously. However, the results from the linear mixed model indicated that school was a key determinant to physical activity.

The impact of a child’s school on the development of physical activity levels has been recognised as part of the environmental determinants in several conceptual models (Welk, 1999; Stodden et al., 2008). Ridgers, Stratton and Fairclough (2006) and Ferreira, van der Horst, Wendel-Vos, Kremers, van Lenthe, and Brug (2006) also noted the limited investigations into the relationship between specific features of school environments and physical activity. However of the studies undertaken in the last decade, Sallis and Owen (1999) and Sallis et al. (2000) have reported on the positive association between physical environment variables (access to facilities, programs, time, opportunities to exercise) and child and adolescent physical activity, with school identified as an important setting in which to promote physical activity (McKenzie, 1999). In addition, McKenzie (1999) acknowledged that schools were already established within the community, had trained staff, housed facilities and equipment for physical activity and required physical education classes for most children up to a certain grade.

In a study on Western Australian schools environments and physical activity, Martin, Bremner, Giles-Corti, Salmon and Rosenberg (2006) found that children attending schools that provided supportive environments, such as higher amounts of grassed area per child and apparatus to support sport, were more likely to participate in significantly increased MVPA during class time. Having an appointed Physical
Education coordinator within school was also significantly associated with children’s MVPA during class time. In an American study, McKenzie et al. (1995) observed that classes of children taught by physical education specialists (compared to generalist teachers) received longer and more active lessons, leading to higher energy expenditure. In 24 Californian middle schools, Sallis et al. (2001) reported that environmental characteristics, such as area size, equipment, adult supervision, and organised activities, explained 42% of the variance in the proportion of girls, and 59% of boys who were physically active. Cohen, Scott, Zhen Wang, McKenzie and Porter (2008) also found small but significant associations between the number of active outdoor facilities and physical activity among sixth grade girls.

Other specific school factors have been reported as affecting children’s activity behaviours. Zask, van Beurden, Barnett, Brooks and Dietrich (2001) identified school size, length of recess and the availability of balls in the playground in Australian primary schools as correlates of higher engagement in physical activity. In addition to this, playground markings have a positive effect on children’s physical activity levels (Stratton, 2000; Stratton & Mullan, 2005). Stratton (2000) found that the introduction of playground markings increased MVPA in primary school children by 18 minutes per day. This was also observed among children in infant and junior schools (40% and 60% increase respectively) (Stratton & Mullan, 2005). Other factors such as the encouragement of physical activity by supervisors, management and organisation of the playground, and the individual school’s playground regulations may also positively influence physical activity levels (Ridgers et al., 2006).

In exploring the extent to which children’s intuitive interest in physical activity was predicted by personal, school and family/home factors, Chen and Zhu (2005) suggested that influences from school and family played a significantly more important role than a child’s personal factors. Corbin (2002) also argued that schools may offer a more structured environment for learning physical skills through physical education lessons and instruction, which can be effective in stimulating children’s interest in physical activity, and even their future participation in sport and games. Since the current study has identified the significant impact of school, yet limited research into school-based factors, it is suggested future studies should use
evidence based interventions to investigate which characteristics within school settings influence interest and physical activity behaviour. Ferreira et al. (2006) also suggested that there is a need for future studies with clear, possibly standardised, objective methods of environmental attributes and physical activity assessment. As school provides an important setting within which to develop physical competencies and influence behaviour, increasing teachers and physical educators’ awareness of the relationship between AMC and physical activity may be valuable in supporting children to develop skills and become physically active. However, there also should be consideration of developmental gender differences and the impact such differences will have on performance outcomes when planning school based programs.

**Age and Gender Differences for Physical Activity, Perceived Motor Competence and Actual Motor Competence.**

*Physical activity in children*

Initial descriptive statistics examined age and gender differences among the key variables, physical activity, AMC and PMC. It was hypothesised that boys would have higher physical activity levels than girls across all ages. From the findings, boys did have significantly higher mean daily step counts than girls at every age from 6 to 9 years of age. The magnitude of these significant differences between boys and girls were moderate in the younger age groups (6- and 7-year-olds) and large in the older age groups (8- and 9-year-olds). The boys’ mean daily step counts also increased with age, whilst girls’ step counts remained relatively stable over the three year age span. The trends in physical activity levels will be firstly examined before discussing gender differences.

Previous research has reported that physical activity levels decrease with age in childhood, with the greatest decline being evident in the teenage years and the rate of decline being greater in females than males (Sallis, et al., 2000; Trost et al., 2000, Hands et al., 2004; Hands & Parker, 2008; Nader et al., 2008). However, most research examining age-related trends of physical activity has involved children older than 9 years old using subjective measures of physical activity. Thompson et al. (2003) administered a physical activity questionnaire biannually or triannually to Canadian children 9 to 18 years old in a longitudinal study. They reported that
physical activity levels were decreasing with increasing age in both boys and girls. Riddoch et al. (2004) also investigated physical activity with accelerometers in European children aged 9 and 15 years. The majority of boys (97.4%) and girls (97.6%) achieved the recommended guidelines of 60 minutes of daily moderate-intensity physical activity at age 9. By age 15, fewer children achieved these guidelines. One study involving young children also used accelerometers to record physical activity (Trost et al., 2002), and they reported a decline of physical activity in childhood and adolescence. Interestingly, they observed the greatest age-related decline occurred during primary school from grades 1 - 3 (6- to 9-year-olds) to grades 4 - 6 (10- to 12-year-olds).

The current study reported an increase in physical activity step counts with age (Refer to Figure 4), with the increase greater among the boys than the girls. These current data support other Western Australian studies also using pedometers that showed increasing activity levels from 7 years old which peaked at 14.3 years for males and 12.8 years for females before gradually declining (Hands et al., 2004). There was no decline in the current findings which suggests a reduction in physical activity is not currently a concern in this group of young children since they are sufficiently active. The average daily counts for 6-year-olds to 9-year-olds are all above the President Council on Fitness and Sport’s (2002) recommended daily step counts of 11,000 for girls and 13,000 for boys.

Gender differences in physical activity have been a focal point of previous research for years. Many studies have shown that boys are more physically active than girls from an early age (Garcia, et al. 1995; Sarkin, MacKenzie & Sallis, 1997). The current findings support these previous results with boys having significantly higher physical activity levels than girls at every age. Hands and Parker (2008) also used pedometers to assess physical activity and reported boys took significantly more steps per day than girls from 7 years to 16 years. Telford et al. (2005) also observed gender differences in physical activity levels in Australian children as young as 5 and 6 years old, particularly for vigorous-intensity activity. Even though the physical activity measurement tools differed between studies, both highlight the activity differences in boys and girls even from a young age.
Boys have not only been reported as being physically active for longer and more often but also at a higher intensity. Several studies have found that girls participate in significantly less MVPA in comparison to boys (Trost et al., 1996; Trost et al., 2002; Sherar et al., 2007; Commonwealth Department of Health and Ageing, 2007). Trost et al. (2002) proposed that gender differences are perhaps evident because boys participate in greater intensity activity, therefore their overall activity levels are higher than girls.

Although significant differences between male and female step counts is a key finding, and gender differences have certainly been a focus for earlier research, it is important to note that that these young boys and girls both exceed physical activity benchmarks (President Council on Fitness & Sport, 2002). However, the current study has emphasised that boys and girls are developmentally different, therefore perhaps for a change in future research and direction, there is a need to cease comparisons of girls to boys and produce outcomes and pathways for girls that are distinctive, rather than discussing them as inferior based on their level and intensity of activity when evaluated against boys. On the other hand, it may also be important to focus on AMC and PMC’s changing contribution to physical activity and in determining gender differences in later childhood and adolescence where declines in physical activity below sufficient levels evidently becomes a more serious problem.

*Actual motor competence in children*

For AMC, the key finding was boys had significantly higher AMC than girls at every age (Refer to Figure 7). This confirmed the initial hypothesis proposing that boys would record higher AMC scores in comparison to girls. The magnitude of these differences between boys and girls were large in the youngest (6 years) and oldest ages (8 and 9 years), and moderate in 7-year-olds. In previous cross sectional and meta-analysis research, boys were found to be more skilful than girls in childhood. This difference increased into the adolescent years (Branta, Haubenstricker & Seefeldt, 1984; Thomas & French, 1985; Ulrich, 1987; Eaton, 1989; Raudsepp & Pasuuke, 1995; Hands & Larkin, 1997). However, whilst previous research support the current findings in that gender differences were apparent, most previous research has focused on gender differences within different fundamental motor skills, rather than differences between boys and girls in overall motor competence. It is also
difficult to compare due to researchers using a variety of measures to assess skill competence. Although developmental change in individual skills was not a focus of this study, the following section provides a brief overview of previously reported gender differences in specific skills.

Reported gender differences in performance of locomotor tasks, such as running and jumping, favouring either boys or girls are not consistent. For example, some studies reported boys out performing girls on most locomotor tasks (Morris et al., 1982; Thomas & French, 1985; Keogh & Sugden, 1985), with exception of the hop and skip. However, Branta et al. (1984) found no gender differences for the run and standing broad jump. These studies were all based on quantitative results, generally emphasising speed or strength. Cratty (1986) and Roberton (1984) suggested that boys were better on quantitative, force production tasks like the jump, but girls were better performers on qualitative testing of balance and the hop and the skip. Using qualitative assessment in 1- to 8-year-old children to score patterns of motor skills from stages 1 (immature form) to 5 (mature form), Haubenstricker, Branta and Seefeldt (1999) found that girls mastered each stage of hopping and skipping earlier than boys. Dynamic balance is most commonly tested by a line or beam walking task, as used in the current study. However, few studies have investigated gender differences for these tasks with Plimpton and Regimbal (1992) reporting no significant gender differences for walking forward on a balance beam.

For object control tasks, such as throwing and catching, researchers have consistently reported results favouring boys. From Haubenstricker, Branta and Seefeldt’s (1999) qualitative assessment, boys attained each stage of the overhand throw and kicking at an earlier age than girls. In other qualitative studies, boys were also reported as more proficient in their throwing action than girls (Raudsepp & Paasuke, 1995; Raudsepp & Pall, 2006; Wrotniak et al., 2006). Using throwing distance as a quantitative measure, boys outperformed girls in the overarm throw (Halverson, Roberton & Langendorfer, 1982; Morris et al., 1982; Thomas & French, 1985; Nelson, Thomas, Nelson & Abraham, 1986; Goodway & Rudisill, 1996). McKenzie et al. (2002) also used quantitative assessment to measure catching skills in children 4 to 6 years old, and found that boys scored significantly higher than girls on the number of successful catches from six attempts. Other previous research on catching skills has
also reported results favouring boys using both quantitative (Thomas & French, 1985) and qualitative (Kelly, Reuschlein & Haubenstricker, 1990) assessments. Measures of overall actual motor competence vary in the literature. In the current study AMC was measured by deriving a composite score from a criterion-based assessment of the run, throw, jump and line walk using a methodology adapted from previous assessments of movement skills in Australian adolescents (Okely et al., 2001a; 2001b). Raudsepp and Liblik (2002) and Rudisill, Mahar and Meaney (1993) both investigated age and gender differences of AMC in cross sectional studies. Rudisill et al. (1993) measured AMC on a series of gross motor tests including 50 metre run, shuttle run, standing broad jump, and over arm throw. Raudsepp and Liblik (2002) assessed AMC through fitness measures including shuttle run, sit-ups and the sum of five skinfolds. Both reported boys having significantly higher motor competence than girls between the ages of 9 to 13 years old. Actual motor competence scores within the current sample suggest gender differences are apparent from an early age.

It is most likely that both biological and environmental factors ultimately contribute to gender differences (Nelson et al., 1986). Yet, not all studies reported skill performances favouring boys, and this could be partly attributed to differences in measurement protocol (quantitative measures or qualitative observations), or age-related biological differences. Sarkin et al. (1997) proposed that gender differences in motor performance were related to higher levels of physical activity among boys in free time. This concept is based on an understanding that they develop greater skill levels from being more physically active. However, this assumption was based on correlation data, and the question still remains whether motor skill enhances activity level, or whether the time spent in activity enhances motor competence (Butcher & Eaton, 1989). Consideration must also be given to the variation in measures of both motor competency and physical activity. Differences in research design, the operational definition of motor competence and the method of assessing and reporting physical activity and actual motor competence have contributed to the equivocal findings in this research area (Okely et al., 2001a). However despite variations in measures of physical activity and AMC, the common findings to emerge are that boys are, in general, more active and have higher proficiency in the early years.
Perceived motor competence in children

Overall, the PMC scores in the current sample were shown to be high. Across the three year age span, the boys’ scores remained consistently high, although the girls’ scores decreased slightly from 6 to 9 years old.

Harter and Pike (1984) suggested children’s perceptions of competence in various domains (academic, physical ability, appearance) are clearly differentiated by around 5 years of age. Though children can distinguish between particular domains, on entry into school most children’s self perceptions are very positive but potentially unrealistic as they often do not match their actual competence (Wigfield, 1994). In middle childhood, previous results are inconsistent regarding age-related trends in self perceptions for the physical /sport domain. In their longitudinal study, Wigfield et al. (1997) reported no age differences in competence perceptions across middle childhood, whereas Marsh et al.’s (1984) cross sectional research reported age related declines in children from 7 to 10 years old. More recently, Jacobs et al. (2002) investigated self perceptions of children across grades 1 to 12 in the sports domain as part of a longitudinal study. They found minimal changes in perceived competence in the first years of school and then a steep decline through the primary and high school years, with the competency measures of both boys and girls declining at the same rate.

Harter (1982), Nicholls (1984) and Rudisill et al. (1993) all found no differences in PMC scores for 9- to 11-year-old children. These investigators argued that age differences do not exist at these ages because of similarities in cognitive functioning. According to Piaget (1955), it is not until ages 11 or 12 years that children advance into the formal operational intelligence stage in which children are capable of problem solving and performing logical and abstract thinking. With the advancement of cognitive processing abilities, a child is more critical in their self-evaluation and begins to develop the ability to differentiate the “real” self from the “ideal” self (Horn, 2004). Despite the inconsistency of previous findings about when self perceptions become more accurate, developmental trends are still evident. For early childhood, the current study supports some of the previous findings of Eccles and Harold (1991) and Wigfield (1994) that self perceptions are unrealistically high in
the early primary years and the scores remain relatively consistent up to 9 years of age, especially for boys.

There were also no significant gender differences at any age in this study, therefore, the null hypothesis is accepted. Girls’ recorded higher perception scores at 6 and 7 years old compared to the boys who recorded higher scores at 8 and 9 years old. However, previous cross sectional Australian research by Marsh et al. (1983; 1984; 1991) with the Self Description Questionnaire, which reported large sex differences in self concept for physical ability with boys having significantly higher perceptions than girls in 5- to 10-year-old children. Significant gender differences have also been reported in 8- to 13-year-olds, boys had higher levels of perceived competence than girls (Harter, 1982; Harter & Connell, 1984; Harter & Pike, 1984; Ulrich, 1987; Raudsepp et al., 2002). Rudisill et al. (1993) suggested that the higher PMC in boys may be related to the fact that boys’ AMC is higher than girls, although it appeared the significant differences in actual competence for boys and girls in the current study did not reflect significant differences in self perceptions.

Other studies have also indicated that boys are more accurate than girls in assessing their own physical competence (Horn & Hasbrook, 1987; McKiddie & Maynard, 1997). This question of gender and congruency is addressed further in the next section on the development of the relationship between perceived and actual motor competence in young boys and girls.

**Relationship between Actual Motor Competence and Perceived Motor Competence**

One of the key research questions in the current study addressed the nature of the relationship between actual and perceived motor competence in young children. A direct relationship was proposed between AMC and PMC in boys and girls. Although no significant relationship was evident in the 6-year-olds for either boys or girls, a moderately positive and significant relationship became apparent in the older age groups. For boys, this significant relationship was evident at an earlier age (7-year-olds) than girls (8-year-olds). Interestingly, 9-year-old girls showed a stronger positive relationship whilst for boys the relationship remained constant with a moderate significant relationship (Refer to Table 3).
The current study is one of the few that has looked at developmental changes in this relationship in children younger than 9 years. Although earlier research has investigated determinants of physical activity, previous studies into the relationship between perceived and actual motor competence have focused on children 9 to 13 years old. Of interest, findings from the present sample of young children are similar to those with slightly older children.

According to Roberts (1984), the correlation between children’s PMC and AMC increases with age. This is comparable to the significant relationship that emerged with age in the current study, particularly with girls from 8 to 9 years of age. Harter (1982), when developing her scale for measuring children’s perceived competence, also noted that accuracy of children’s perceptions improved until about 8 years, and then showed no further improvement in accuracy until 12 years. Both Rudisill et al. (1993) and Raudsepp and Liblik (2002) examined the cross-sectional relationship between perceived and actual motor competence in 9- to 13-year-old children, however they used different measures than the current study to examine perceived and actual motor competence. Raudsepp and Liblik (2002) used fitness measures only as an assessment of AMC (shuttle run, 30 seconds sit-up test, sum of five skinfolds) and measured PMC with Motor Skill Perceived Competence Scale. Rudisill et al. (1993) derived an upper and lower body factor for AMC from a motor test battery including shuttle run and 50 yard dash, standing long jump and two ball throws. They assessed PMC through the Children’s Physical Self Perception Profile (CPSPP). Both studies found that these 9- to 13-year-old children were only moderately accurate at perceiving their AMC. This moderate correlation was also evident in the current sample for children younger than 9 years old, though the correlation is increasing particularly in girls, whilst boys tended to level off at 9 years.

Overall, Rudisill et al. (1993) found that the correlation between perceived and actual motor competence increased significantly when age was added to the regression model ($r = .48$ increased to $r = .51$, $p < .03$). They also found that older children had significantly higher actual motor competence scores than younger children, yet there were no significant differences between the two age groups perceptions of motor competence. Therefore, as the ages of the children increased, AMC increased but
PMC remained the same. However, Harter (1982) and Rudisill et al. (1993) reported that despite these changes, the AMC and PMC of 9- to 11-year-olds’ did not become more congruent, as there were no significant changes in correlations with age.

In comparison, in the current sample, whilst significant differences between correlations in each age group were not found, a stronger relationship emerged with age, particularly for the girls. Both boys and girls had high PMC scores across all ages but whilst boys’ PMC scores remained relatively stable, the girls’ self perceptions decreased at 8- and 9-year-olds whilst AMC increased. The fact that boys had significantly higher AMC scores than girls at an earlier age, may also explain why a significant correlation between perceived and actual competence was clear earlier in boys than girls. Therefore, it might not be a case of young children becoming more accurate, instead AMC just increases so a greater association between perceptions and actual skill is evident.

Sources of information that can influence perceived competence change as children age. Previous explanations by Rudisill et al. (1993) and Raudsepp and Liblik, (2002) as to why 9- to 13-year-olds are only moderate assessors of their actual motor competence have proposed four psychological constructs which contribute to the development of accurate perceived motor competence proposed by Harter (1978). The four constructs, (1) past experience, (2) difficulty or challenge associated with outcome, (3) reinforcement and personal interactions with significant others, and (4) intrinsic motivation, are all evaluated by the individual in forming self perceptions of competence. Piaget (1955) found that by approximately 12 years of age, children reach the operational stage of cognitive development and become more competent at combining all the information (the four psychological constructs) into an accurate assessment of their own competence. At younger ages, children do not have the cognitive capacity to differentiate between the four constructs and develop accurate perceptions about their performance. However, Raudsepp and Liblik (2002) found that 12 and 13-year-old boys and girls were still not highly accurate in their perceptions of competence, leading them to speculate that perhaps the development of accurate self-perceptions continues through adolescence. McKiddie and Maynard (1997) also reported a relatively weak association between perceptions and actual
competence in 11- and 12-year-olds but a stronger association for 14- and 15-year-olds.

Previous authors investigating congruency between competencies have also focused on the sources of information chosen by children for judging their competence. Potential sources available to children include game outcome, parent’s evaluation, coaches’ evaluation, internal criteria (improvement, ease of skill learning), affect, and peer comparison (Horn & Hasbrook, 1986; Horn & Weiss, 1991; Weiss, Ebbeck & Horn, 1997; Horn & Amorose, 1998, Weiss & Amorose, 2005). According to Horn (2004) younger children rely more on parental feedback, simple task mastery, and effort, whilst older children and early adolescents rely on peer comparison, and evaluation and teacher/coach feedback.

More recently, Weiss and Amorose (2005) measured both level and accuracy of perceived competence in 8- to 14-year-old children. Cluster analysis revealed five profiles of children who varied in age, actual and perceived competence and accuracy, and by the importance they placed on information sources. However, profiles were not separated according to gender. Two of the profiles, Pretenders (high in self perceptions) and Optimists (lower in self perceptions), were both inaccurate in their perceptions of sport ability and in rating below average importance the subjective performance/improvement or feedback by coaches and parents for judging their sport ability. This finding supports Harter’s (1978) contentions that children with varying profiles of level, accuracy and sources of perceived competence will differ in related behaviours such as anxiety, motivational orientation and effort. The greater percentage of girls in the present study who preferred informal games and sport, compared to boys who preferred organised and competitive sport may relate to the different sources of information that boys and girls use to form their self perceptions. Boys prefer sports within a more competitive context, which may contribute to them forming perceptions based on peer comparisons and may explain the significant relationship between AMC and PMC developing earlier in boys than girls.

Future research should examine these sources of information with regards to the relationship between perceived and actual motor competence, not only with level,
age and accuracy, but also with gender. The current findings suggest that boys and girls may use different sources of information that could be contributing to accuracy of self perceptions across the primary years.

*Levels of Actual Motor Competence and Perceived Motor Competence and Level of Physical Activity.*

The children’s continuous scores for physical activity, PMC, and AMC were grouped into low, middle and high categories based on tertiles. These data were analysed for matching groupings of males and females within low and high tertiles of physical activity corresponding with low and high tertiles of perceived and actual motor competence. Overall, more boys than girls were in the high physical activity and high AMC tertiles and also high PMC and physical activity tertiles. More girls than boys were in the low physical activity and AMC groups, and low physical activity and PMC groups (Refer to Table 4 and 5).

Few studies have compared the congruency between males and females who are high or low active, and their levels of PMC and AMC. However, Hands et al. (2004) classified Western Australian children and adolescents into high, medium, low activity groups based on mean daily step counts. They found that twice as many females as males were represented in the lowest active group, while the reverse was apparent in the high active group. Also, the high active, primary-aged group participated in slightly more vigorous sports activities and active transport bouts that the low active groups. For younger children, Butcher and Eaton (1989) investigated levels of gross and fine motor proficiency in association with free play behaviour and activity level in 5-year-old preschoolers. They reported that whilst girls had better visual motor control, they spent significantly more time in low active play, whereas boys had better running scores and spent more time in high active play. Children who participated in high active, gross motor play were more likely to have good running skills, while children who participated in low active, fine motor play were more likely to have good visual motor control and balance. However, Butcher and Eaton (1989) caution that causal direction is not determinable from correlational data, and whether proficiency in gross motor tasks helps activity level and tasks, or whether time spent in practice and activity produces proficiency remains an open question.
More recently, Fisher et al. (2005) examined the relationship between movement skills scores and habitual physical activity levels in young children 4 years old. Physical activity was measured over 6 days via accelerometers and 15 movement skills were assessed using the Movement Assessment Battery (Smits-Engelmen, Henderson & Michels, 1998). Movement skill level was classified by quartiles and compared with total physical activity and intensity levels of physical activity. The levels of physical activity intensity were classified as sedentary, light-intensity, and moderate-vigorous (MVPA) intensity physical activity based on cut off points for accelerometer counts per minute. Whilst there was no significant association between movement skills level and total physical activity for the children, there was a significant association between quartiles of movement scores and the percentage of time spent in moderate-vigorous physical activity. In both boys and girls, those in the upper quartile of movement skills spent significantly more time in MVPA compared to those children in the lower quartile of movement skills. Children with the most limited engagement in MVPA also had the poorest performance in the motor skills assessment. Fisher et al (2005) suggested a two-way interaction is possible, that limited performance in MVPA might hinder the opportunity for motor skill development or that limited motor skill development might restrict participation in MVPA.

As previously mentioned in this chapter, Wrotniak et al. (2006) also found that in 8- to 10-year-old children, motor proficiency was positively associated with physical activity and negatively related to percentage of time in sedentary activity. Motor proficiency was measured by BOTMP and when separated into quartiles of motor proficiency, children in the highest quartile were the most physically active compared with children in the lower quartiles who had lower levels of physical activity. However, they found that there was no association between level of self perceptions and level of physical activity. Li and Dunham (1993) also reported in physical education classes, children with movement difficulties were engaged in MVPA for less time compared with children with moderate or high competence levels.

Children with motor coordination difficulties engaged in significantly less time in vigorous activities than well-coordinated children (Bouffard et al., 1996). Despite the
lack of gender comparisons in previous work, evidence suggests that overall the level of AMC is linked to both level and intensity of physical activity in children. However, there are no clear findings that the level of perceived competence is related to level of physical activity.

It was originally hypothesised that girls and boys with higher levels of both AMC and PMC would have higher levels of physical activity. However, even though there was a greater percentage of boys than girls with both high AMC and physical activity levels, and also high PMC and physical activity levels, the percentage of boys within these high tertile groups were still only moderate, suggesting that there is still a lack of congruency between actual and perceived competence levels in these young children and the direct link to physical activity levels is still not clear.

Revised Conceptual Framework

Initially, the conceptual framework for this mixed-longitudinal study was based on the Welk (1999) and Stodden et al.’s (2008) models of the relationship of AMC and PMC to physical activity across age and gender. The results of the study have clarified some of the developmental differences between boys and girls and the conceptual framework can now be re-evaluated. The revised model is more specific for boys and girls in the early primary years and takes account of the significant contribution of AMC at any earlier age in boys than girls, the significant relationship between AMC and PMC earlier in boys than girls, the lack of input from PMC, the influence of contextual factors such as type of play choices at different ages, and the significant contribution of school to physical activity levels. Boys’ and girls’ preferences for competitive sport or informal play have been included given their links to the development of PMC and AMC.

The conceptual model has now been changed to distinguish between boys and girls at each age and specify emerging relationships based on the empirical evidence. Figures 9 to 12 represent the building relationships between AMC, PMC and physical activity. The significant contribution of AMC from 7 years of age in boys (Figure 10) and 9 years of age in girls (Figure 12) is represented, as is the significant relationship between AMC and PMC evident firstly in 7-year-old boys (Figure 10) and then in 8-year-old girls (Figure 11). Preferred types of play choices and the
influence of school are also displayed. For boys and girls at different ages, the
distinct lines within the Figures represent the strength of the relationships between
AMC, PMC and contributions to physical activity. The weak relationship line in the
legend represents AMC and PMC correlation values ≤ .2 and within the regression
models ≤ 5% physical activity variance explained. The moderate relationship line
represents correlation values between .2 - .5 and between 5 - 30% variance
explained. The strong relationship line represents correlation values ≥ .5 and ≥ 30%
variance explained.

Figure 9. Conceptual model for 6-year-old boys and girls. There were no significant
contributions from AMC or PMC to physical activity in either boys or girls. The
influence of different play choices for boys and girls and school is displayed in all
Figures
Figure 10. Conceptual model for 7-year-old boys and girls. The significant contribution of AMC to physical activity and relationship between AMC and PMC is evident in boys only.

Figure 11. Conceptual model for 8-year-old boys and girls. The continuing significant contribution of AMC to physical activity in boys is represented. A significant relationship between AMC and PMC is evident in both boys and girls.
Figure 12. Conceptual model for 9-year-old boys and girls. The significant contribution of AMC to physical activity in both 9-year-old girls and boys is evident. A significant relationship between AMC and PMC was found for boys and girls.

Conclusion
Given the value of physical activity to a developing child’s health, the current study has provided insight into the contribution of perceived and actual competence to physical activity behaviour. For the young children in this study, actual motor competence is important in influencing physical activity level, particularly with age. Additionally, school was revealed as having an important effect on physical activity in young children. This poses questions for future research into what specific characteristics within schools may positively influence physical activity. The diversity between boys and girls that emerged also demonstrates the need for a greater understanding of the influences and activities in young children that may explain the different developmental pathways of physical activity behaviour. Ultimately, these relationships are influenced by contextual factors, such as play choices, environment, peers, family and culture, that impact on an individual’s opportunity to be active (Stodden, et al., 2008). Our knowledge of these influences in young children will enable us to provide better direction and greater opportunities for physical activity at an early age.
CHAPTER SIX

SUMMARY AND CONCLUSIONS

The dynamic and evolving relationship between perceived motor competence, actual motor competence and physical activity in young children was examined in this study.

Summary
A total of 201, 6-, 7- and 8-year-old boys and girls living in Perth, Western Australia were assessed on physical activity levels, perceived motor competence and actual motor competence in four data collection cycles across 18 months. The purpose of the mixed-longitudinal study was to investigate the emerging nature of the relationship between perceived motor competence, actual motor competence and physical activity over time in young children. The primary instruments for gathering data for this study were pedometers and physical activity diaries for physical activity, the Self Description Questionnaire - I (Marsh, 1988; 1990) for perceived motor competence and observation records from the Fundamental Movement Skills Teacher Resource Manual (Education Department of Western Australia, 2001) for actual motor competence.

To measure physical activity, participants wore a pedometer for 7 consecutive days. Participants, with assistance from parents, completed the diary at the end of every day over the 7 day period, including participation in any activities before school, recess, lunch, after school, any physical education or fitness classes, and the number of steps recorded. For perceived motor competence, participants answered 5-point Likert scale questions based on a scoring system of 1 (No always) to 5 (Yes always) and a total score out of 120 recorded. Actual motor competence was measured by videoing run, overhand throw, standing broad jump, line walk and scored as the number of skill criteria demonstrated. A total actual motor competence score out of 26 was possible from the combination of criteria for all 4 skills.
Key Findings

1. Boys recorded higher step counts and greater actual motor competence than girls at every age.
2. There were no significant differences between boys and girls in perceived motor competence scores at any age.
3. The relationship between perceived and actual motor competence was weakly correlated in 6-year-olds. The degree of congruency strengthened earlier in boys (7 years) than girls (8 years).
4. Actual motor competence made a greater significant contribution to physical activity levels than perceived motor competence. This was evident at an earlier age in boys (7 years) than girls (9 years).
5. Actual motor competence, gender and school the children attended significantly impacted on physical activity across the 18 month period in young children.

Limitations

The interactions between perceived motor competence, actual motor competence and physical activity in young children will require further investigation as some degree of caution is necessary when interpreting results for a number of reasons. First, the measurement of the variables within this study is one of the key issues and challenges within developmental research of young children. Other limitations relate to specific data on schools that was not collected. School was an important contributor to children’s physical activity, affected the sample size, and therefore the generalisation of these findings to other cultures and age groups.

Measurement issues

For each of the three variables measured in the current study, a wide range of assessment tools are available. Many direct, such as accelerometers and pedometers, and indirect, such as self report, measures have been used to examine various aspects of physical activity behavior in young children. The validity and reliability of physical activity measures in young children is still being scrutinised. The decision to use pedometers in this study was based on the established validity and reliability of using these tools with young children (Hands, Parker & Larkin, 2006). The other advantages of low cost, ease of interpretation, and suitability for measuring daily step
counts were also considerations (Bassett et al., 1996; Rowlands, Eston & Ingledew, 1997; Hands, Parker & Larkin, 2001). However, due to a lack of agreement on which measures to use, it is often difficult to compare findings given there is considerable disparity in protocol and methods.

A similar problem exists when measuring actual motor competence given that there are many different measures used to assess motor development, motor ability, motor competency and motor proficiency. Although there are consistencies in findings, researchers must be cautious when making direct inferences across diverse methodologies. Another limitation relates to the use of qualitative observation tools to assess actual motor competency, which, despite being used in various studies of fundamental movement skills in Australia, specific protocols have not been validated.

Furthermore, Stodden et al. (2008) believes meaningful relationships between physical activity and motor competence is not shown in previous work because assessment of this relationship does not consider the developmental nature of actual motor competence. The different approaches for measuring motor competency have focused on scores representative of either “product” (quantitative) as a result of the child’s movement (e.g. number of hits or catches) or “process” (qualitative), a child’s way of moving. Stodden et al. (2008) stated that the problem with studies that have used the process approaches to measuring motor skill competence are that none have related the movement description to a developmental continuum.

A number of previous researchers have proposed different developmental sequences for motor skill mastery and ability (Wickstrom, 1983; Roberton & Halverson, 1984; Seefeldt & Haubenstricker, 1982; Hands & Larkin, 2001). Both Wickstrom (1983) and Seefeldt and Haubenstricker (1982) described developmental sequences for motor skills from a whole body approach, which views developmental change as a process that occurs throughout the whole body simultaneously at given ages. Seefeldt and Haubenstricker (1982) then took into account gender differences and created separate time lines for boys and girls of the developmental levels of eight motor skills between 12 months and 10 years of age. Roberton and Halverson (1984) described developmental sequences for motor skills from a component approach,
which views developmental change as occurring within different parts of the body at different stages from 1 (least proficient) to 3 (most proficient). Hands and Larkin (2001) had also considered gender differences and produced separate developmental scales for boys’ and girls’ motor ability. Furthermore, Walkley (VICED, 1996) developed an age and acquisition sequence for separate motor skill criteria as part of the Victorian Education Department Manual for Fundamental Movement Skills. Both Hands and Larkin (2001) and Walkley (1996) used the item-response theory to locate motor ability (Hands & Larkin) and skill components (Walkley) on a scale of difficulty. Walkley (1996) then created a developmental continuum for the sequence of mastery of the skill components based on a child’s age which was then tabulated for eleven movement skills.

In summary, there have been different approaches in describing developmental sequences for boys and girls and their mastery of skills, the whole body approach (Wickstrom, 1983; Seefeldt & Haubenstricker, 1982) and the component approach (Roberton & Halverson, 1984), whilst there has also been a sequence of acquisition developed by age for mastery of specific skill criteria, however gender difference was not considered (Walkley, 1996). Stodden et al. (2008) also suggested when using criteria in comparison with an “expert” performer, the components in observation checklist used to assess skills can be too simplistic; often resulting in ceiling effects that are unable to differentiate between a child with low level skills and a child who is more skilled. However, the method of constructing a composite score based on criteria mastered within each skill has been used in previous research (for example Okely, 2001a; 2001b). Unfortunately overall, there has been a lack of recent progress on a developmental continuum of actual motor competence. The findings from this study emphasise that boys and girls have different developmental paths of motor competence which need to be acknowledged.

Influence of school

The study revealed that school was a significant main effect in young children’s physical activity levels. A key concern at the beginning of the study was recruitment of individuals rather than the potential of school influence, therefore school characteristics (equipment, play areas, specialist physical education teachers) were
not recorded so plausible explanations of how the school setting might influence physical activity were not possible.

The order in which school visits occurred was replicated through each data collection cycle so the time between each collection was around 6 months. However, at times it was unavoidable for the order to be interrupted as the testing days often had to accommodate things such as school carnivals and school holidays.

The sample for this study was limited to Western Australian children from primary schools in middle socio economic areas, therefore results are not generalisable to other cultures or broader socio demographic areas.

Although it is common for young children to be inconsistent when performing motor skills and performance can be affected by such factors as level of motivation, feeling tired or unwell, and short attention spans, the research design and sample size was calculated to account for any fluctuating performance.

**Implications**
The implications of these findings are now discussed in relation to three areas: theory, future research and practice.

**For Theory**
This study used two sources to develop the foundation for the original conceptual framework, first from the dynamic systems theory related to identifying ‘enablers’ and their dynamic interaction within development of complex behavior i.e. non-linear, changing, and secondly, Welk (1999) and Stodden et al.’s (2008) conceptual models. From previous empirical studies, the current research identified physical activity as the behavior emerging from the influence of interacting control parameters of perceived motor competence, actual motor competence and the individual (age and gender differences). Based on the model developed by Welk (1999), emphasising the importance of perceived competence in influencing physical activity, and the model proposed by Stodden et al. (2008) purporting the value of actual competence, the conceptual framework considered the influence of these two determinants on physical activity in young children. The dynamic systems
theory proposes that whilst development may appear inevitable and pre-ordained, in fact there are no rules of development, only that behavior is emergent (Ulrich, 1997). There is complexity and relationships among behavioural subsystems and from these continuous developing processes children discover the fit between their capabilities and their goals to acquire stable and functioning behaviours.

At the beginning of the study, it was hypothesised that actual motor competence, perceived motor competence, age and gender of the individual would interact and impact to different extents on physical activity. The outcomes of the investigation revealed that in these young children actual motor competence, gender, and school influenced physical activity behaviour. Perceived motor competence however, did not contribute to physical activity in the early primary years. For boys, actual motor competence became more influential on physical activity with age and at an earlier age than girls. These empirical findings allowed for the refinement of the conceptual framework for the study to reflect the transition and changes in these dynamic relationships and the emergence of physical activity specifically for boys and girls at different ages.

This study emphasised gender as a key factor for understanding influences on children’s physical activity levels. In the formation of models and frameworks with explanatory power, consideration should be given to boys and girls developing physical activity behaviours differently, with determinants of physical activity having the potential to have differing influences both within the same age for boys and girls and across time.

For Future Research
Findings for this sample of young Western Australian children reveal the significant impact of key factors of actual motor competence, gender and school on physical activity levels in the early primary years. The fact that school emerged as a factor reveals that in future, closer examination into what school attributes may influence physical activity levels is warranted. Investigations could focus on the influences of features such as the importance of physical education programs, appointment of specialist physical education teachers, and physical environment (playground markings, equipment, ovals, play areas) on physical activity levels in children. Also,
future research may adopt a study design based on a cluster-randomised trial, with schools as the unit of randomisation. This means the variability would be captured both at the level of the cluster and also within clusters (such as students within schools). Therefore, future research of this nature would require an increased time frame for collection of data, a larger sample size and greater number of schools.

Additionally, with actual motor competence, but not perceived motor competence, being established as a significant factor in 6- to 9-year-old boys and girls, future longitudinal research should extend to middle and upper primary age groups to provide information about how the relationships with physical activity change over time. Stodden et al. (2008) proposed that the relationship between motor competence and physical activity will strengthen in late childhood and early adolescence while perceived motor competence will be a mediating variable. The revised conceptual framework illustrates the changing and developing relationship between physical activity, actual and perceived motor competence in younger children. Future research on these relationships focusing on late childhood and adolescence would test Stodden et al.’s (2008) conceptual model and contribute to the knowledge about the dynamics of these relationships.

As mentioned above, in order to advance research into motor competency there is a primary need for further progress on a common motor competence assessment instrument that not only considers the developmental continuum of skill proficiency (Walkley, 1996), but also the different pathways apparent in young boys and girls. The construction of a motor competence assessment tool may also provide concurrence amongst studies measuring motor competence. As stated previously, the pilot project for the development of a Fundamental Movement Skills (FMS) Quotient carried out during the study, attempted to validate and quantify movement observations of motor competence assessment for future research. An FMS quotient score was derived from run, throw and jump skill Z- scores of a small group of children from the current sample. The same children were then assessed using the MAND (McCarron Assessment of Neuromuscular Development). The Z-scores were normed around a mean of 100 and SD of 15 to equate to the NDI from the MAND. Ulrich (TGMD, 1985; 1999) had also developed a Gross Motor Development Quotient around a mean of 100 and SD of 15. In the current pilot, balance was not
included as scores did not differentiate between children this age. For the 10 boys and girls, a mean FMS Quotient for the three skills was 106.54 in comparison to a mean NDI of 105.43. Further expansion on this pilot will endeavor to provide validation for the measurement of AMC through observation of fundamental movement skill components. The emerging relationship between physical activity and actual motor competence in this study and the diversity in motor competence measurement, provide confirmation of the need for further advancement in an assessment tool for motor competence.

The important finding of gender differences raises questions regarding the comparative contributions of biological, environmental, and socio cultural factors in children’s development. Greater knowledge regarding both the physical competencies and type of play activities that young boys and girls consider important in their lives may also increase our understanding of why subsequent differences are apparent in the development of motor competencies and also self perceptions in boys and girls. Whilst it may be difficult to extricate the degree to which the influences interrelate and effect children’s physical activity levels, studies with older children and other cultures may assist in corroborating and further clarifying their role in development.

For Practice
The research has application to practice, particularly in the primary school setting and for physical activity interventions.

The emergent behaviour of physical activity over time is affected by gender, actual motor competence, and school. The challenge for teachers and physical education programs is to provide a learning environment which considers the relationship between actual motor competence and physical activity, but which also accounts for developmental gender differences. Again, having valid measures of motor skill competence will be critical to provide teachers with the tools to track the progress of young boys and girls. In addition, the learning environment of schools can provide both the setting and opportunities that can significantly impact children becoming proficient and practiced performers of fundamental skills. Overall, teachers and developers of education initiatives need to understand and provide opportunities that
recognise different developmental patterns of young boys and girls and how these differences impact performance outcomes.

Although perceived competence did not have a significant impact upon physical activity at these young ages, it appeared to have a strengthening relationship with actual motor competence. The extensive literature regarding the importance of perceived competence in motivating the individual and increasing his/her persistence at tasks means that perceived competence plays an important role in encouraging both effort and developing actual competence. Stodden et al. (2008) also proposed the shift from early to late childhood signified a period of vulnerability in which children who have lower actual motor competence will demonstrate lower perceived competence and are less physically active. Therefore, despite the presence of artificially high perceived competence in these younger children, one must question if this is really an important problem when the forthcoming years of middle and upper primary may be critical in fostering affirmative self perceptions. Horn (2004) also reported that the early childhood years are an important period in encouraging positive self perceptions and these perceptions are best facilitated through mastery experiences and provision of clear, consistent and constructive feedback from significant adults.

Conclusion
Finally, the need to comprehend the development of physical activity behaviours in young children was the inspiration for this research. The outcomes of this study provided longitudinal evidence into the impact of both a physiological and psychological determinant on physical activity. The empirically derived models for the study illustrated the important developmental changes of boys and girls across early childhood. If there is an understanding of the interactions and contributions of perceived and actual competence and acknowledgement of the resulting differences that are apparent in boys and girls, then evidence for education and health initiatives on what to base practice and provide direction for interventions, may support and encourage children’s lifelong commitment to physical activity and a healthy lifestyle.
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APPENDIX A

Physical Activity and Pedometer Diary
WHEN DO I WEAR THE STEP COUNTER?
Because the step counter is small it is easy to lose. The step counter should be worn at all times except:

- while you are swimming or playing with water
- during bath or shower times.
- while you are sleeping.

Each morning wear the step counter in the same position as you wore it the day before, on your right hip!

IMPORTANT RULES
1) Do not open your step counter - you might accidentally press the reset button.
2) Do not swap step counters with other students. The step counter is yours to look after for seven days.
HOW DO I FILL OUT THE DIARY?
Mum and Dad will help you fill in your diary.

1) Open the diary to the first page, write in today’s date. That is the day you are going to tell us about.

2) Answer the first questions about today and what you did before school.

3) If you can, after morning recess, lunch, physical education or sport think about what you need to remember to write in your diaries. You will notice that on the pages for Saturday and Sunday you will need to remember what you did before lunch and after lunch.

4) Take your diary home and keep it somewhere you will remember to fill it out each day.

5) Mum &/or Dad will help you record your activities in your diary, as well as the number of steps you take each day. You can read the step counter together when you take it off before going to bed. Enter the number in your diary and Mum or Dad will then reset your counter for the next day.

6) After your last day please remember to take your diary to school.

Thanks mum and dad for your help!
Today's Date: ____________ Wednesday
Today is the first day that you have worn your step counter.
Step Counts ________ taken at what time? ________
(Don’t forget to reset the counter)

<table>
<thead>
<tr>
<th>What did you do?</th>
<th>Did you huff and puff?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before school</td>
<td></td>
</tr>
<tr>
<td>How did you get to school?</td>
<td>Walk/bike/bus/car/scooter</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Recess</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch time</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>Physical Education or Sport</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>How did you get home from school?</td>
<td>Walk/bike/bus/car/scooter</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>After school</td>
<td></td>
</tr>
</tbody>
</table>

Did you wear the step counter all day since putting it on? Yes No
If no, how long was it off? ____________________________
Why? ____________________________

Did you do any of the following activities?
Ride your bike? Yes No
Roller blade or skateboard? Yes No
Go swimming? Yes No
Were you sick or injured? Yes No
Today's Date: ___________ Day: Saturday

Step Counts _______ taken at what time? _______

(Don't forget to reset the counter)

Did you take the step counter off before going to bed last night?  Yes  No

Did you put the step counter on when you got dressed this morning?  Yes  No

<table>
<thead>
<tr>
<th>What did you do?</th>
<th>Did you huff and puff?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before lunch</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>After lunch</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

Did you wear the step counter all day?  Yes  No

If no, how long was it off? ______________________________

Why? ______________________________

Did you do any of the following activities?

Ride your bike?  Yes  No

Roller blade or skateboard?  Yes  No

Go swimming?  Yes  No

Were you sick or injured?  Yes  No
SDQ1- (Edited for subscales and type of play choices)

Surname: ___________________ First Name: ___________________ Sex (M or F):
Year (K, 1, 2, 3): __________ School: ____________________
Age: ______ Date of Birth (e.g. 11/09/05): _____________ Today's Date ________

<table>
<thead>
<tr>
<th>No always</th>
<th>No sometimes</th>
<th>Child understands sentence but does not state yes or no</th>
<th>Yes sometimes</th>
<th>Yes always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can run fast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am good looking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I have lots of friends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I like to run and play hard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I like the way I look</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I make friends easily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I enjoy sports and games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I have a nice looking face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I get along with other kids easily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I have good muscles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am a nice looking person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td>I am easy to like</td>
<td></td>
<td></td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am good at sports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other kids think I am good looking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other kids want me to be their friend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can run a long way without stopping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I have a good looking body</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I have more friends than most other kids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I am a good athlete</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

149
Type of Play Questions (added by Fleur McIntyre to original SDQI – IA)

1. Some kids can’t wait to play active games, other kids would rather do something else, what do you like to do?
   Active Games
   Something Else
   ______________________

   What active games / something else do you like to play best?

2. Why?

3. Who do you like to play with?

<table>
<thead>
<tr>
<th>Mum and Dad</th>
<th>A lot</th>
<th>A little</th>
<th>Not much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brothers and Sisters</td>
<td>A lot</td>
<td>A little</td>
<td>Not much</td>
</tr>
<tr>
<td>Friends</td>
<td>A lot</td>
<td>A little</td>
<td>Not much</td>
</tr>
<tr>
<td>Other?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

EDWA Observation Records and Skill Criteria
# LINE OR BEAM WALK

<table>
<thead>
<tr>
<th>Global Check</th>
<th>Legs</th>
<th>Head and Trunk</th>
<th>Arms</th>
<th>Formal or informal observational setting</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Names</td>
<td>1. Uses sleepwalking action</td>
<td>2. Walks fluidly without pauses</td>
<td>3. Keeps both feet on the boundary, Toes pointed forward</td>
<td>4. Head and trunk stable and facing the foot</td>
<td>5. Uses arms when necessary to maintain balance</td>
</tr>
</tbody>
</table>

**Observation position** To either side

**Instruction** Walk along the line slowly and carefully. Keep your feet on the line.
# Sprint Run

<table>
<thead>
<tr>
<th>Global Check</th>
<th>Legs</th>
<th>Head and trunk</th>
<th>Arms</th>
<th>Formal or informal observational setting</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Names</td>
<td>✓ or ✗</td>
<td>1. Foot land along a narrow path</td>
<td>3. Head and trunk stable</td>
<td>5. Elbows bent at 90 degrees</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Footchez to buttocks and high knee lift</td>
<td>4. Eyes focused forward</td>
<td>6. Arms drive vigorously forward and backward</td>
<td></td>
</tr>
</tbody>
</table>

**Observation position**  To either side for legs. Front or back for placement of feet.

**Instruction**  Run as fast as you can
# JUMP FOR DISTANCE

<table>
<thead>
<tr>
<th>Global Check</th>
<th>Preparation</th>
<th>Propulsion</th>
<th>Landing</th>
<th>Formal or informal observational setting</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Legs</td>
<td>Head and neck</td>
<td>Arms</td>
<td>Legs</td>
<td>Arms</td>
</tr>
<tr>
<td>Names</td>
<td>1. Ankle bend and hips hinge</td>
<td>2. Eyes focused forward</td>
<td>3. Arms swing behind body</td>
<td>4. Legs straight</td>
<td>5. Both feet leave ground together</td>
</tr>
</tbody>
</table>

**Observation position**
To either side

**Instruction**
Jump as far as you can
## OVERHAND THROW

<table>
<thead>
<tr>
<th>Global Check</th>
<th>Preparation</th>
<th>Propulsion</th>
<th>Follow through</th>
<th>Formal or informal observational setting</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Legs</td>
<td>Arms</td>
<td>Legs</td>
<td>Head and Trunk</td>
<td>Arms</td>
</tr>
<tr>
<td>Names</td>
<td>1. Stands side on to direction of throw</td>
<td>2. Throwing arm moves in a downward and backward arc</td>
<td>3. Opposite leg to throwing arm steps forward</td>
<td>4. Hips turn shoulders rotate forward</td>
<td>5. Elbow bends as throwing arm moves behind head</td>
</tr>
</tbody>
</table>

**Observation position**
To the throwing arm side

**Instruction**
Throw the ball as far as you can

---

*Image and text content adapted from a physical education activity sheet.*
APPENDIX D

Research Team Confidentiality Agreement
Confidentiality Agreement for Research Team Member

(Research Team member)________________________________________

- I have read the Information Sheet and any questions have been answered to my satisfaction.
- I agree to treat all information gathered and data collected for the study, whether in printed, electronic or audio form, as strictly confidential.
- I agree to follow the designated research protocols.

Signed: Research Team Member:__________________________ Date:____________

Signed: Investigator:____________________________________ Date:____________

The Human Research Ethics Committee at the University of Notre Dame requires that all members of the research team are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the researcher, or please contact the Dean of Research, Office of Research Quality Management. 94330868.
APPENDIX E

Principal and Parent Information and Consent Forms
Physical activity plays an important role in children’s healthy development and early competence in motor skills is an important predictor of healthy development. Identifying key factors of physical activity in early childhood is essential, to increase activity levels in young children and lead to a physically active lifestyle in future years.

In this project we will investigate the contribution of perceived motor competence, and actual motor competence to physical activity in boys and girls from ages 6-8 years. This involves the participation of yourself and approximately 30 children (10 – 6 year olds, 10 – 7 year olds and 10 – 8 year olds) in your school. The project involves tracking the initial group of participants over 18 months and assessing them four times during this period. During the testing periods, a team of investigators will visit your school on two days during a week. They will conduct a series of skill assessments on the school oval as quite a large space is required. The testing will take approximately two hours.

Would you and your school like to help us by participating in this project?

If the children participate in the study, they will be asked to perform a series of skills to assess their motor competence. These activities include running, jumping, throwing and line walk and will be conducted on the school oval by the Chief Investigator. This session will be videotaped to enable us to reliably assess the children’s competence. Secondly, each child will wear a pedometer around his/her waist during waking hours for a 7 day period to capture periods of physical activity. Pedometers are quite unobtrusive and the children find them comfortable to wear. Children will be required to complete a simple diary for the 7 days, listing physical activities they have been involved in. Thirdly, the children will be asked to answer a Self-Description Questionnaire on their perceptions of their ability to perform motor skills.

This project requires children who are turning 6, 7 or 8 years old in January, February, March, April, May or June 2005. Your school is under no obligation to participate but if you are willing to help us with this study, we ask you to complete the consent form below.

You can be assured that this information will be treated confidentially and that your children’s data will remain anonymous.
SCHOOL OF HEALTH SCIENCE

MEASURING PERCEIVED MOTOR COMPETENCE,
ACTUAL MOTOR COMPETENCE AND PHYSICAL ACTIVITY
IN YOUNG CHILDREN

Informed Consent for School Principal

I (Principal) ______________________________________________________ of
(School) ______________________________________________________

hereby consent to the children attending the school being volunteer participants
in the above project.

• I have read the Information Sheet and any questions have been answered
to my satisfaction. I agree that the children may participate in this study,
realising that I, or the children, may withdraw at any time without prejudice.

• I understand that all information gathered is treated as strictly confidential
and will not be released by the investigator unless required to do so by law.

• I agree that research data gathered for the study may be published provided
the children’s name or other identifying information is not used.

Signed Principal: __________________________________________ Date: ___

Signed: Chief Investigator:______________________________ Date: ___

The Human Research Ethics Committee at the University of Notre Dame
requires that all participants are informed that, if they have any complaint
regarding the manner in which a research project is conducted, it may be given to
the researcher, or please contact the Dean of Research, Office of Research Quality
Management. 94330868.
Dear Parent,

Information

Physical activity plays an important role in children’s healthy development and early competence in motor skills is an important predictor of healthy development.

Identifying key factors of physical activity in early childhood is essential, to increase activity levels in young children and lead to a physically active lifestyle in future years.

The purpose of this study is to understand how the factors of skill level and the child’s perception of motor competence, contribute to physical activity. This project will guide primary school, education and health initiatives in promoting the importance of perceived competence and actual competence in motor skills to encourage children to be physical active and contributing to a healthier lifestyle.

During a 7 day period on each occasion, a variety of measures (listed below) will be collected. This means your child will be assessed on four occasions at 6 month intervals over 18 months. The assessment will involve the following tasks:

- Physical Activity measures
  - Pedometer (step counter): The child will wear a pedometer for 7 days during waking hours. It is a small electronic device that records how many steps a child takes during the day and is designed to measure physical activity. This instrument is quite unobtrusive and the children find them comfortable to wear
  - Diary: During this 7 day period the child will record in a simple diary, the main physical activities they undertake.

- Child’s Perception of Movement Skills
  - Self Description Questionnaire: The child will be assist the researcher (during this 7 day period at school), in filling out a questionnaire describing how he/she feels about their ability to perform certain movement skills.

- Motor Skill Measures
  - The child will complete the following skills during 30 minutes of the 7 day testing period; overarm throw for distance, standing broad jump, 50m run and line walk. The child will be videoed performing
these skills so the research team can adequately assess the skills later on. All these tasks are developmentally appropriate for children to perform and from my past research experience you can be assured that children enjoy doing them. Some children might experience muscle soreness the day after participating but this would be no greater than normally expected from running, throwing or jumping in a school sports carnival.

**Who is eligible for the study?**
The motor tasks will require physical exertion. If your child is **medically unfit** or has a chronic illness that medically precludes him/her from physical education then it would not be appropriate for them to participate in the study. This project requires children who are turning 6, 7 or 8 years old in January, February, March, April, May or June, 2005.

**Where will the assessment take place?**
A team of trained people will administer the assessments over the 18 months. They will ensure the children are properly warmed up, that there is plentiful drinking water and that adequate rest is allowed during tasks to minimise fatigue.

Meetings and skill assessments will take place at the school during school hours. At the conclusion of data collection, the research team will be pleased to post out your child’s individual results. Please be assured that all individual data, including video images, will be treated confidentially and accessed by the research team only.

All research information will be stored in a secured office at the University of Notre Dame. In reporting results I will use group averages and if individual results are reported, these will be anonymous.

To enrol your child in this study please **complete and sign the attached consent form** and return to Reception at (School) ________ by __________ 2005. A copy of this form will be returned to you.

Please note that parent AND child consent is required. Participation is entirely voluntary and either you or your child is free at any time to withdraw consent from further participation without prejudice in any way.

If you have any questions about this study, please contact Fleur McIntyre at the College of Health, The University of Notre Dame on 9433 0219 or email fmcintyre@nd.edu.au.

Yours Sincerely,

Fleur McIntyre
Doctoral Candidate
School of Health Science
University of Notre Dame Australia
MEASURING PERCEIVED MOTOR COMPETENCE, ACTUAL MOTOR COMPETENCE AND PHYSICAL ACTIVITY IN YOUNG CHILDREN

Informed Consent for Parent

I (parent/guardian’s name) _______________________________________

Of (address) ____________________________________________________

Contact numbers:
Phone number (work hours) __________________ (after work hours) __________

Hereby consent to my child (insert child’s name) __________________________

Please tick the boxes to indicate whether you consent to the following:

☐ I consent to my child being a volunteer participant in the above project

☐ (Optional) I consent to my child’s video footage or image being used as part of a research paper or conference presentation. I understand that any images or footage presented are treated as strictly confidential and my child’s identity will not be revealed.

☐ (Optional) I consent to my child’s individual results being passed on to my child’s school.

• I have read the Information Sheet and any questions have been answered to my, and my child’s satisfaction. I agree that my child may participate in this study, realising that I, or my child, may withdraw at any time without prejudice.

• I understand that all information gathered is treated as strictly confidential and will not be released by the investigator unless required to do so by law.

• I agree that research data gathered for the study may be published provided my child’s name or other identifying information is not used.

Signed: Parent/Guardian: _______________________________ Date: ____

Signed: Child: _______________________________ Date: ____

Signed: Investigator: _______________________________ Date: ____

The Human Research Ethics Committee at the University of Notre Dame requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the researcher, or please contact the Dean of Research, Office of Research Quality Management. 94330868]