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, Coviak, 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).

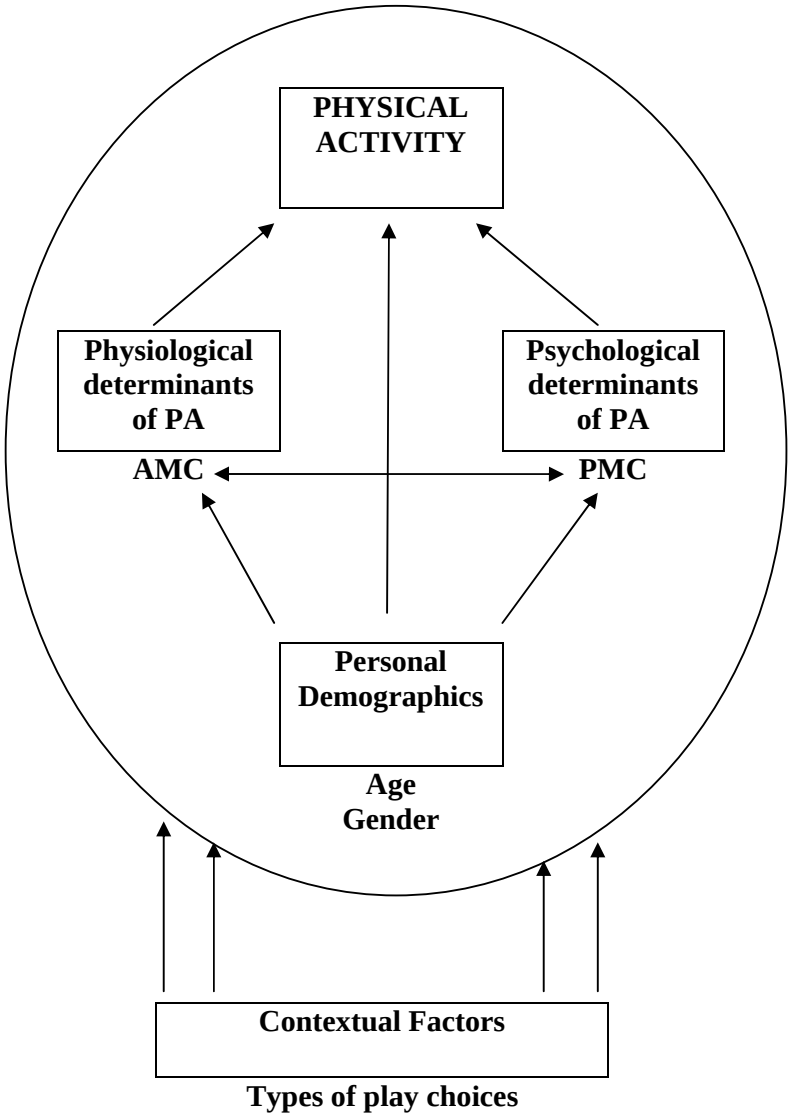

Figure 1. Conceptual framework for the current study, adapted from Welk's (1999) and Stodden et al.'s (2008) models and physiological and psychological levels of physical activity determinants (Lindquist, Goran & Reynolds, 1999).

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 an 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 assesses 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.