The Effects of Interventions on Fundamental Movement Skills, Physical Activity, and Psychological Well-being among Children

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STUDY 1: Associations of Fundamental Movement Skills and Physical Self-Perceptions with Physical Activity, Fitness and Percent Body Fat in 9-10 Year Old Children: The A-CLASS Project

STUDY 2: The Effects of a 9-Week Intervention on Fundamental Movement Skills, Physical Self-Perceptions and Body Mass Index in 8-9 year Old Children: An Exploratory Trial

STUDY 3: The Effects of a Group Randomised 12 month Intervention on Fundamental Movement Skills, Physical Self-Perceptions, Physical Activity, Fitness and Body Fatness in 9-10 Year old children: The A-Class Project

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ABSTRACT

A large proportion of UK children do not meet the recommended guidelines for participation in physical activity, which is a public health concern as the prevalence of overweight and obesity among children is rising. Increasing perceptions of competence and levels of fundamental movement skill proficiency are potential strategies to promote physical activity. The aims of this thesis were to, a) investigate the prevalence of skill proficiency and levels of perceived physical competence in UK children, b) examine the relationships between fundamental movement skill competence and physical self-perceptions with children's physical activity, fitness and body fatness, and c) determine the effectiveness of non-curricular interventions to increase fundamental movement skills and enhance perceptions of competence.

The first stage of research presented is the cross-sectional study of 152 children (41% boys; Age mean 9.7±0.3 years), which were recruited from 8 primary schools. Children completed the Children and Youth Physical Self-Perception Profile (CY-PSPP) and were assessed on 8 skills using video-analysis and process measures. In addition, cardiorespiratory fitness was directly measured during a treadmill protocol to exhaustion; body fat (%) was determined by dual-energy x-ray absorptiometry; and physical activity was assessed by accelerometers over 7 days. The results revealed that children generally had positive perceptions of their physical self. However, levels of physical self-perceptions did not significantly predict physical activity behaviour. Perceptions of physical condition and physical strength were weak predictors of cardiorespiratory fitness and percent body fat, collectively explaining 7% and 7.8% of variance. Children's perceptions of competence were not related to their actual competence levels. Prevalence of proficiency in fundamental movement skills was low-to-moderate in boys and low in girls. Chi-square tests revealed a significantly ($P < 0.01$) higher proportion of boys were rated as proficient than girls in the kick ($\chi = 37.4$), catch ($\chi = 25.3$), strike ($\chi = 28.4$) and throw ($\chi = 44.1$). Total skill score significantly ($P < 0.01$) accounted for 11% and 9.2% of the variance in physical activity and percent total body fat, respectively. Locomotor skills significantly ($P<0.01$) predicted 7.7% of unique variance in moderate-to-vigorous physical activity, 5.6% of total physical activity, 13.4% of cardiorespiratory fitness, and 23.7% of variance in percent body fat. Object-control skills weakly predicted total body fat (2%; P=0.04) but did not account for variance in other outcomes. This study highlighted the importance of fundamental movement skills to children's health and identified the need for interventions to enhance skill competence in older children.

The next stage of research sought to determine the efficacy of interventions to increase skill competence and physical self-perceptions. An exploratory study examined the effects of a 9 week afterschool multi-skills club on skill proficiency, physical self-perceptions and body mass index (BMI) in 8-9 year old children. Two schools were randomly assigned to either a comparison ($n = 15$) or multi-skill club ($n = 19$) group. The multi-skill club received 18 coaching sessions designed to improve movement skills, while the comparison group followed normal routines. Children completed the CY-PSPP and assessments of seven movement skills, and were measured for stature and mass to calculate BMI. It was found that children in the multi-skill club had higher BMI (P<0.05) and possibly lower perceptions of body attractiveness and physical condition than children in the comparison group at post-

test. Participation in the multi-skill club delivered significant ($P<0.01$) improvements in proficiency at post-test in static balance, whilst potentially practically important improvements were observed in performance of the catch, throw and kick skills. It was concluded that an afterschool multi-skill club offers a viable opportunity for movement skill acquisition, but any such programme would need to run for a longer duration to identify if this type of activity could benefit all skills.

The final study was unique in that it was the first study to assess the impact of three different 12 month interventions on children's skill levels and perceived physical competence. One hundred and fifty-two 9-10 year old children were randomised by school to one of four conditions: a bi-weekly high-intensity physical activity after-school club (HIPA; n=36); a bi-weekly multi-skill (fundamental movement skill) after-school club (FMS; n=37); a behaviour-modification programme (PASS; n=45); or a control-comparison (CON; n=34). Outcome measures, as employed within the cross-sectional study, were assessed at baseline, 9- and 12 months. It was found that participation in the FMS group was associated with moderate positive intervention effects on skill competence and increased the likelihood of attaining proficiency at post-test skill in 7 out of 8 skills. Participation in HIPA was associated with a small positive intervention effect on locomotor skill competence, and increased likelihood of proficiency in 5 skills, while PASS had no effect on skill competence but did increase the likelihood of attaining proficiency in 3 skills. In boys, participation in FMS and HIPA were associated with higher perceptions of sports competence, condition, and physical self-worth; HIPA elevated perceptions of strength, and, FMS increased perceived body attractiveness. PASS was associated with more positive perceptions of sports competence and body attractiveness at 9- but not 12-months. In girls, there were no positive intervention effects on CY-PSPP subscales, whilst all interventions were associated with more negative perceptions of body attractiveness. No group differences were found for body fat or physical activity, which increased from baseline to mid-test but fell sharply at post test in all conditions. Boys in HIPA improved fitness levels relative to controls, whilst girls participating in the FMS and PASS groups had lower fitness at post-test. It was concluded that multi-skill after-school clubs are most effective at improving fundamental movement skills. After-school clubs may provide a means to augment boys' perceptions of competence, irrespective of activity mode; however, after-school clubs do not appear to enhance physical self-perceptions in girls. Behaviour-modification programmes appear least effective at improving actual and perceived competence, but a combined structured exercise and behaviour modification programme may be necessary to improve health outcomes. A subsequent follow-up study is required to assess long term impact of the interventions.

The studies within this thesis have provided a detailed insight into the effects of different interventions on children's actual and perceived competence. To summarise, it was found that many children are not proficient at fundamental movement skills, which is important given their associations with important health outcomes. A multi-skill club programme can best impact such skills, whilst other forms of physical activity can also promote skill development. Perceptions of physical competence do not appear to have strong associations with children's health at this age. The influences of interventions on perceptions of competence appear complex and gender differences suggest that different forms of interventions may be necessary for girls.

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GLOSSARY OF TERMS

Δ	Change
ACLASS	Active City of Liverpool Active Schools and SportsLinx
ANCOVA	Analysis of Covariance
BMI	Body Mass Index (kg/m^2)
CON	Control-Comparison Group
CI	Confidence Interval
CPM	Counts Per Minute (physical activity)
CV	Coefficient of Variation
CY-PSPP	Children and Youth Physical Self Perception Profile
DXA	Dual-Energy X-ray Absorptiometer
FMS	Fundamental Movement Skills
HIPA	High-Intensity Physical Activity
HR	Heart Rate
IMD	Index of Multiple Deprivation
ISAK	International Society for Advancement in Kinanthropometry
MPID	Minimum Practically Important Difference
MSC	Multi-skill club
MVPA	Moderate-to-vigorous Intensity Physical Activity
n	Sample size
PA>4	Minutes spent in physical activity above $4 km \cdot h^{-1}$
PA>6	Minutes spent in physical activity above $6 km \cdot h^{-1}$
PA>8	Minutes spent in physical activity above $8 km \cdot h^{-1}$
PASS	Physical Activity Signposting Scheme
PSPP	Physical Self-Perceptions Profile

RER	Respiratory Exchange Ratio
SD	Standard Deviation
SES	Socio-Economic Status
V CO_2	Carbon Dioxide Production ($ml.kg^{-1}.min^{-1}$)
V O_2	Oxygen Uptake ($ml.kg^{-1}.min^{-1}$)
V O_{2Peak}	Peak Oxygen Uptake ($ml.kg^{-1}.min^{-1}$)

Chapter 1

Introduction

A large proportion of UK children do not achieve the recommended guidelines of 60 minutes of daily moderate-to-vigorous physical activity (Department of Health, 2004); a factor which has been linked to the increasing prevalence of overweight and obesity among children (Butland et al., 2007; Lobstein, Baur, & Uauy, 2004; Wang & Lobstein, 2006). This is important as obesity is associated with a number of serious health complications in children, including type 2 diabetes and non-alcoholic fatty liver disease (Ebbeling, Pawlak, & Ludwig, 2002; Loomba et al., 2009). Increasing pursuits of sedentary behaviours (video games, television viewing, internet surfing) have also been linked to the obesity epidemic and may restrict opportunities for physical activity (De Mattia, Lemont, & Meurer, 2007; Salmon et al., 2005). International concerns of an obesity epidemic have led the World Health Organisation (2004) to develop a "Global Strategy on Diet, Physical Activity and Health" and intensified the need to develop interventions to reduce the prevalence of obesity.

A recent Cochrane review highlighted a dearth of research on childhood obesity prevention studies, and many lack scientific rigour (Summerbell et al., 2005). The available evidence suggests that the inclusion of a physical activity component within the intervention discriminates between effective and ineffective trials (Connelly, Duaso, & Butler, 2007). Aside from obesity prevention and treatment; participation in physical activity has other important health benefits including reducing risk of cardiovascular disease and metabolic syndrome, and positively impacting skeletal and psychological health (Strong et al., 2005). However, there is scant evidence of successful trials to increase physical activity in children (van Sluijs, McMinn, & Griffin, 2007). Schools are popular settings for interventions as large numbers of children can be accessed simultaneously and school infrastructures are in place which can facilitate delivery of the intervention and cost-effectiveness (Stone, McKenzie, Welk, & Booth, 1998). However, there is inconclusive evidence that school-based physical activity interventions are effective in increasing habitual physical activity in children and more research is needed (van Sluijs et al., 2007). Additionally, most studies that have examined the effectiveness of school-based interventions have been conducted in the

United States, and there are concerns surrounding the generalisability of these findings to other cultures (van Sluijs et al., 2007). Two randomised controlled trials conducted in UK primary school children were not effective in increasing self-reported physical activity (Sahota et al., 2001; Warren, Henry, Lightowler, Bradshaw, & Perwaiz, 2003).

Interventions to increase physical activity within schools have primarily focused on changes to the physical education curriculum and some have demonstrated increases in physical activity within PE lessons as well as improvements in children's fitness (Sallis et al., 1997; van Beurden et al., 2003). Others have successfully increased physical activity during school recess following the introduction of playground markings (Ridgers, Stratton, Fairclough, & Twisk, 2007; Stratton & Mullan, 2005). School extra-curricular opportunities such as after-school clubs can also significantly contribute to children's habitual physical activity levels (Trost, Rosenkranz, & Dzewaltowski, 2008) and may provide an additional opportunity for interventions to increase physical activity.

Determinants of children's physical activity are complex. Recommended strategies to influence children's enjoyment and participation in physical activity include maintaining or enhancing perceptions of competence and mastery of fundamental movement skills (Fox & Wilson, 2008; Stodden et al., 2008; Weiss, 2000; Weiss & Ferrer-Caja, 2002). Fundamental movement skills are basic movements and include locomotor skills (e.g. hopping) and object-control skills (e.g. catching), whilst perceptions of competence reflect an individual's judgements about their ability (Weiss, 2000). These are identified as key determinants of physical activity, with mastery of skills thought to *enable* children to be more active and perceptions of competence potentially *predisposing* children to physical activity (Welk, 1999). That is, children who are proficient in basic movement skills will have high beliefs regarding their physical competencies and therefore be more likely to enjoy and sustain interest in physical activity than those who are less skilled and consequently low in perceived physical competence (Stodden et al., 2008; Weiss, 2000). Young children have high perceptions of their own competence but as they approach adolescence this changes and they become more aware of their ability, which has implications for their feelings and motivation (Harter, 1988b, 2003). For this reason, learning to move proficiently in the early years is essential, and provides the necessary foundation and confidence for lifelong physical activity.

Cross-sectional research highlights the importance of mastering movement skills and having high perceived physical competence to children's health, with both correlates associated with increased participation in physical activity, higher levels of fitness, and lower incidence of overweight and obesity (Crocker, Eklund, & Kowalski, 2000; Okely, Booth, & Chey, 2004; Okely, Booth, & Patterson, 2001a, 2001b; Ulrich, 1987; Welk & Eklund, 2005; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). The strength of these associations has been weak-to-moderate, which has led some to question the importance placed on motor skills within the paediatric exercise science field (Pate, 2001). However, this is likely due to methodological limitations and further research is needed (Stodden et al., 2008). Nevertheless, as skill competence appears to be associated with important health benefits it is important to establish the level of proficiency in children. Research from other countries has revealed worryingly low levels of proficiency (Booth et al., 1999; Okely et al., 2001a; Ulrich, 2000; van Beurden, Zask, Barnett, & Dietrich, 2002) but little is known about the prevalence of proficiency in UK children. These issues provided the rationale for the cross-sectional study in this thesis where perceptions of physical competence and the prevalence of skill proficiency were assessed in a representative sample of primary school children in Liverpool. Additionally, the importance of these variables to children's physical activity, fitness, and body fatness was also addressed.

Since 2004, there has been a shared Public Service Agreement (PSA 22) between the Department for Culture, Media and Sport and the Department for Education and Skills that schools should provide "a minimum of two hours each week on high-quality PE and 2 hours school sport within and beyond the curriculum" (Department of Health, 2004b; increased in 2008 to 3 hours of sport). Primary physical education represents an opportunity for children to develop competence in fundamental movement skills. However, as stated above, research from the United States and Australia suggests that many children are not gaining proficiency in such skills (Okely et al., 2001a; Ulrich, 2000; van Beurden et al., 2002), signifying that the quality and quantity of physical education is not sufficient for skill development. Increasingly in primary schools, time devoted to physical education is being limited to focus on core subjects (OFSTED, 2002). Physical education lessons are often brief and usually delivered by non-physical education specialist teachers (Morgan & Bourke, 2008). Additionally, physical education programmes have a number of objectives i.e. health-related fitness; cognitive, social and emotional development; as well as motor skill learning (McKenzie, Alcaraz, Sallis, & Faucette, 1998). Alternative opportunities for fundamental movement skill development may be necessary in order for children to reach levels of proficiency. Consequently, outside of school physical activities may provide a perfect chance for movement skill acquisition in children (Raudsepp & Päll, 2006).

Multi-skill clubs are designed to provide an out-of-hours opportunity for skill development. Multi-skill clubs were established as part of the United Kingdom government Physical Education, School Sport and Club Links strategy ((PESSCL) DfES/DCMS, 2003; now the Physical Education and Sport Strategy for Young People (PESSYP)), which, by the end of 2008, had received £978 million worth of government investment. The strategy is part of an overall objective to enhance the take up of sporting opportunities by 5-16 year olds. One programme within PESSCL – "Club links" aims to ensure young people maintain an active involvement in sport beyond school. As part of Club links, the Youth Sport Trust established 1,600 clubs by 2008 (see www.youthsporttrust.org). Multi-skill clubs are run as open access and regular sessions in which children aged 7-11 can increase their fundamental movement skills and general sport skills. Such clubs can take place in numerous settings including a child's primary school, at a local secondary school, or within a local authority leisure centre. Although the UK government has invested a significant amount of funds in the Multi-skill club programme, little is know about its effectiveness at improving skill proficiency or how long such clubs need to run for to gain competence in all forms of movement skills. Additionally, it is unknown whether other forms of physical activity programmes benefit movement skills and whether this investment is cost-effective. Behaviour-modification programmes seek to educate children to adopt healthy lifestyles, including participation in physical activity. It would be interesting to examine whether these interventions, which may not include structured exercise provision, can enhance movement skills.

Mastering skills is thought to increase perceptions of competence and, in turn, competency beliefs influence children's motivation to be physically active (Weiss, 2000). Although there is some evidence that children's actual competence and perceived competence are related (Raudsepp & Liblik, 2002), there is scant evidence of skill development programmes successfully increasing competence beliefs. In fact, there is limited paediatric research on the effectiveness of any form of physical activity programmes on enhancing perceptions of physical competence. Some have sought to increase competency beliefs through fitness activities (Walters & Martin, 2000), others have targeted adolescent girls through changes to physical education programmes including provision of dance lessons (Burgess, Grogan, & Burwitz, 2006; Lindwall & Lindgren, 2005; Schneider, Dunton, & Cooper, 2008). Findings have been mixed and more evidence is needed from randomised-controlled trials (Fox & Wilson, 2008), as it is important to establish the type, duration, and setting necessary to create a motivational climate to best impact physical self-perceptions.

In Liverpool, over one-third of children are classed as overweight or obese (Stratton et al., 2007) and physical activity has been identified as a key component of the strategy to combat obesity. The research within this thesis was conducted as part of the A-CLASS Project (Active City of Liverpool, Active Schools and Sportslinx), which is a multi-dimensional physical activity intervention conducted in primary school children from deprived areas of Liverpool. The A-CLASS Project was designed to support the PESSCL strategy (DCMS/DfES 2003) and was originally established to investigate the health impact of offering children two hours of physical education and two hours of school sport each week. The A-CLASS project was designed in partnership with the local authority SportsLinx team and the Partnership Development Managers from each of the 3 school sports partnerships that were in existence (subsequently increased to 4). Partners agreed the aims of the programme (which reflected the policies related to physical activity at that time) and approved the research evaluation framework. The project was co-ordinated by four 'Research Coaches' whose distinct role involved managing and delivering the intervention whilst simultaneously measuring the effectiveness of the programme. There were four main scientific themes within the project, with one Research Coach responsible for data collection and analysis in each area. These themes were:

1) Cardiovascular health
2) Body composition and bone health
3) Physical activity and cardiorespiratory fitness
4) Fundamental movement skills and physical self-perceptions.

This thesis represents the work of the Research Coach responsible for fundamental movement skills and physical self-perceptions arms of the project. As discussed above, mastery of movement skills and increasing perceptions of competence have been identified as potentially important determinants of physical activity in children but little is known about how best to enhance these variables. The significant funding allocated by the UK government to the multi-skill club programme warrants a robust evaluation. This provided the rationale for the 9-week exploratory study, which modelled a 'multi-skill club' to examine its influence on skill proficiency and physical self-perceptions. Additionally, the implementation of different types and durations of physical activity programmes would help to inform the scientific literature of the influence of such interventions on these important correlates. This provided the basis for a longer (12 month) definitive trial which included fundamental movement skill-development (multi-skill club), fitness and lifestyle interventions, and concomitantly assessed changes in physical activity, fitness and body fatness to help elucidate the mechanisms for the intervention effects.

The thesis comprises of the following three studies:

Study 1. A cross-sectional study in a sample of 9-10 year old Liverpool primary school children to examine the prevalence of skill proficiency and levels of perceived physical competence; and to assess the importance of fundamental movement skills and physical self-perceptions to children's physical activity, fitness and body fatness.

Study 2. An exploratory trial to investigate the effects of a 9-week bi-weekly after-school multi-skill club on the fundamental movement skill proficiency and physical self-perceptions of primary school children

Study 3. A 12 month intervention study investigating the effects of bi-weekly fundamental movement skill or high-intensity physical activity after-school clubs, or a lifestyle intervention on children's fundamental movement skills and physical self-perceptions with reference to changes in physical activity, fitness, and body fatness.

Chapter 2

Literature Review

2.1 Introduction

The purpose of this chapter is to review the literature concerning the physical activity behaviour of children and to examine the evidence surrounding the importance of fundamental movement skills and physical self-perceptions as key determinants of physical activity, fitness and obesity, thus setting the context for this thesis. Each topic will be reviewed separately and inter-relationships between variables will be discussed using evidence from cross-sectional, longitudinal and experimental research to form the basis of the rationale for each study.

2.2 Physical activity

The purpose of this section is to (i) define physical activity, (ii) briefly review the methods for assessing physical activity, (iii) discuss the health benefits of physical activity, (iv) identify the recommended guidelines for physical activity in children, (v) describe the proportion of children meeting the recommended guidelines, and (vi) review the key correlates and determinants of physical activity in children.

2.2.1 What is physical activity?

Physical activity is defined as "any bodily movement produced by skeletal muscles that results in caloric expenditure" (Caspersen et al., 1985, p.126). The terms 'exercise' and 'physical fitness' are often used interchangeably with physical activity, but each term has a distinct meaning. Exercise is a sub-category of physical activity that is "planned, structured, repetitive, and results in the improvement or maintenance of one or more facets of physical fitness." Physical fitness refers to "a set of outcomes or traits that relate to the ability to perform physical activity" (Caspersen et al., 1985, p.126). Components of physical fitness can be broadly categorised within two categories - skill-related (agility, balance, reaction time, speed and co-ordination) or health-related (aerobic fitness, muscular strength, muscular endurance, flexibility and body fatness) (Armstrong & Welsman, 2000). In this thesis, the terms 'physical fitness', 'fitness', 'endurance' and 'aerobic fitness' will be used to describe cardiorespiratory fitness, which is "the overall capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged exercise"(Ortega, Ruiz, Castillo, & Sjostrom, 2008, p.2). Thus, physical activity is an umbrella term for a series of health-related behaviours and represents an important component of total energy expenditure.

2.2.2 Measurement of physical activity

It is necessary to accurately assess physical activity in order to determine children's physical activity levels, to examine the effectiveness of interventions to promote physical activity, and to investigate the dose-response relationship between physical activity and health. Physical activity is an infinitely variable, unstable and complex behaviour, which is therefore extremely difficult to measure (Harro & Riddoch, 2000). The dimensions of physical activity include:

- Duration
- Intensity – measured as energy expenditure ($kcal \cdot min^{-1}$), oxygen consumption ($ml \cdot kg^{-1} \cdot min^{-1}$) or heart rate ($beats \cdot min^{-1}$)
- Frequency
- Mode or type (e.g. walking or cycling)

Over 30 different instruments have been developed to assess the dimensions of physical activity (LaPorte, Montoye, & Caspersen, 1985), but no single method is capable of assessing all aspects of behaviour. The difficulties associated with the accurate measurement of physical activity are often amplified in children due to the "cognitive, physiological, and biomechanical changes that occur during natural growth and development" (Corder, Ekelund, Steele, Wareham, & Brage, 2008, p. 978). Additionally, another complexity when measuring physical activity in children is the nature of their physical activity. Unlike adults, whose physical activity bouts are typically sustained periods of light to vigorous intensity, children's physical activity patterns are characterised by short, intermittent bouts of vigorous physical activity (Bailey et al., 1995; Baquet, Stratton, Van Praagh, & Berthoin, 2007), with up to 96% of activity bouts shorter than 10 seconds.

As such, a sub-group of methods have been selected for use in paediatric research. These include subjective methods such as self-report questionnaires, interviews, proxy-reports, diaries, and direct observation, and objective methods such as heart rate monitoring, motion sensors, indirect calorimetry, and the 'doubly water' method (Harro & Riddoch, 2000). However, there are a number of strengths and weaknesses attached to each assessment method (Dale, Welk, & Matthews, 2002). Doubly labelled water and indirect calorimetry techniques measure energy expenditure and are considered gold-standard assessment methods that are often used as a validation criterion against which other methods are validated. However, even these approaches have limitations. The doubly labelled water method is a non-invasive technique that uses biological markers to directly measure carbon dioxide production. The main disadvantages of this approach are that it is expensive; a measure of total energy expenditure (which includes the energy cost associated with metabolism at rest and the thermic effects of food rather than just physical activity energy expenditure); and is incapable of qualitatively describing physical activity patterns. Indirect calorimetry precisely measures energy expenditure using respiratory gas analysis of oxygen consumption and carbon dioxide production. However, this approach is disadvantaged by the high financial cost of the equipment, the invasiveness of the measure, and the lack of practicality of the method as a measure of physical activity in the field.

Another physiological assessment of physical activity that can be employed is heart rate monitoring. The disadvantages of this approach are that some monitors have limited recording capacity and so are not suitable for assessing habitual physical activity. Additionally, heart rate can be influenced by the climate and a child's emotional status, hydration, age, gender, and training status (Dale et al., 2002). Further, assessment is compounded by the time-lag of heart rate response to physical activity (Corder et al., 2008).

Direct observation represents a subjective method of assessing physical activity that is also used as a validation criterion. However, the main disadvantages of this method are that data collection is very labour intensive and time consuming for the investigator which limits the number of participants that can be assessed. Also, this approach is not suitable for the assessment of free-living physical activity as it would infringe on the privacy of participants. Self-report techniques are the most popular method for assessing physical activity in large sample sizes. However, there are a number of issues surrounding the reliability and validity of this approach in children including concerns over the ability of children to think abstractly and perform accurate recall of their physical activity, which is highly sporadic and therefore less memorable (Corder et al., 2008; Harro & Riddoch, 2000; Sallis, 1991). Physical activity diaries are suggested as being superior to retrospective questionnaires, but this approach places a heavy burden on the participant and relies on children completing them fully (Armstrong & Welsman, 1997). Proxy-questionnaires (e.g. information by parents on activity patterns of children) have been employed in studies with children; however recall of children's physical activity is also difficult for adults and proxy-questionnaires may also be subject to misrepresentation and respondent bias from parents and teachers (Corder et al., 2008; Murphy, Alpert, Christman, & Willey, 1988). Interview-administered recall affords higher validity than self-administered questionnaires, but this approach requires substantial training and is labour intensive, thus can only be conducted with a limited number of participants(Harro & Riddoch, 2000).

Motion sensors such as pedometers and accelerometers represent objective measures of physical activity. The disadvantages of pedometers are that they cannot record non-locomotor activities; are susceptible to child tampering with the device (for example shaking); and are not able to determine intensity of physical activity, for example, to distinguish between steps counted as a result of running or walking (Dale et al., 2002). As a results of such limitations, pedometers have been superseded by accelerometers as the most common objective method for assessing physical activity in youth (Harro & Riddoch, 2000).

Accelerometers provide objective information on the intensity of accelerations or movement. Accelerometers are small, unobtrusive units which are simple to use - they are simply attached to the child's hip on a belt (see Figure 1). These instruments can quantify the intensity and frequency of movement in a specific plane (uniaxial) or in multiple dimensions (multiaxial) and are therefore capable of determining patterns and intensity of physical activity as well as the total volume of physical activity. The accelerometer produces a signal which is integrated over a set time sampling period (epoch), then summed and stored as 'counts'. The epoch can be between 1 s and several minutes, but has typically been set at 1 minute in paediatric research (Rowlands, 2007). However, a 1 min epoch can underestimate high-intensity and vigorous activity (Nilsson et al., 2002; Rowlands et al., 2006). Therefore it has been recommended that a short epoch sampling interval of 10 s or less be used to assess physical activity in children (Corder et al., 2008; Rowlands, 2007) to better reflect the nature of children's physical activity, which is characterised by short intermittent bursts of physical activity (Bailey et al., 1995; Baquet et al., 2007). Limitations of hip mounted accelerometers are that they are not able to account for increased energy expenditure as a result of walking up a gradient, carrying loads, cycling, or activities which mainly involve use of the arms (Rowlands, 2007). Accelerometers are also fairly expensive which means they may not be feasible for some studies. Nevertheless they have established reliability and validity (Rowlands, 2007) and have been recommended for use in small to medium sized experimental trials (van Sluijs et al., 2007).

Figure 1 An Actigraph GT1M accelerometer and where it is positioned when worn on the hip

2.2.3 What are the recommendations for participation in physical activity?

Guidelines have been issued specifically for youth on the amount and type of physical activity necessary for health benefits. The recommended guidelines for physical activity state that:

> Children and young people should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. At least twice a week this should include activities to improve bone health (activities that produce high physical stresses on the bones), muscle strength and flexibility.
>
> (Biddle et al, 1998; Department of Health, 2004)

The Chief Medical Officer (Department of Health, 2004) defines moderate intensity physical activity as activity that results in an increase in breathing rate, heart rate and body warmth (which may be accompanied by sweating on hot or humid days), for example brisk walking. Vigorous physical activity, which represents higher intensity physical activity, is defined as activity which causes a large increase in heart rate, hard breathing and sweating (e.g. jogging). Moderate-to-vigorous physical activity (MVPA) is the term most commonly used to characterise physical activity in paediatric research and represents all physical activity at or above moderate intensity.

Physical activity intensity can be defined based on different measurements, including energy expenditure ($kcal \cdot min^{-1}$), oxygen consumption ($ml \cdot kg^{-1} \cdot min^{-1}$) or heart rate ($beats \cdot min^{-1}$). It is common to classify the intensity of physical activity in multiples of resting energy expenditure (METs). In adults, one MET (energy expenditure at rest, sitting quietly) is equal to approximately 1 $kcal \cdot kg^{-1} \cdot hr^{-1}$ of energy expenditure (Ainsworth et al., 1993), or approximately $3.5 mL \cdot kg^{-1} \cdot min^{-1}$ of oxygen consumption. Moderate intensity activity is classified as between 3 and 5.9 METS, that is, 3 to 5.9 times greater than resting metabolic rate, or 40-59% of their cardiorespiratory fitness. Vigorous physical activity is denoted as activity levels above 6 METS, which corresponds with about 60% of maximal aerobic capacity (Howley, 2001). The use of adult-based MET values to classify children's activity (for example to convert children's physical activity questionnaire recalls into energy expenditure) is contentious. Children's resting energy expenditure is higher than in adults, but progressively declines with increasing age and pubertal status (Harrell et al., 2005). Further, the energy cost of completing a task may be greater for children than for adults. However, the ratio of activity energy expenditure to resting energy expenditure is similar to that found in adults (Harrell et al., 2005; Ridley & Olds, 2008), and the current consensus is that classification of activity between 3-5.9 METs as moderate intensity and activity over 6 METs as vigorous activity can be applied to children.

In accelerometry, accelerometer data is expressed as movement 'counts', which can be used to estimate physical activity intensity. However, movement 'counts' are dimensionless arbitrary values that are not standardised between accelerometer brands (Corder et al., 2008). Additionally, the count thresholds for intensity in young people have been the subject of much debate in paediatric research with wide disparities between studies in the counts/min used to define moderate and vigorous physical activity (Corder et al., 2008). Several different thresholds have been used in children (Nilsson et al., 2002; Treuth et al., 2004; Freedson et al., 2005; Puyau et al., 2002), which makes comparisons between studies problematic (Rowlands, 2007). This means that applying different thresholds to the same accelerometer data can reveal significant differences in the time spent in MVPA for each child, which would have considerable permutations for describing the proportions of children meeting the recommended physical activity guidelines. This makes it difficult to answer with certainty the question of "*how active are children*", which will be discussed later.

2.2.4 What are the health benefits of physical activity for children?

The effects of physical inactivity are most visible in the form of overweight and obesity. Levels of overweight and obesity among children in England are high and increasing (Department of Health, 2004). In 2002, using UK National BMI reference curves (Cole et al., 1995), 30.3% of boys and 30.7%

of girls aged 2-15 years were classified as at least overweight, and 16% of boys and 15.9% of girls aged 2-15 years were obese (Sproston and Primatesta, 2003). In under ten years obesity prevalence has increased by almost two-thirds in girls and doubled in boys (Department of Health, 2004) and prevalence of overweight and obesity among children is increasing (Butland et al., 2007; Lobstein et al., 2004). In Liverpool, over one-third of children are overweight (Stratton et al., 2007), as defined by the International Obesity Taskforce BMI reference curves (Cole et al., 2000). The promotion of physical activity is a key component in the strategy to combat obesity and physical activity *per se* has important health benefits in children. Effects are predominantly seen in amelioration of risk factors for cardiovascular disease, avoidance of adiposity, achieving a high peak bone mass for better skeletal health, and enhanced mental and emotional well-being (Biddle et al., 2004; Boreham & Riddoch, 2001; Department of Health, 2004; Strong et al., 2005).

The European Youth Heart Study (EYHS) is an ongoing multi-national investigation addressing the prevalence and cause of cardiovascular disease risk factors in children aged 9 and 15 years from four countries – Estonia, Norway, Portugal and Denmark (Riddoch et al., 2005). Anderson et al. (2006) assessed the associations of physical activity with clustering of cardiovascular disease risk factors (systolic blood pressure, triglyceride, total cholestoral/HDL ratio, insulin resistance, sum of four skinfolds, and aerobic fitness). It was found that risk decreased with increasing physical activity (expressed as mean counts per minute). Compared to the most active quintile, the least active quintile had an odds ratio of clustered risk of around 3, and each of the first (least active) to third quintiles of physical activity had a raised risk. The mean time spent in MVPA in the fourth quintile, which was not associated with increased risk of clustered cardiovascular disease risk factors, was 116 minutes per day in 9-year old and 88 min per day in 15 year old children, considerably higher than the current recommended guidelines of one hour per day. Anderson et al. proposed that a new recommended guideline of 90 minutes of daily MVPA may be needed for children. Other research conducted as part of the EYHS has found that vigorous physical activity is negatively associated with metabolic syndrome and body fatness

(Ruiz et al., 2006; Rizzo et al., 2007). Dencker et al. (2006) also found an inverse association between total body fat and vigorous physical activity in 7-11 year old children. Whilst data from the ALSPAC study (Avon Longitudinal Study of Parents and Children) of 11-12 year old UK children (n=5500) found a strong negative dose-response association between MVPA and obesity (Ness et al., 2007), which was measured using dual-energy x-ray absorptiometry (DXA). Results suggested that a modest increase of 15 minutes of MVPA is associated with lower odds of obesity of over 50% in boys and nearly 40% in girls. Additionally, physical activity has important mental health benefits. For example, there is evidence that physical activity is associated with higher levels of self-esteem, and lower levels of depression and anxiety in children (Ekeland, Heian, & Hagen, 2005; Parfitt & Eston, 2005).

The evidence for a link between childhood physical activity and adult health is inconsistent and weak (Biddle et al., 2004; Boreham & Riddoch, 2001). Nevertheless, childhood physical activity is beneficial for obesity prevention, which may be detrimental in adult health, whilst higher bone mineral density as a result of increased physical activity in childhood may help prevent osteoporosis in old age (Boreham & Riddoch, 2001). Further, active children may be more likely to be active in adult life (Janz et al., 2000; Malina, 1996), and there is strong evidence that physical activity in adulthood is associated with reduced risk of cardiovascular disease and psychological well-being (Department of Health, 2004).

2.2.5 What proportions of children meet the recommended physical activity guidelines?

The 2002 Health Survey for England (Sproston & Primatesta, 2003) found that only 70% of boys and 61% of girls (aged 2-15 years) reached the recommended levels of physical activity to benefit their health, and physical activity declined with age. Studies reporting physical activity levels measured using objective measures show inconsistent data. Riddoch et al. (2007)

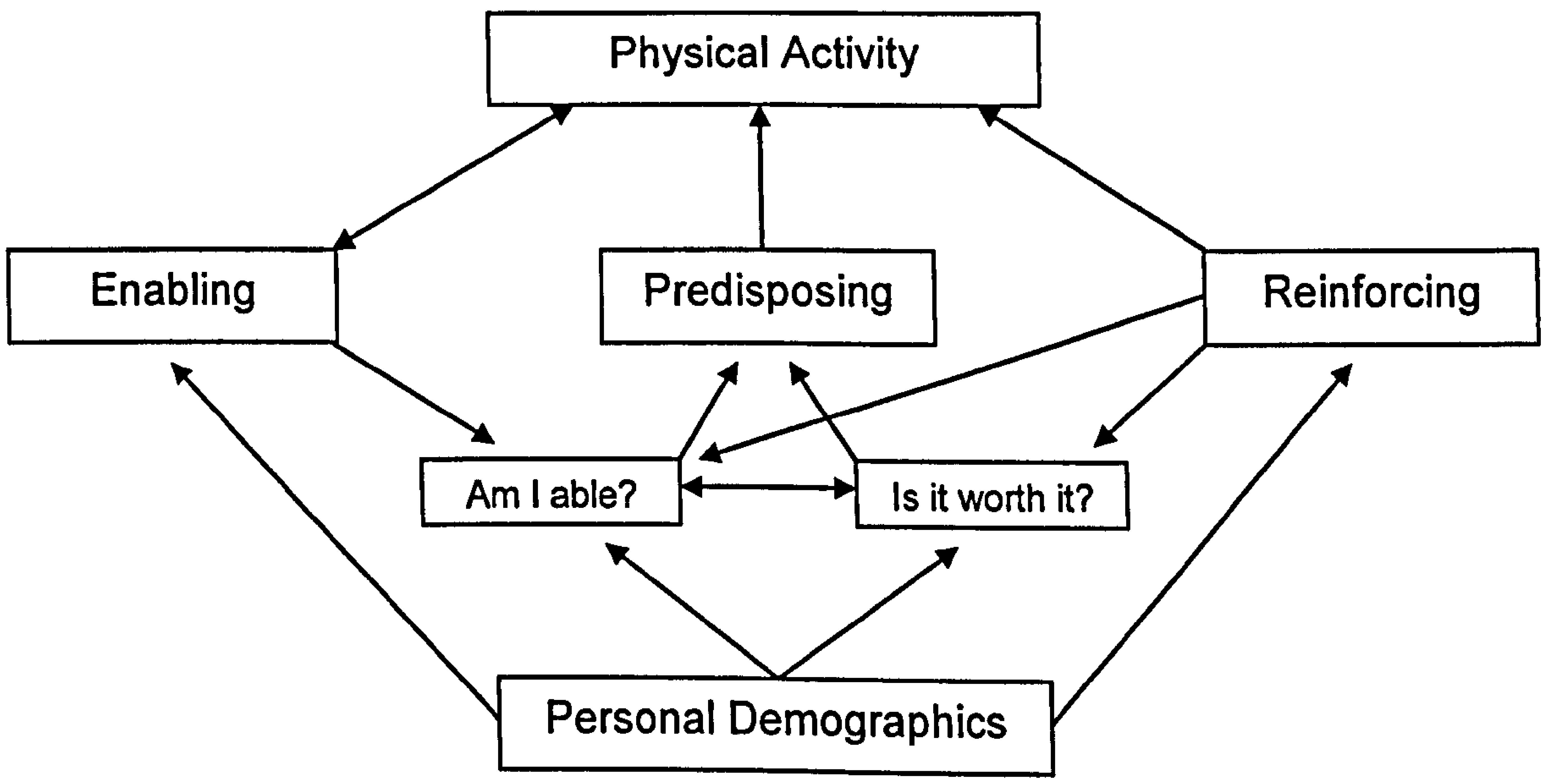
collected accelerometer data on 5500 eleven year-old children as part of the Avon Longitudinal Study of Parents and Children (ALSPAC). Only 5.1% of boys and 0.4% of girls met the recommendations for physical activity, with boys spending more time in MVPA (25 min/day) than girls (16 min/day). Conversely, data from the European Youth Heart Study (EYHS) found that a large proportion of children (97.4% boys; 97.6% girls) from Denmark, Portugal, Estonia and Norway met the recommended guidelines at 9 years old. At age 15, fewer children were sufficiently active, indicating a marked reduction in activity during the adolescent years (Riddoch et al., 2004). This age related decline has also been reported in US children and youth (Trost et al., 2002; Pate et al., 2002). More recently, accelerometer data from the SPEEDY study (Sport, Physical activity and Eating Behaviour: Environmental Determinants in Young people; van Sluijs et al., 2008) involving 1888 children from Norfolk, England, reported that 69.1% of children met the recommended guidelines, with boys (84.1 mins/day) participating in more MVPA than girls (66.1 mins/day). This is substantially higher than the values reported in British children by Riddoch et al. (2007). However, physical activity data is not directly comparable across studies due to the different thresholds used to define MVPA, for which no current consensus exists (van Sluijs et al., 2008). For example, Riddoch et al. (2007) used a threshold of 3600 counts per minute to define MVPA, whilst 2000 counts per minute was used in the SPEEDY study. Overall, the results suggest that the proportion of children that meet the recommended guidelines is unclear, with some studies finding many children are sufficiently active whilst others report the opposite. There is, however, consistent evidence that boys are more active than girls, and that physical activity declines from childhood to adolescence.

2.2.6 Determinants of physical activity in children

The promotion of physical activity in youth is a public health priority (Department of Health, 2004). Examining key correlates and determinants of physical activity in children can inform interventions seeking to prevent the age-related decline in which occurs as children approach puberty (van Sluijs et al., 2008). A review of correlates of physical activity of children was conducted by Sallis et al. (2000). Of the 40 variables which were analysed, those consistently associated with children's physical activity were sex (male), parental overweight status, physical activity preferences, intention to be active, perceived barriers (inverse), previous physical activity, healthy diet, program/facility access, and time spent outdoors. Van Der Horst and colleagues (2007) recently updated this review to include sixty studies published between 1999 and 2005. The results of their review suggest that correlates of physical activity for children (aged 4-12 years old) are gender (male), self-efficacy, parental physical activity for boys, and parental support. Unlike Sallis et al. (2000), no associations were found for access to facilities, preference for physical activity, and barriers to physical activity. Interestingly, there was no evidence for an inverse relationship between body mass index and physical activity in children. Taken together, the reviews imply that youth physical activity is a complex behaviour with multiple determinants. This supports social-ecological models of physical activity behaviour which consider determinants from multiple environments, including intra-personal (e.g. psychological), inter-personal (e.g. social) and physical environments (Sallis & Owen, 1999).

Welk (1999) incorporated these multiple influences within the "Youth Physical Activity Promotion Model", which provided a conceptual framework for understanding children's physical activity (see Figure 2). Within this model, Welk classified various correlates as factors that predispose, reinforce, or enable physical activity behaviour. Predisposing factors are "variables that collectively increase the likelihood that a person will be physically active on a regular basis" (p.11). This intention is influenced by the answers to two fundamental questions – *Am I able*? and *Is it worth it*? The former question addresses self-evaluative psychological constructs such as perceptions of competence and feelings of self-efficacy, and represents "...a person's perceived degree of control over personal behaviour" (p.12). The second question relates to the cognitive and affective psychological appraisal of perceived outcomes. This element is influenced by factors such as enjoyment of physical activity, and attitudes and beliefs about physical activity.

Figure 2 A conceptual overview of the Youth Physical Activity Promotion Model (Welk, 1999).



"Reinforcing" factors are variables that reinforce a child's physical activity behaviour. These primarily stem from social influences such as parents, peers and coaches and such influences can be direct or indirect. For example, parents can directly influence behaviour by transporting children to team practice. Parents may also help to shape their child's attitudes and beliefs regarding physical activity, thus indirectly reinforcing behaviour. Parents can also indirectly influence competence beliefs by positively encouraging their child (Brustad, 1993), which will increase perceptions of competence. For example, boys may receive more reinforcement and encouragement for physical activity from parents than girls (Brustad, 1993), which may partly explain gender differences in physical activity. "Enabling" factors are the "...variables that allow youth to be physically active" (p.14). These factors include biological and environmental attributes. Environmental factors include access to facilities, parks, neighbourhood safety and availability of equipment. Biological factors include fitness, body fat, and physical skills. Finally, Welk (1999) includes demographics at the base of the model, acknowledging how individual differences in factors such as gender, age, socio-economic status and ethnicity will present various differences in enabling, predisposing and reinforcing factors.

In Welk's view (1999), perceptions of competence and enjoyment of physical activity are fundamental to a child's predisposition to physical activity – influencing the *Am I able?* and *Is it worth it?* constructs within the model. Welk also identifies that mastering a number of skills will *enable* children to find physical activity more enjoyable and increase the activities they can perform well, stating that "youth who are physically fit and skilled are more likely to seek out opportunities to be active and will most likely persist, whereas children with poor fitness and skills are less likely to achieve the same level of success" (p.14). This is consistent with Weiss' perspectives on the motives for children and adolescents' participation in physical activity (Weiss, 1993, 2000). Weiss (2000, p. 1) states that "youths want to *develop* and *demonstrate* physical competence, such as athletic skills, physical fitness, and physical appearance" and that perceptions of competence is an essential influence on physical activity in children, alongside enjoyment and social support from parents, peers and teaches/coaches. Next, the thesis will focus on these two important correlates of physical activity. First, the influence of perceived physical competence (children's judgements' regarding their ability in sports, physical attractiveness, and physical fitness) will be reviewed. Second, the importance of children developing proficiency in fundamental movement skills will be examined.

2.3 Physical self-perceptions

Physical activity is associated with elevated levels of self-esteem and there is sizeable evidence that children who have stronger beliefs about their physical abilities are more likely to enjoy and persist in physical activity than children who report lower physical competence (Fox, 2000a; Fox & Wilson, 2008; Weiss, 2000; Weiss & Ebbeck, 1996). This section of the literature review will seek to explain the mechanisms for this important relationship and begin by focussing on the theoretical underpinnings of physical self-perceptions, including descriptions and definitions of self-esteem and the physical self. The research evidence will be reviewed, including studies which have assessed gender differences in physical self-perceptions and those examining the relationships between physical self-perceptions and physical activity, fitness and overweight. Finally, experimental trials that have sought to increase physical self-perceptions will be discussed. Summaries of the evidence will be provided and limitations in the research will be highlighted, which will provide the rationale for the thesis.

2.3.1 Self-esteem

Self-esteem (often termed self-worth) can be defined as "an awareness of good possessed by the self" (Campbell, 1984, p. 9). Self-esteem is frequently used interchangeably with the term self-concept. However, for the purpose of this thesis self-concept will be separately defined as "a person's self-description of who and what they are" (Whitehead, 1995, p. 132). Self-esteem is evaluative in nature, and this evaluation is based on self-perceptions in different aspects of the self, known as domains (Shavelson, Hubner, & Stanton, 1976). These self-perceptions are influenced by the dominant culture, beliefs and values held by the individual (Fox & Wilson, 2008). Self-esteem is therefore based on being an okay person, depending on what the individual thinks is okay (Fox & Wilson, 2008). As a key index of emotional stability and adjustment to life demands, self-esteem is a critical indicator of psychological well-being (Fox & Wilson, 2008) and self-esteem and domain specific self-perceptions influence engagement and perseverance in day-to-day pursuits (Harter, 1996). There is strong evidence linking self-esteem to physical activity behaviour in children (Ekeland, Heian, Hagen, Abbott, & Nordheim, 2004; Fox, 2000a). Children high in perceived physical competence will have elevated levels of self-esteem and will be more motivated to participate in physical activity (Harter, 1981; Weiss & Ebbeck, 1996).

2.3.2 The structure of the self

In order to understand how self-esteem influences behaviour, it is necessary to understand the structure and constructs within the self system. Contemporary theorists have supported, extended, and operationalised the framework proposed by Shavelson et al. (1976) who, following an extensive literature review, contended a hierarchical and multi-dimensional model of self-esteem. Specifically, they proposed a model with self-esteem at the apex of a hierarchical root-like structure. At the second level, four life domains form the basis of self-esteem - academic self-concept; and social, emotional, and physical self-concept. Academic self-concept is then further divided into different academic subjects, whilst each non-academic domain is split into sub-domains. In turn, these sub-areas of self-concept are influenced by appraisal of behaviour in specific situations. Higher order self-concept constructs would be more stable than the facets at lower levels.

Shavelson et al. (1976) also posited that self-concept would be increasingly differentiated with age, a proposition incorporated by Harter and colleagues (1990), whom developed multi-dimensional self-perception profiles using a developmental perspective. Harter established that the life domains used to evaluate the self vary, and become increasingly complex and differentiated with age. Harter (Harter & Pike, 1984) found that young children (4-7 years) are capable of making reliable judgements about four domains: cognitive competence, physical competence, social acceptance, and behavioural conduct. However, at these ages, children have difficulty differentiating between domains, and are not able to make overall judgements of self-worth.

In middle childhood (ages 8-12), children can make an overall evaluation of global self-worth, and make a distinction between five domains (Harter, 1985b):

- Scholastic competence
- Social acceptance
- Athletic competence
- Physical appearance
- Behavioural conduct

2.3.3 The Physical Self

The acknowledgement of the multi-dimensionality of self-concept has enabled more detailed study of specific components of the self, including the physical form. Fox (2000b, p. 230) states "the physical self has occupied a unique position in the self-esteem system because the body, through its appearance, attributes, and abilities provides the substantive interface between the individual and the world". The physical self is therefore a medium for expression and social interaction (Fox & Wilson, 2008). Physical self-perceptions have been shown to be positively related to indicators of psychological well-being such as depression, mood, and life adjustment (Sonstroem & Potts, 1996), and social enhancement (Fox, 1990). Elevated self-esteem is considered to be a psychological benefit of participation in physical activity (Sonstroem, 1984), and perceptions of self-concept in the physical domain are considered to be a key contributor in determining levels of global self-worth (Fox, 2000a).

Given the potential influence of physical self-perceptions on physical activity behaviour, Fox (1990; Fox & Corbin, 1989) sought to clarify the content, structure and function of self-perceptions in the physical domain and developed the Physical Self-Perception Profile (PSPP). Initially, Fox (1990; Fox & Corbin, 1989) examined previous research before conducting open-ended questionnaires from US college students to discover the important features of the physical self. Next, using exploratory factor analysis, Fox identified five scales:

- **Sport competence** (athletic ability, ability to learn sport, confidence in sport)
- **Condition** (condition, stamina, fitness, ability to maintain exercise, confidence in exercise setting)
- **Body** (attractive physique, ability to maintain an attractive body, confidence in appearance)
- **Strength** (perceived strength, muscle development, confidence in situations requiring strength)
- **Global Physical Self-Worth** (general feelings of pride, satisfaction, happiness and confidence in the physical self).

In Fox's hierarchical model (Fox, 1997) self-perceptions vary from one level to another: the super-ordinate (global self-esteem), domain (physical), sub-domain (e.g. sport competence), facet (e.g. soccer ability), sub-facet (e.g. passing ability) and state (e.g. I can pass to this player). Consistent with the model proposed by Shavelson et al. (1976), lower order facets are more amenable to change than higher levels of the hierarchy. Repeated mastery experiences at the foundation level (e.g. a successful pass) will generalise upwards to other more abstract constructs within the physical domain (Fox & Wilson, 2008). The psychometric properties of the subscales were found to be robust. Reliability, construct and factorial validity, and internal consistency (Cronbach's α = .81 to .92) was confirmed in US college students (Fox, 1990; Fox & Corbin, 1989). While support for a hierarchical structure was evidenced by global physical self-worth mediating the relationship between global perceptions of self-esteem and lower levels such as sub-domains or situation specific perceptions of competence (Fox & Corbin, 1989)

2.3.4 The Children and Youth Physical Self-Perception Profile

Whitehead (1995) modified the PSPP for use in younger populations. The original sports competence scale was replaced with the previously validated athletic competence scale from Harter's Self-Perception Profile for Children

(SPPC: (Harter, 1985b), and other questions were simplified using age-appropriate terminology. This modified scale was then renamed the Children and Youth Physical Self-Perception Profile (CY-PSPP), to distinguish it from the PSPP. Using a sample of 505 US junior high students (aged 12-14 years), Whitehead (1995) found support for the four factor PSPP subscale structure, and the hierarchical framework, with sub-domains accounting for 64% and 70% of the variance in physical self-worth for boys and girls, respectively. The model successfully discriminated between high and low scoring children (as perceived by PE teachers) to provide evidence of construct validity. Furthermore, with the exception of the strength sub-domain in males, subscales moderately correlated with corresponding physical education fitness scores such as pull-ups, sit-ups, shuttle run, 50 yard dash, and long jump, signifying concurrent validity. Good stability and internal consistency (cronbach α = .79 to .92) were found across subscales.

Additional support for the model structure was confirmed in a large sample of 13-15 year old American adolescents (Eklund, Whitehead, & Welk, 1997). Crocker and colleagues (2000) found comparable results with the original PSPP instrument in 10-14 year old Canadian children. The CY-PSPP has also been shown to be suitable for use in children as young as 9 or 10 (Welk, Corbin, Dowell, & Harris, 1997; Welk & Eklund, 2005). However, within this age group some minor cross-loadings of items between scales have been observed (Welk et al., 1997), and correlations of subscales with objective measures of fitness were lower than those found in older populations, indicating less accurate self-perceptions (Welk & Eklund, 2005). This is likely due to children having a less differentiated sense of the fitness, which is also evidenced by high correlations across the CY-PSPP subscales (Welk et al., 1997). This could be because children can be both the strongest and the fastest amongst their peers, however as children grow and develop these abilities tend to diverge and more distinct dimensions of fitness are formed (Welk & Eklund, 2005). Cross-cultural support for the CY-PSPP dimensions is evident in children and youth from Britain, Hong Kong, Russia, and Sweden (Hagger, Biddle, Chow, Stambulova, & Kavussanu, 2003; Liggett, Burwitz, & Grogan, 2002; Raustorp, Stahle, Gudasic, Kinnunen, & Mattsson, 2005).

Marsh and colleagues (1994) have also designed a popular multi-dimensional physical self-concept measurement tool – the Physical Self-Description Questionnaire (PSDQ). The PSDQ includes nine subscales: strength, body fat, activity, endurance/fitness, sports competence, coordination, health, appearance, flexibility, and the domain of physical self-concept, as well as Global self-esteem. Like the PSPP and CY-PSPP, the PSDQ lends support to hierarchical and multi-dimensional views of the self. While both the PSDQ and the CY-PSPP are valid and reliable instruments, the CY-PSPP has been used most extensively by researchers (Fox, 1997), particularly in studies of children and young people. Therefore the CY-PSPP will be used to assess perceived physical competence in this thesis.

2.3.5 Gender differences in physical self-perceptions

A meta-analysis (Kling, Hyde, Showers, & Buswell, 1999) examining gender differences in self-esteem found that males have slightly higher self-esteem than females (Effect size: 0.21), with the larger effects occurring in adolescence. Gender differences were particularly prominent within the physical domain, with evidence of males having higher physical self-perceptions than females observed in adults (Fox & Corbin, 1989; Hayes, Crocker, & Kowalski, 1999; Sonstroem, Speliotis, & Fava, 1992), adolescents (Daley, 2002; Maiano, Ninot, & Bilard, 2004; Trew, Scully, Kremer, & Ogle, 1999), youth (Crocker et al., 2000; Raudsepp, Liblik, & Hannus, 2002; Raustorp et al., 2005; Whitehead, 1995), and children (Welk et al., 1997; Welk & Eklund, 2005). Primarily, boys score more highly than girls across all age groups in perceptions of sports competence, physical condition, strength and domain-level physical self-worth. Further gender differences in body attractiveness appear to be absent in children (Welk et al., 1997; Welk & Eklund, 2005) but become apparent as children enter into adolescence, with most studies reporting boys rating their appearance as higher than girls

(Daley, 2002; Raustorp et al., 2005; Whitehead, 1995). However, Estonian girls had higher perceptions of body attractiveness than boys (Raudsepp et al., 2002), possibly indicating diversity in perceptions of children from western and eastern cultures. Although some studies have found no gender differences (Gilson, Cooke, & Mahoney, 2005; Hagger, Ashford, & Stambulova, 1998), it appears that gender differentiation in physical self-perceptions occurs from an early age.

There are many reasons posited for gender differences in physical self-perceptions. One potential source of perceived competence is actual competence. Several studies have reported boys having higher levels of sport skills, fitness and strength, and lower body fat % than girls (Rudisill, Mahar, & Meaney, 1993; Welk & Eklund, 2005). This difference in actual competence may explain why girls have lower perceptions of sports competence, physical condition, physical strength and body attractiveness than boys. However, Welk and Eklund (2005) suggest that perceptions of competence are likely conceived by comparisons with peers of the same-sex rather than the opposite sex. They argue that reasons for gender differences are more likely to be based on social and cultural factors. Children may differ by gender in their beliefs and values about sport and physical abilities. Girls may not see themselves as "the sporty type", whilst boys have higher expectations of success in physical activity and sport, value sport more positively than girls, and feel more confident physically (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Lee, Carter, & Xiang, 1995). Boys also have increased societal pressure on them to be strong and masculine (Reddy, Fleming, & Adesso, 1992), which may be reflected in boys' higher scores than girls'. Other possible social reasons include gender differences in the amount of parental encouragement offered. Brustad (1993) found that boys received more parental encouragement to be physically active than girls, with higher parental encouragement being linked to greater perceived competence in children. Finally, it is also possible that girls may simply be more modest than boys, who could exaggerate competence (Mullan, Albinson, & Markland, 1997).

It is widely reported that girls engage is less physical activity than boys (Van Der Horst et al., 2007; Riddoch et al., 2007). Consequently, several studies have examined whether gender differences in physical self-perceptions may explain why girls are less active than boys. Carroll and Loumidis (2001) showed that boys have higher perceptions of competence than girls, and higher perceptions of competence were linked with more enjoyment and increased participation in physical activity. Raudsepp and colleagues (2002) found that girls self-reported participating in less MVPA than boys, and had lower perceptions of all CY-PSPP sub-domains than boys, with the exception of body attractiveness. Crocker et al. (2000) also used a 7-day recall instrument to assess physical activity, finding that boys were more active than girls, and had higher perceptions of sports competence and strength. Whilst Swedish girls participated in less physical activity than boys, as determined by pedometer steps, and had lower perceptions of competence in all CY-PSPP domains (Raustorp et al., 2005).

In summary, the majority of studies reveal significant gender differences in physical self-perceptions which are likely explained by social and cultural factors. As no recent studies have examined UK children, further research into gender differences in physical self-perceptions is needed. Prospective and intervention studies would also be useful in investigating gender differences in perceptions of competence and actual competence over time. The theoretical mechanisms' by which differences in physical self-perceptions may influence physical activity are discussed next.

2.3.6 Physical self-perceptions, physical activity and exercise: motivational perspectives

According to Fox (1997), the role of the physical self in the motivation and commitment to be physically active, and in contributing to global self-worth, can be viewed from two perspectives: self-enhancement hypothesis and skill-enhancement hypothesis.

Self-enhancement hypothesis proposes that "people constantly strive for situations in which they can demonstrate laudable qualities" (Fox & Wilson, 2008, p. 57), and views the self system as a primary determinant of physical activity. Whilst skill-enhancement hypothesis suggests that physical activity interventions improve physical fitness, sports skills, and health, which then strengthen self-perceptions (Fox, 1997). Self-enhancement hypothesis shares common concepts with other motivational theories such as competence motivation (Harter, 1978), which evolved from White's (1959) theory of effectance motivation. This hypothesis purports that humans seek to maximise positive feelings or effectively master challenging tasks:

> This drive manifests itself through activity choice, intensity of engagement, and persistence over time in the face of obstacles. The central tenet of this approach is that a flow of motivational energy stems from the self to regulate investment in behaviours that offer positive benefits while simultaneously avoiding negative outcomes such as shame or embarrassment.
>
> (Fox & Wilson, 2008, p. 58)

Thus individuals tend to seek out activities that are in harmony with their self-perceptions in order to demonstrate competence. This theory is supported by evidence that physically active people have higher perceived competence and greater expectations for success (Biddle, 1997), suggesting that individuals are motivated in domains where their competence can be displayed and shun situations that highlight low ability to others (Fox & Wilson, 2008). Similarly, competence motivation theory (Harter, 1978) posits that individuals will strive to demonstrate mastery and continue mastery attempts in activities within domains, if they feel competent. Those who feel confident whilst participating in physical activity are more likely to enjoy involvement, and consequently feel motivated to continue effort and participation in the future. Conversely, those who feel less competent and demonstrate failure will not enjoy participating and so seek to avoid the activity and corresponding negative feelings thereafter.

Alternatively, skill-enhancement hypothesis states "....participation in certain behaviours will (perhaps through actual or perceived physical changes) exert a positive effect on elements of the self system" (Fox & Wilson, 2008, p. 60). Thus a more positive sense of the self is gained through improving physical attributes, fitness, appearance or health (Fox & Wilson, 2008). From this perspective exercise participation will increase self-perceptions and self-esteem. However, physiological change is not necessary to achieve psychological benefits from exercise. The mechanisms of change in physical self-perceptions are likely psycho-social (Fox, 2000a).

Self-enhancement and skill-enhancement hypotheses should be viewed as complementary rather than exclusive, and most likely work in parallel to exert motivational influences on the individual (Lindwall & Lindgren, 2005). It is likely that the self-perception-exercise effect is bi-directional. For example, those who begin participation in an exercise class may experience enhanced perceptions of competence and enjoyment following attendance. These positive feelings may then provide the stimulus to participate in other activities in order to maintain physical self-perceptions and demonstrate competence (Lindwall & Lindgren, 2005).

2.3.7 Physical self-perceptions, physical activity, fitness and body composition: cross-sectional and longitudinal studies

Physical self-perceptions and physical activity

Focusing on children and youth, cross-sectional research investigating the perceived competence-physical activity/exercise relationship appears to support a self-enhancement perspective. In a sample of 122 English adolescents (13-14 years), Gilson and colleagues (2005) found that for boys, sports competence, physical condition and strength were positive correlates ($r = .36$ to $.42$) of sport and exercise involvement, however in girls only strength was related ($r = .29$). With regards to self-reported lifestyle moderate physical activity, surprisingly perceived sports competence was negatively correlated in boys, yet all sub-domains were positively related with activity in girls (r = .26 to .32). Whilst in a large study of similar-aged British adolescents (14-15 years), Daley (2002) found that children who self-reported participation in extra-curricular activities also had higher scores of body attractiveness and physical self-worth.

Support for perceptions of physical competence as a correlate of activity can be found across nations and cultures. The CY-PSPP sub-domains successfully discriminated between high and low active participants in leisure time exercise in British and Russian mid-adolescents with 60-70% accuracy (Hagger et al., 1998). Sports competence and strength were the most important discriminator functions in British boys and girls, respectively. While in Russian boys and girls, physical condition was the most important discriminator, with sports competence the next critical function. Body attractiveness was least important across genders for both nationalities (Hagger et al., 1998). Crocker and colleagues (2000) related scores on the original PSPP with physical activity participation, as assessed using the Physical Activity Questionnaire for Older Children (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997), in 446 Canadian youth. All sub-domains were significantly correlated with physical activity in boys (r = .26 to .47) and girls (r=.28 to .47). Structural equation modelling revealed that, irrespective of gender, perceived sports competence and physical condition best predicted PAQ-C score, explaining 27-29% of the variance. Raudsepp et al. (2002) found self-reported habitual physical activity was positively related to CY-PSPP sub-domains in a random sample of Estonian boys (r = .17 to .37) and girls (r = .17 to .30). Interestingly, for boys the strength and body attractiveness scales were the highest and lowest correlates of activity, respectively, whereas for girls the opposite was true. Regression analyses found strength, sports competence and physical self-worth explained 21% of the variance in physical activity in boys. For girls, body attractiveness, physical self-worth and sports competence accounted for 14% of the variance in moderate to vigorous physical activity (MVPA). In a rare study incorporating an objective measure of physical activity, Raustorp et al. (2005) used pedometers to assess physical activity over 4 days in a large sample of Swedish youth (aged 10-14 years). In boys, fair correlations were found between the CY-PSPP sub-domains and physical activity (r = .30 to .39), whilst in girls correlations were weak (r = .13 to .19). Regression analyses revealed that perceived physical fitness, strength and sport competence predicted 20% of the variance in physical activity in boys but physical self-perceptions explained only 4% of the variance in girls (no significant predictors).

Self-perceptions also appear to be related to activity in young children. Welk and Eklund (2005) used the PAQ-C to assess physical activity in their CY-PSPP validation study in US elementary children. For boys, the PAQ-C score was significantly correlated with all of the CY-PSPP sub-domains (r = .39 to .45). In girls, the correlations were more diverse with sports competence (r = .39) representing the highest correlation, and body attractiveness (r = .20) the lowest.

Few studies have employed longitudinal approaches. In a one-year longitudinal study involving adolescent girls, Crocker and colleagues (2003) found that physical self-perceptions, particularly perceived physical condition, predicted changes in physical activity participation. Crocker et al. (2006) extended this work and examined changes in self-perceptions of 501 Canadian adolescent females from grades 9 to 11 (14-17 years). Whilst self-reported physical activity moderately decreased, physical self-perceptions remained fairly stable, showing only small declines. The authors posited that the stability of the physical self in this sample may suggest that early adolescents or even children may need targeting.

Following this call, Knowles et al. (2008) examined changes in physical activity and physical self-perceptions in 150 early-adolescent Scottish females (Mean age: 12.79 years) over a one-year period. Self-reported physical activity, perceptions of body attractiveness and physical self-worth were significantly lower over 12 months. Perceived condition significantly predicted activity change, though physical self-perceptions only explained a small proportion of the variance in activity. Contrary to these findings, recent research in the USA involving children of nurses recruited as part of the "Growing Up Today" study found that increasing activity was associated with increased perceived athletic competence scores among boys and girls, with decreases in activity associated with lower competence (Stein, Fisher, Berkey, & Colditz, 2007).

Physical self-perceptions and cardiorespiratory fitness

As well as physical activity (process), physical self-perceptions may be related to measures of fitness (product). Theoretically, perceptions of physical condition and sports competence should be higher in those with high fitness scores (Welk et al., 1997), with perceived body attractiveness and physical strength less related.

Whitehead (1995) found that adolescents' perceptions of body attractiveness, sports competence and physical condition were fair to moderate correlates of shuttle run and mile run times, with the latter sub-domain being the strongest correlate. Whilst Biddle et al. (1993) found that performance in a shuttle run fitness test was moderately correlated with perceived sports competence, physical condition and physical self-worth in similar-aged British adolescents. Interestingly, Raudsepp et al. (2002) found that all sub-domains, including strength, were positively related to endurance in Estonian youth, predicting 28% and 23% of the variance in boys and girls shuttle run performance, respectively. Sports competence was the strongest correlate ($r = .42$) and predictor for both sexes. In younger children, Welk et al. (1997) found that mile run time was only related to the sub-domain of perceived sports competence in boys ($r = -.32$). Whilst in girls, the largest correlate of mile run time was perceived physical condition ($r = -.45$), with body attractiveness, sports competence, and physical self-worth also showing fair correlations ($r = -.33$ to $-.45$). In a larger sample of young children, Welk and Eklund (2005) found that the highest correlate of predicted VO_2 max for boys and girls was the physical condition scale (r = .45 and .38, respectively). However, low to moderate correlations were also found with body attractiveness, and sports competence (boys only).

Physical self-perceptions and body composition

Obese children and adolescents are "subjected to social rejection, discrimination and negative stereotyping" (Wardle & Cooke, 2005, p. 437), which could have negative psychological consequences, although these are not inevitable. For example, Strauss (2000) showed that no differences were found in self-esteem between non-obese and obese (9-10 year old children. However, by mid-adolescence (13-14 years) obese children had significantly lower levels of self-esteem than their non-obese counterparts. This is important as obese children with lower self-esteem at follow-up demonstrated significantly higher rates of sadness, loneliness, and nervousness (Strauss, 2000).

Global self-esteem may be maintained in overweight children; however more specific aspects of the self, particularly within the physical domain can be negatively affected. Obese and overweight young girls had significantly lower perceptions of physical appearance and athletic competence than non-overweight girls (Phillips & Hill, 1998). Similarly, in a large population of Year 5 and Year 6 Australian primary school children, Franklin and colleagues (2006) found that children classified as obese from body mass index (BMI) scores had significantly lower perceived athletic competence than non-obese children.

Overweight children are less active than non-overweight children (Riddoch, et al., 2007; Trost, Kerr, Ward, & Pate, 2001). This may be due to overweight children having negative attitudes towards exercise, caused by weight criticism directed towards them during physical activity (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002). Additionally, overweight children are less proficient in fundamental movement skills than non-overweight children, and perceive themselves to be less competent in such skills (Southall, Okely, & Steele, 2004), which may influence their motivation to take part in physical activity. Moreover, markers of obesity are negatively associated with several physical self-perception sub-domains. For example, Raustorp et al. (2005) found that BMI was associated with low-to-moderate negative correlation coefficients with perceptions of sports competence, body attractiveness, physical condition and physical self-worth in girls and boys. This inverse relationship was stronger in girls, with physical self-perceptions predicting 7% of the variation in the BMI in boys and 26% in girls. Welk and Eklund (2005) also found perceived body attractiveness to be inversely correlated with BMI (r = -.39) and body fat % (r = -.39) and perceived physical condition was also negatively related to BMI (r = -.25) and body fat % (r = -.25). In a 3-year longitudinal study of Canadian adolescent girls, Crocker et al. (2006) found that small increases in self-reported BMI were not associated with changes in perceptions of body attractiveness.

2.3.8 Summary of evidence from cross-sectional and longitudinal studies

In summary, cross-sectional research appears to support the ability of the CY-PSPP model to predict physical activity participation. Weak-to-moderate correlation coefficients were observed between sub-domains and physical activity, with perceived sports competence and physical condition emerging as particularly influential. Some studies (Raudsepp et al., 2002; Raustorp et al., 2005) suggested that physical self-perceptions are a more important determinant of activity for boys than girls. Prospective studies in adolescents (Crocker et al., 2003; Crocker et al., 2006; Knowles et al., 2008) point towards physical self-perceptions explaining only a small amount of the change in physical activity, with perceived physical condition the best predictor of change. The results of these studies may have been limited by the method of assessing physical activity with only one study using an objective method (pedometers). In view of the limitations of using self-report instruments in young people and the disadvantages associated with pedometers, research using accelerometry is warranted. This would enable the precise nature of the physical self-perceptions – physical activity relationship to be determined.

In terms of cardiorespiratory fitness, most cross-sectional studies (Biddle et al., 1993; Raudsepp et al., 2002; Welk et al., 1997; Welk & Eklund, 2005; Whitehead, 1995) appear to document that perceived sports competence and physical condition are moderately related to fitness. The strength of these correlation coefficients are not as high as one might expect, and this is likely due to younger children having a less differentiated nature of fitness (Welk & Eklund, 2005). This may also explain observed moderate correlations with fitness across several physical self-perception sub-domains, rather than high correlations with a single scale (such as physical condition). Surprisingly, most studies (Raudsepp et al., 2002; Welk et al., 1997; Welk & Eklund, 2005; Whitehead, 1995) also reported that perceived body attractiveness is positively related to cardiorespiratory fitness, particularly in younger girls. Lower perceptions of body image have been associated with overweight and obesity (Franklin et al., 2006). Therefore, it may be that those children who rate themselves highly in perceived body attractiveness have more athletic body shapes, which in turn enables them to perform better in endurance fitness tests.

Despite these studies appearing to support an association between fitness and perceived physical competence, the strength of observed relationships may have been confounded by the methods used to determine cardiorespiratory fitness. Each of the studies reviewed used distance runs or shuttle runs as indirect markers for fitness. However, while these studies give an indication of the nature of this relationship, future research needs to clarify the strength of this connection using direct measures of cardiorespiratory fitness and maximal fitness tests.

Cross-sectional research suggests that lower perceptions of body attractiveness appear to be a negative consequence of obesity (Phillips & Hill, 1998; Raustorp et al., 2005; Welk & Eklund, 2005), though longitudinal research did not support this association (Crocker et al., 2006). Overweight children may also have lower perceptions of physical condition and sports competence than their non-overweight counterparts (Raustorp et al., 2005; Welk & Eklund, 2005). However, no research exists that has investigated the relationship between overweight/obesity and physical self-perceptions using a laboratory measure of body composition. Obesity is defined as an excess accumulation of body fat (Prentice & Jebb, 2001). The use of BMI as a proxy for obesity is contentious as BMI is a measure of weight relative to height, not adiposity. Additionally BMI cannot distinguish fat from muscle or bone (McCarthy, Cole, Fry, Jebb, & Prentice, 2006), and therefore can exaggerate fatness in athletic or muscular individuals. Further, BMI assumes an average degree of maturation and growth but children can be early or late maturers and the concomitant changes in body size (lean muscle mass, fat mass) and shape can significantly affect BMI values (Lohman, 1986; Prentice & Jebb, 2001). Others have used skin fold thickness as a measure of adiposity (Welk & Eklund, 2005). However, skin fold measurements are not easily replicated, and usually only a few body sites are measured. Consequently, concerns have been expressed regarding the accuracy of this approach (Mei et al., 2007).

The criterion method for the assessment of body composition is the 4-compartment model, combining measurements of body density, total body water, and total body bone mineral to estimate percent body fat, fat, or fat-free mass (Sopher et al., 2004). The 4-compartment model 'ameliorates the effect of maturation, hydration status of the fat-free mass, and bone mineralization in the estimation of body fatness' (Fields & Goran, 2000, p. 619). However, the cost of the 4-compartment model does not allow wide implementation in most laboratories. In addition, this method is tedious, time consuming, difficult to perform and requires fasting (Sopher et al., 2004). Therefore more practical measurements are needed, particularly in paediatric populations.

One alternative to 4-compartment models is the assessment of body composition by dual-energy x-ray absorptiometry (DXA). Several studies have compared DXA with the criterion 4-compartment model for percent body fat in paediatric populations but the findings are not consistent (Fields & Goran, 2000; Roemmich et al., 1997; Sopher et al., 2004; Wells et al., 1999; Wong et al., 2002). Indeed, all DXA systems differ from the 4-compartment model but this does not obviate the use of DXA for the measurement of percent body fat in children (Sopher et al., 2004). While it should be recognised that DXA differs from the criterion measure, DXA provides a more precise indication of fatness than BMI or skin fold assessments; and is quick, safe, easy to perform and increasing in availability - making it a practical measurement tool for use in medium to large trials of children (Sopher et al., 2004).

Despite the limitations of past research, the evidence suggests that physical self-perceptions have important associations with physical activity, fitness, overweight and obesity, although cause and effect cannot be determined from cross-sectional research. As such, experimental studies have sought to increase physical self-perceptions in light of potential impact on these health parameters. The effectiveness of such trials will be discussed next.

2.3.9 Physical self-perceptions, physical activity, fitness and body composition: experimental studies

Few controlled experimental trials have been conducted to clarify the direction of causality between physical self-perceptions and health behaviour/outcomes (Fox & Wilson, 2008). The skill-enhancement hypothesis is best evaluated through controlled experimental trials, which are likely to be most effective in those with low self-esteem initially (Fox, 2000a). Recent reviews and meta-analyses (Ekeland et al., 2005; Fox, 2000a; Spence, McGannon, & Poon, 2005) advocate exercise participation having a weak-to-moderate positive effect on global self-esteem, lending some support to skill-enhancement hypothesis. Several experimental studies have recently examined whether physical activity influences physical self-system in children and adolescents, with most targeting specific populations such as adolescent girls.

One non-randomised experimental trial was conducted by Schneider and colleagues (2008) in Grade 10 and 11 US female adolescents. The intervention included changes to the physical education curriculum such as student selection of activities, and lectures on the health benefits of physical activity. Intervention classes took place for 60 minutes, five times a week, with the control comparison following a similar dose of the regular PE curriculum. Despite increases in fitness and self-reported vigorous physical activity (VPA), physical self-concept, was not enhanced following the 9-month intervention programme. However, these findings may have been limited by most of the comparison group also participating in a physical education programme. Consequently authors speculated that the nature of the activities (intensity/type) may be less important than the group interaction experienced through the classes.

Burgess et al. (2006) used a cross-over experimental design to investigate the effects of a twice-weekly aerobic dance intervention on inactive, non-exercising Year 9 British schoolgirls (13-14 years) with high body image dissatisfaction and low physical self-perceptions. Participants were split into two groups, with half completing six weeks of the aerobic dance intervention whilst the other half participated in 50 minutes of swimming per week. After 6 weeks the groups swapped over, completing 6 weeks of the alternate curriculum. The aerobic dance intervention brought significant improvements in body attitude items such as 'feeling fat', 'fitness' and 'salience', alongside positive changes in perceptions of body attractiveness and physical self-worth (CY-PSPP). However, this study was limited by not having a distinct control-comparison group. The results of this study appear to conflict with Schneider et al. (2008), suggesting that the nature of activity is important, with adolescent girls responding better to aerobic dance than swimming activities. Alternatively, as the exercise dose was lower in the swimming comparison, it could be that the volume of swimming was not sufficient to bring about positive psychological gains.

Lindwall and Lindgren (2005) conducted a randomised-controlled trial in Swedish inactive girls aged 13-20 (mean age 16.35). Participants were randomised by school to intervention (n = 56) or control (n = 54) treatments. The intervention consisted of 60 minutes of exercise classes (45 minutes of exercise and 15 minutes of discussion) which occurred twice-a-week for six months. The intervention was designed to increase moderate physical activity, physical self-perceptions and body image, and used empowerment strategies, as well offering students the opportunity to select activities. No forms of alternate activities were offered to the control group. Average attendance in the intervention was 56%. Using an intention-to-treat analysis, the intervention improved social physique anxiety scores but had no effect on the CY-PSPP sub-domains. However, a less conservative, as treated analysis revealed that the intervention group had significantly higher scores on the CY-PSPP domains of sports competence, physical condition and body attractiveness. Whilst the results suggest that an intervention designed from a psychological rather than physiological perspective can be effective, observed effects were small, with no effect larger than 0.09. However, limitations of the study include the high drop-out rate of participants, and the failure to quantify habitual physical activity, which may have changed during the research period, and had an indirect influence on physical self-perceptions.

Experimental support for the fitness-perceptions of competence relationship is yet to be documented. A 13-week intensive aerobic exercise intervention (Walters & Martin, 2000) had no effect on self-perceptions in 8-11 year old children, compared to the control which followed the usual school PE curriculum. However, the findings are limited by methodological weaknesses as the study lacked a control group and did not measure of fitness. Additionally, the self-perception profile instrument (Harter, 1985b) used may lack the specificity required to detect change in perceptions of physical condition (i.e. only a measure of perceived athletic competence).

Alternatively, the presence of a ceiling effect in self-concept, with scores in both groups at baseline and post test above average, may have restricted the findings.

Goldfield and colleagues (2007) conducted a small randomised controlled trial involving Canadian overweight and obese children aged 8-12 years. The effect of the intervention, which aimed to increase physical activity and decrease sedentary behaviour, on psycho-social adjustment was investigated. The intervention successfully increased total physical activity and MVPA, which were measured using accelerometers worn everyday over an 8-week period. Increases in activity were associated with increases in perceived physical condition, body satisfaction and physical self-worth, independent of changes in BMI. This may suggest that participation in physical activity, rather than actual weight loss, may offer a mechanism to increase physical self-perceptions in overweight and obese children.

2.3.10 Summary of evidence from experimental studies

There is a paucity of experimental research of appropriate methodological quality to determine the influence of physical activity participation in psychological health promotion (Fox & Wilson, 2008). Evidence from experimental research is inconsistent. Some studies have shown no effect for exercise/physical activity and fitness on perceptions of the physical self (Schneider et al., 2008). Others have found partial support (Burgess et al., 2006; Lindwall & Lindgren, 2005), with exercise appearing to benefit perceptions of body image and body appearance in adolescent girls and obese children. Due to the lack of available evidence, and weaknesses in the research design of studies conducted, our ability to draw causal inferences are constrained. More randomised-controlled trials are needed, particularly in younger children who have less stable self-perceptions. Additionally, trials should include objective measures of physical activity, body fatness and fitness in order to fully account for and describe changes in perceived competence. Finally, it would be interesting to examine whether intervention programmes have different effects on boys and girls physical self-perceptions.

The appropriate intervention strategies required (type, dose, and intensity of physical activity/exercise) to enhance physical self-perceptions in children and adolescents' remain unclear and require further research. Typically programmes have involved changes to physical education curriculum and alternative programmes should be explored. Different types of physical activity interventions should be undertaken to determine whether some strategies are more beneficial in increasing self-perceptions than others. The mastery of fundamental movement skills has been advocated as a potential strategy for increasing perceived physical competence and enabling children to be physically active. Such skills will be the focus of the next section of the literature review.

2.4 Fundamental movement skills

Welk (1999) stated that perceptions of competence may be more important than actual competence in predisposing children to physical activity. Investigators from the motor development field argue that the importance of children's motor skill competence in the initiation, maintenance, or decline in physical activity has been underplayed, contending that children's skill competence is the "primary underlying mechanism that promotes engagement in physical activity" (Stodden et al., 2008). So what are these skills and how do they *enable* children to be more physically active and lead healthier lifestyles? The purpose of this section of the literature review is to: i) define fundamental movement skills, ii) discuss the importance of fundamental movements skills, iii) identify assessment tools for such skills, iv) describe the prevalence of proficiency in movement skills among children and examine gender differences, v) examine cross-sectional research to allude to the importance of movement skills, and vi) review the effectiveness of interventions that have sought to increase such skills. Following a synthesis of past research, the rationale for the study of fundamental movement skills in this thesis will emerge.

2.4.1 Definition of fundamental movement skills

In early childhood, children begin to learn a group of skills called fundamental movement skills (FMS). FMS are "...an organised series of basic movements that involve the combination of movement patterns of two or more body segments." (Gallahue & Donnelly, 2003, p. 52). Such skills can be categorised as stability, locomotor or object-control (manipulative) skills (see **Table 1** for examples). Gallahue and Ozmun (1998) define stability skills as fundamental to all movement and involve "the ability to maintain one's relationship to the force of gravity" (p216). Whilst locomotor movements are those that involve "...projection of the body into an external space by altering its location relative to fixed points on the surface" (p222), and object-control skills involve "giving force to objects and/or receiving force from them" (p236).

Table 1 Examples of fundamental movement skills (Gallahue & Donnelly, 2003, p. 54)

Stability	*Locomotor*	*Object-control*
Bending	Walking	Throwing
Stretching	Running	Catching
Twisting	Jumping	Kicking
Turning	Hopping	Trapping
Swinging	Skipping	Striking
Inverted supports	Galloping	Volleying
Body Rolling	Sliding	Bouncing
Landing/Stopping	Leaping	Ball rolling
Balancing	Climbing	Punting
	Dodging	

2.4.2 Importance of fundamental movement skills

FMS are the building blocks of movement, forming the basis of more advanced and more specific motor actions, and representing the foundation for future participation in physical activity and sport (Clark & Metcalfe, 2002; Seefeldt, 1980; Wickstrom, 1983). FMS therefore correspond to one level in the continuum of skill development (Walkley, Holland, Treloar, & Probyn-Smith, 1993). The FMS stage of development follows a period of infant motor development and is a prerequisite to the learning and mature performance of specialised sport skills in late childhood (Gallahue & Donnelly, 2003). Specialised sport skills encompass the application of a single FMS, or a combination of FMS, to be used in the performance of a specific sport task (e.g. jumping to head a football). For example, the badminton smash, tennis serve, javelin throw, and basketball/netball shoulder pass are advanced versions of the overarm throw (Walkley et al., 1993). Consequently, failure to master FMS may hinder development of specialised sport skills, and provide a barrier to participation in later life as children will not have the necessary skills to be active or play sport. For example, a child who can catch a ball is more likely to succeed at cricket, basketball, or netball in which catching is a vital skill. Seefeldt (1980) called this a hypothetical "proficiency barrier", stating that children need to master these basic skills to be able to successfully apply them to sport and physical activity. Children who fail to surpass this critical threshold of motor skill competence will experience failure and physical activity will decline. As Gallahue and Donnelly (2003, p. 52) comment:

> Failure to develop and refine fundamental and specialized movement skills during the crucial preschool and elementary school years often leads to frustration and failure during adolescence and adulthood. Children cannot take part with success in an activity, if they have not learned the essential movement skills within that activity.

A child's movement skill ability will also significantly influence how peers view them (Gallahue & Ozmun, 1998; Ulrich, 2000). Children who lack competence in FMS compared to his or her peers will often be selected last during games at playtime and afterschool activities, and this is likely to have a negative impact on a child's physical self-perceptions and motivation to participate in physical activity (Ulrich, 2000). That is, low actual motor skill competence may cause children to have low perceived skill competence and these children will not believe they have the prerequisite skills to be active and seek to withdraw from physical activity to avoid public displays which may cause embarrassment (Horn & Weiss, 1991; Stodden et al., 2008; Weiss & Amorose, 2005). The development of proficiency in FMS in the early years is particularly important as the accuracy of children's judgements of motor skill competence increases with age. In early childhood, children's accuracy of motor skill competence is limited and perceptions of motor skill competence are exaggerated compared to actual abilities (Goodway & Rudisill, 1997; Harter, 2003; Stodden et al., 2008). Children's cognitive capacity develops with increasing age and by middle childhood children are better able to judge competence (Harter, 2003). If a child has not developed proficiency in FMS in the early years then perceptions of competence will drop when that child has the ability to accurately assess his or her competence level (Goodway & Rudisill, 1997; Stodden et al., 2008). This could influence their motivation and confidence in physical activity.

2.4.3 Development of fundamental movement skills

Proficient performance of FMS requires the development of motor control, precision and accuracy, which in turn builds movement efficiency and confidence (Gallahue & Donnelly, 2003). Children's motor performance normally improves with age (Branta, Haubenstricker, & Seefeldt, 1984; Ulrich, 2000; Walkley et al., 1993), and childhood is a sensitive learning period for reaching proficiency in FMS. In particular, early childhood (3-8 years) represents a 'window of opportunity' for FMS development (Gallahue & Donnelly, 2003). However, this process is not automatic; the rate and extent of FMS development is idiosyncratic (Gallahue & Donnelly, 2003) and dependant on several factors.

Motor development is due to biological (genetics, puberty, maturation, and growth) and environmental sources, or an interaction between these factors (Newell, 1986; Thomas, Gallagher, & Thomas, 2001). For example, both increased leg length and improved running technique account for changes in running speed during childhood (Thomas et al., 2001). Environmental factors are crucial: to reach proficiency in FMS children need frequent encouragement; access to equipment and facilities; high quality instruction using developmentally-appropriate activities; opportunities to practice and refine the skills; and an appropriate learning environment (Gallahue & Donnelly, 2003). If such conditions are present, it is possible for children to develop much higher levels of skill than is normally expected for their age (Wickstrom, 1983). Conversely, if opportunities to develop skill competence are not available, motor development may be delayed. As such, these individual and environmental constraints mean that children can follow very different "developmental trajectories" (Clark & Metcalfe, 2002). As children develop motor skill competence at different rates, it is important to accurately assess each child for monitoring purposes, such as identifying those at risk of developmental delay, and to examine relationships between FMS and health outcomes. The FMS assessment tools are discussed next.

2.4.4 Assessment of fundamental movement skills

When measuring movement skills researchers usually adopt a process or product orientation (Payne & Isaacs, 2008). Popular product-orientated test batteries include the Movement Assessment Battery for Children (MABC: (Henderson & Sugden, 1992) and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP: (Bruininks, 1978). In a product-orientated measurement tool only the outcome of the movement is assessed. For example, product assessments include measures of the distance thrown, or time taken to sprint 100m, or simple "Yes/No" checklists based on whether a desired outcome is achieved. However, product measures do not examine the movement process that produced the performance outcome, and scores can be unrelated to the child's motor development (Stodden et al., 2008). For example, a child can have same number of catches by catching a tennis ball between their wrists and at the second attempt, or they can demonstrate a technically proficient movement pattern and catch the ball (eyes on ball, feet move in line, arms move to meet ball, ball cushioned and caught in hands, and brought into their chest). Product-orientated assessments therefore provide limited information to guide interventions about the technical aspects of performance that need to be improved.

Consequently researchers have advocated process-orientated measures, as "there is a need to focus on the process or mechanics of movement prior to the product, or performance aspects of movement skill development." (Gallahue & Donnelly, 2003, p. 53). FMS have "...definable characteristics that are observable and which serve to underlie the unique characteristics of the skills" (Wickstrom, 1983). A process approach to assessment seeks to measure whether observed characteristics were demonstrated during a performance and emphasises measurement of the quality of movement and technique; focusing on the way a skill is performed rather than the end result.

A popular process measurement tool considered valid and reliable is the Test of Gross Motor Development 2 (TGMD-2: (Ulrich, 2000), however this is only designed for children aged between 3 and 10 years old. A number of studies (Booth, Denney-Wilson, Okely, & Hardy, 2005; Booth, Macaskill, Phongsavan, McLellan, & Okely, 1998; Okely & Booth, 2004; Okely et al., 2004; Okely et al., 2001a, 2001b; Salmon et al., 2005; van Beurden et al., 2002) have used process measures based on the "Get Skilled Get Active" Australian resource (NSW Department of Education and Training, 2000) or the original manual version (Victoria Department of Education, 1996). This resource provides functional checklists for 12 fundamental movement skills that can be used to assess skill proficiency in children and adolescents, and has been shown to be valid and have good test-retest reliability (Okely & Booth, 2000). In fact, this assessment protocol represents the only process-orientated measurement tool that is appropriate for use in children and adolescents - an important factor for experimental researchers who may wish to conduct a long term follow up of participants. The number of studies including FMS assessments based on this resource, and the evidence of validity and reliability, suggests this is a sound instrument appropriate for the measurement of skill proficiency in scientific study.

2.4.5 Prevalence of proficiency in FMS among children and adolescents

Several studies have described the prevalence of mastery or near-mastery (i.e. mastered all, or all but one, of the required skill components: also termed 'proficiency') of FMS among children and adolescents (Booth et al., 2006; Booth et al., 1999; Hume et al., 2008; Okely & Booth, 2004; Ulrich, 2000; van Beurden et al., 2002; Walkley et al., 1993). Ulrich (2000) provided data on the percentage of 3-10 year old US children demonstrating mastery from a standardisation sample (n=1,208) for the examiners manual of the Test of Gross Motor Development 2 (TGMD-2), which includes tests of six locomotor and six object-control skills. With the exception of the run (40%), prevalence of mastery at age 3 did not surpass 13% in any of the skills tested. At age 10, the proportion of children rated as at mastery was higher, ranging from 42% in the underhand roll to 86% in the slide. However, the proportion of children rated as mastery in the gallop, hop, leap, jump, strike, and throw did not surpass 56%.

Most descriptive studies have emerged from Australian populations. Walkley et al. (1993) used video analysis to assess proficiency in the overhand throw, catch, forehand strike, two-hand sidearm strike and instep kick in 1,182 children (grades 2, 4, 6, 8) from schools in the state of Victoria, Australia. It was found that, with the exception of the catch, the prevalence of mastery of each skill by Grade 8 (13-14 years old) in boys and girls did not exceed 65%. Additionally, less than 20% of Grade 8 girls tested were rated as at mastery on the forehand strike, two-arm strike and instep kick. In 1997, the New South Wales Schools Fitness and Physical activity Survey assessed the FMS proficiency of a representative sample of school children in years 4, 6, 8, and 10 (approximately aged 9.3, 11.3, 13.3, and 15.3 years of age respectively). This study indicated that FMS proficiency was low, finding that, apart from one skill (the overarm throw in Year 10 boys), levels of mastery/near mastery did not exceed 40% for boys and girls in any one year group (Booth et al., 1999). A second statewide survey (New South Wales Sport Physical Activity and Nutrition Survey, 2004: NSW SPANS 2004) was conducted seven years later to gather data on FMS mastery and examine trends in skill proficiency from 1997-2004. In 2004, the levels of FMS proficiency had increased since 1997 (Booth et al., 2006). Prevalence of FMS mastery surpassed 40% on 19 occasions, and for five out of seven skills (jump, throw, kick, catch, side gallop). Okely and Booth (2004) also reported prevalence of FMS proficiency in a large sample of young children (Grades 1-3) in Sydney, Australia. For girls and boys of all ages the prevalence of mastery of a skill did not go above 35% for any FMS, whilst static balance was the only skill in which the proportion of children who displayed advanced skills (mastery or near mastery) exceeded 50%.

Two recent interventions have also reported FMS proficiency prevalence at baseline. The 'Move it Groove it' program (van Beurden et al., 2002) rated proficiency of 7-10 year old primary school children (n=1045) in skills including balance, throw, catch, sprint, hop, kick, side gallop and jump. Field staff conducted FMS measures and found that less than 50% of all child tests were rated at mastery (21.3%) or near-mastery (25.7%) level. 75.4% of Grade three children were rated as mastery or near-mastery in the balance, however less than half did so for any other FMS. In Grade four, with the exception of the side gallop (59%) and catch (56%), less than half of children were rated as mastery or near-mastery for any other skill. Hume et al. (2008) reported baseline data from the Switch-Play intervention which included video-analysis of five FMS (run, vertical jump, kick, overhand throw, and two-handed strike). The proportion of boys (n=123) at mastery or near mastery ranged from 20.3% in the run and vertical jump to 76.4% in the kick. Whilst in girls (n=125), prevalence of mastery or near mastery ranged from 5.6% in the overhand throw to 44% in the kick.

In summary, the research indicates that prevalence of proficiency in FMS among children and adolescents is low-to-moderate. Normative data of skill proficiency is limited as the use of process orientated assessment tools has only recently begun to increase; nevertheless this statement is supported by the fact that children have the capacity to reach proficiency in FMS by 6 years of age (Gallahue & Ozmun, 1998; Payne & Isaacs, 2008). Many children are not reaching proficiency, which suggests that there is great potential to improve FMS in children and adolescents. Some studies (Booth et al., 2006; Booth et al., 1999; Ulrich, 2000; Walkley et al., 1993) report higher prevalence of mastery and near-mastery than others (Okely & Booth, 2004; van Beurden et al., 2002). However comparisons across studies should be made with caution due to variation in methodologies employed to assess FMS, and differences in populations studied. There is no recent evidence (i.e. within the past decade) on the prevalence of proficiency at FMS in primary school aged children from the UK, and descriptive research is urgently needed.

2.4.6 Gender differences in fundamental movement skills

A large body of literature has compared boys and girls performance of motor tasks. Thomas and French (1985) conducted a large meta-analysis of gender differences among children and adolescents in 20 motor skills (assessed using product measures), using data from 64 studies including over 31,000 girls and boys. A significant effect, favouring boys, was found for 12 out of 20 skills. Effect sizes for gender differences were moderate across childhood (~0.5 SD) but become larger and continue to increase throughout adolescence, when boys increase strength and size during puberty. Small gender differences favouring girls were found in two tasks - fine eye-motor coordination and flexibility. Thomas and French (1985) suggested that in the early years many of these gender differences can be explained by cultural and environmental reasons, rather than biological factors.

More recent research highlights that boys are more proficient than girls in object-control skills including the kick, catch, overhand throw, two-hand strike (Booth et al., 2006; Hume et al., 2008; McKenzie, Sallis, Broyles, Zive, & Nader, 2002; Okely & Booth, 2004; Okely et al., 2001b; van Beurden et al., 2002; Walkley et al., 1993). Gender differences in object-control skills may be explained by the different physical activities that boys and girls typically participate in at this age. Boys traditionally participate in sports such as football, basketball and cricket and so have further opportunities to develop object-control skills such as kicking, catching and throwing. If similar opportunities and reinforcement is provided for girls to practice such skills, and they receive appropriate instruction, encouragement and feedback to assist development, then observed gender differences could be abridged (Okely & Booth, 2004; Thomas, 2000; Thomas & French, 1985)

With respect to locomotor skills, studies have reported that young girls have higher levels of mastery than boys in the side gallop (van Beurden et al., 2002), and on balancing and jumping tasks (McKenzie et al., 2002). Okely and Booth (2004) found that significantly more girls mastered skipping than boys, however, no gender differences were observed for the side gallop, balance or jumping skills. Likewise for the sprint run, some studies have reported the absence of a gender difference (Hume et al., 2008; van Beurden et al., 2002), whilst some have found that boys perform better (Okely & Booth, 2004; Okely et al., 2001a). The absence of consistent gender differences in locomotor skills suggests that girls' receive similar opportunities for development of such skills to that experienced by boys. For example, it is not surprising that there is an absence of gender differences in skills such as the sprint run, which is omnipresent and non gender-specific, and likely learned in all sports and physical activities (Booth, et al., 2006; Okely & Booth, 2004). With this in mind, it is important that tests of FMS proficiency account for gender differences and include a range of skills within the test battery which represent those integral to both boys and girls typical activities (Hands & Larkin, 1997).

2.4.7 Fundamental movement skills, physical activity, fitness and body composition: cross-sectional and longitudinal studies

Fundamental movement skills and physical activity

In their conceptual model, Stodden et al. (2008) propose that there is a "reciprocal and developmentally dynamic" relationship between skill competence and physical activity, and that this relationship strengthens over time. Stodden et al. suggest that in early childhood "young children's physical activity might drive their development of motor skill competence" (p294), with increased participation in physical activity promoting neuromuscular development, which in turn improves FMS. They state that young children have very different levels of motor competence and physical activity, due to different experiences. For this reason, they hypothesise that in young children physical activity and motor competence are weakly related. This is partly supported by the literature.

Sääkslahti et al. (1999) found a significant but weak relationship between physical activity and motor skills in 3-4 year old Finnish children (n=105). FMS assessed using product measures included walking, running, standing broad jump, agility, throwing-and-catching, somersaults, clapping, galloping, balancing, and throwing. Children's weekend physical activity was assessed using parental observations recorded in a physical activity diary (5-min sampling points). In a similar sample of 394 Scottish pre-school children aged three to five years old, Fisher et al. (2005) also found a weak association between competence in 15 FMS, measured using the MABC, and total physical activity ($r = 0.10$) and moderate-to-vigorous physical activity ($r = 0.18$), objectively assessed using a 1 minute accelerometry sampling interval. However, Williams et al. (2008) found a stronger relationship between physical activity and FMS in three- and four-year old children using a shorter accelerometer epoch (15s) to record physical activity. FMS were measured using the Children's Activity and Movement Protocol (CHAMP), which assesses process characteristics of six locomotor and six object-control skills. Higher correlations between composite skill score and MVPA ($r= 0.20$), and vigorous PA ($r = 0.26$) were observed compared to Fisher et al. (2005). Further, even higher correlations were found for locomotor skill competence and participation in PA in 4-year-olds (MVPA, $r = 0.31$; VPA, $r = 0.37$), with similar correlations for object-control skills. Williams et al. (2008) hypothesised that the differences in outcomes between the studies may be explained by differences in measures of physical activity (15 sec v. 1 minute epoch) and motor skills (Process v. Product), suggesting their study provided a more comprehensive assessment of physical activity and skill status.

Stodden et al. (2008) hypothesise that the relationship between motor skills and physical activity strengthens with age. During early childhood physical activity drives motor development, but in middle and later childhood motor skill competence will drive participation in physical activity. That is, children who are moderately to highly skilled will elect to engage in higher levels of physical activity but those who are less proficient will opt to participate in lower amounts of physical activity (Stodden et al., 2008).

There is some evidence that motor skills are positively related to physical activity in older children, although generally the results do not suggest this relationship strengthens with age. Ulrich (1987) found that 5-9 year old children (n=250) who participated in organised sport had higher levels of motor competence than non-participants, with discriminant function analysis identifying the soccer dribble as the strongest predictor of organised sport participation. Furthermore, Wrotniak and colleagues (2006) assessed the relationship between motor proficiency and physical activity in a sample of sixty-five 8-10 year old children. Motor proficiency was assessed using the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), a product-orientated measurement tool, whilst physical activity was measured with accelerometers (1 minute epoch). Correlations of BOTMP standard score with total physical activity ($r = 0.32$) and MVPA ($r = 0.30$) were similar to that observed in 4-year-old children by Williams and colleagues (2008). After controlling for confounders such as BMI, motor proficiency explained an additional 8.7% of the variance in total physical activity (cpm). Hume et al. (2008) also used a 1 minute accelerometer sampling interval in a study investigating 9-12 year old children's movement skills and physical activity. Performance in the five skills was positively but weakly associated with MVPA in boys ($r = 0.24$), though only with vigorous physical activity in girls ($r = 0.21$). Finally, the largest study on this topic to date was undertaken by Okely et al. (2001b) in a population study of adolescents (Grades 8 and 10) from New South Wales, Australia. Six FMS (run, vertical jump, catch, overhand throw, forehand strike and kick) were assessed by field staff using process orientated measures whilst participation in non-organised and organised physical activity was self-reported. Movement skills were associated with a positive but weak relationship with participation in organised sport, accounting for only 3% of the variance. Non-organised sport involvement was not related to FMS competence.

However, in contrast to these studies, Reed et al. (2004) found no relationship between pedometer-determined physical activity and selected motor skills including balance, agility and ball manipulation skill in 11-13 year old US students (n=217). Whilst in a multi-ethnic cohort of 207 young children, McKenzie et al. (2002) found that performance of catching, jumping and balancing at ages 4, 5, and 6 did not predict their physical activity at 12 years.

Fundamental movement skills and cardiorespiratory fitness

Low levels of FMS proficiency could provide a barrier to participation in activities which enhance cardiorespiratory endurance (Stodden et al., 2008). Okely, Booth and Patterson (2001a) investigated this hypothesis in a randomly selected sub-sample of 2,026 adolescents (grades 8 and 10) from the New South Wales Fitness and Physical Activity Survey, 1997. Six skills (sprint run, vertical jump, overarm throw, catch, forehand strike, and kick) were assessed by field staff using process measures, whilst cardiorespiratory endurance was indirectly assessed using the multi-stage fitness test. Combined performance of the six skills was significantly and positively associated with the number of laps completed on the multistage fitness test in Grade 8 boys and girls (r = 0.33, r = 0.45, respectively), and Grade 10 boys and girls (r = 0.40, r = 0.50, respectively). When skills were regressed on fitness the relationship explained a low-to-moderate amount of variance in 8^{th} and 10^{th} grade boys and girls (r^2 = 0.13-0.28). Reeves and colleagues (1999) found a similar association between strength and half mile run time (r = 0.40) in a small sample of kindergarten children (5-6 years old). Conclusions drawn from this small evidence base suggest that proficiency of FMS is important in cardiorespiratory fitness.

Fundamental movement skills and body composition

Non-overweight children participate in higher amounts of physical activity than overweight and obese children (Riddoch et al., 2007; Trost et al., 2001), and it is important to understand the underlying mechanisms of this relationship (Stodden et al., 2008). Consequently several studies have examined whether motor skill competence is related to being overweight/obese. Recently, Wrotniak and colleagues (2006) found a negative association (r = -0.30) between motor proficiency and BMI z-score in a small sample of 8-10 year old children. McKenzie et al. (2002) observed a negative association between the mean of two skin folds and young boys and young girls' ability to balance (r = -0.29 and -0.21, respectively); and the jump (r = -0.23) and composite skill score (r = -0.22) in boys. Okely and colleagues (2004b) examined whether proficiency in FMS is related to being overweight/obese using secondary analyses of data collected from over 4000 Australian children and adolescents in grades 4, 6, 8, and 10 as part of the New South Wales Fitness and Physical Activity Survey. BMI and waist circumference significantly predicted performance in six FMS. Interestingly, it was found that only locomotor skills (sprint run, vertical jump) were inversely related to body composition, and non-overweight boys and girls were two to three times more likely to possess more advanced locomotor skills than overweight boys and girls. However, object-control skills (catch, throw, kick and strike) were unrelated to weight status. Southall et al. (2004) conducted a similar study in 9-11 year old children which was much smaller but incorporated a wider range FMS, assessed using the TGMD-2. Overweight and obese children, as classified by BMI, had significantly lower locomotor skill scores than their non-overweight counterparts but no differences were observed for object-control skills. Conversely, Hume et al. (2008) found no relationship between standardised BMI scores and proficiency in locomotor skills (run, vertical jump) or object control skills (kick, overhand throw, two-handed strike) in 248 Australian children aged 9-12 years. Nevertheless, taken together, the research suggests that there are potentially significant differences in skill competence between non-overweight and overweight children. Further, it appears that there may be a stronger link between locomotor skills and overweight/obesity than object-control skills as locomotor skills require more 'whole body' movement of body mass, and so are more difficult to perform given overweight and obese children's increased overall mass (Okely et al., 2004b).

2.4.8 Summary of evidence from cross-sectional and longitudinal studies

There is no recent evidence regarding the levels of proficiency in FMS among children and adolescents in the UK, but studies from other countries suggest rates of FMS mastery are low-to-moderate. This is important, as the evidence suggests that the development of proficiency in FMS is associated with important health outcomes including increased participation in physical activity, higher levels of fitness, reduced likelihood of being overweight or obese, and increased perceptions of competence. However, most studies have observed only weak-to-moderate associations which means that the model proposed by Stodden and colleagues (2008) cannot be fully supported at this stage. This may be due to limitations within methodologies including: 1) using a product based measure of FMS; 2) the validity and reliability of physical activity measurement e.g. use of self-report, or an inappropriate accelerometer epoch sampling interval for use with children; 3) failure to use a laboratory measure for body fatness; and 4) failure to directly measure cardio-respiratory fitness.

2.4.9 Fundamental movement skills: Experimental studies

Descriptive studies report that the prevalence of FMS proficiency in children is low-to-moderate. Therefore it is important to develop effective programmes to increase skill proficiency and enable children to reach their movement skill potential. Wickstrom (1983, p.2) states that the purpose of an intervention is to:

> "...prevent delays in the acquisition of motor skills by encouraging progress at a point when the child becomes developmentally capable of making progress. The aim is to promote optimum skill development. Underlying the aim is the belief that there are critical developmental periods that are ideal for the learning of certain motor skills and these should be exploited."

The preschool and early primary school years represent a 'window of opportunity' or 'critical developmental period' for children to refine and develop motor skills (Branta et al., 1984; Gallahue & Donnelly, 2003), and skill development programmes in young children appear to have a positive impact. Reithmuller et al. (2009) reviewed evidence from controlled trials regarding the efficacy of motor skill interventions in young children. Seventeen studies met the inclusion criteria, of which ~60% observed significant increases in motor skills at follow-up. However, studies were of limited quality and quantity. In one high quality study, a six-month intervention including nursery and home elements produced significant skill improvements, relative to controls in a sample of 545 Scottish preschool children (Reilly et al., 2006). However, the intervention had no effect on BMI, physical activity or sedentary behaviour. Further, in a small study of Greek young children (n=45), a 12-week programme involving self-testing activities significantly improved movement skills when compared to a control group that followed standard physical education curricular (Karabourniotis, Evaggelinou, Tzetzis, & Kourtessis, 2002).

There is also some evidence that older children can benefit from skill development programmes. The 'Move it Groove it' project, a 12-month intervention in 7-10 year old children (van Beurden et al., 2003), delivered significant improvements in each of the 8 eight skills assessed. The intervention followed a whole-school approach to implementation which included a project website, teacher training, teacher buddy systems, school support teams, and small grants for equipment. Compared to controls, the intervention delivered substantial improvements in prevalence of mastery or near-mastery in all skills for boys and girls ranging from 7.2% to 25.7%. In another Australian study, the 'Switch-Play' intervention, which aimed to prevent excess weight gain, reduce screen behaviours and promote physical activity in 9-10 year old children, had mixed findings (Salmon, Ball, Hume, Booth, & Crawford, 2008). Compared to controls, girls participating in either the behaviour-modification group (19 healthy lifestyle educational lessons) or the FMS group (19 PE sessions focusing on FMS delivered by interventionist) significantly increased FMS z-scores at post-test and 12-

months follow-up. However, a combined FMS/ behaviour-modification group did not enhance FMS, and no group intervention effects were found in boys. Baseline data indicated that boys were better at FMS than girls (Hume et al., 2008). Therefore, the authors speculated that girls' skill competence may have been more "receptive" to the intervention. Additionally, improvements in FMS following participation in the behaviour-modification programme (classroom lessons) were surprising and the authors attributed this to associated increases in physical activity. Furthermore, improvements in FMS were inconsistently associated with increases in physical activity or reductions in BMI, with gender moderating intervention effects.

2.4.10 Summary of evidence from experimental studies

The findings of these interventions are promising and suggest that FMS improvements are possible if opportunities for practice and instruction are provided. Curriculum enhancement may offer one intervention strategy for improving fundamental movement skills. However, given the pressures faced by primary educators to meet attainment targets in core subjects and the lack of PE specialists within primary schools, alternative opportunities should be explored. Outside-school physical activities such as after-school clubs may provide an alternative prospect for movement skill acquisition in children (Raudsepp & Päll, 2006). In the UK multi-skill clubs have been established to fulfil this need, yet despite the large investment in the Multi-Skill club programme, little is known about the effectiveness of FMS interventions in non-curricular settings. Additionally more research is needed to determine the appropriate length and nature of interventions that can benefit all skills. Further, only one intervention study (Salmon et al., 2008) has concomitantly assessed FMS, physical activity and BMI (a crude indicator of overweight/obesity). Thus more experimental research is needed that considers "the role of mediating variables such as perceived motor skill competence, health related fitness, and obesity, that might interact and promote/demote the dynamic relationship between physical activity and motor skill competence" (Stodden et al., 2008).

2.5 Summary

The literature review has highlighted the importance of physical activity to children's health and established that there is a need to design effective interventions to increase physical activity in children. Research has identified that fundamental movement skills and physical self-perceptions are correlates of physical activity, fitness and body fatness but methodological limitations mean that these studies may have underestimated the strength of these important associations. Recent evidence documenting the skill mastery and psychological health of UK children aged 9-11 years is sparse. Similarly, there is a lack of evidence from which to draw conclusions surrounding the type, duration and setting for interventions to increase perceived physical competence and skill proficiency.

2.6 Aim and objectives of the thesis

The specific aims of this thesis are to:

a) Investigate the prevalence of skill proficiency and levels of perceived physical competence in UK primary school children.

b) Examine the relationships between fundamental movement skill competence and physical self-perceptions with children's physical activity, fitness, and body fatness (overweight/obesity).

c) Determine the effectiveness of non-curricular interventions to increase fundamental movement skill competence and enhance perceptions of competence.

The aims will be achieved through the following objectives:

- To document through a cross-sectional study the prevalence of skill proficiency and levels of physical self-perceptions in UK primary school children with references to differences by gender. To assess the relationship of these variables with measures of children's physical activity, fitness and body fatness.
- To assess the impact of a 9-week multi-skill after-school club on children's fundamental movement skill proficiency and perceptions of physical competence.
- To assess the impact of a 12 month multi-dimensional physical activity intervention (bi-weekly fundamental movement skill or high-intensity physical activity after-school clubs or a lifestyle intervention) on children's fundamental movement skill competence and perceptions of physical competence, accounting for changes in children's physical activity, fitness and body fatness.

Chapter 3

Study 1

Associations of fundamental movement skills and physical self-perceptions with physical activity, fitness, and percent total body fat in 9-10 year old children: The A-CLASS Project

3.1 Introduction

Physical activity is associated with important health benefits in children (Ekeland et al., 2005; Froberg & Andersen, 2005; Department of Health, 2004; Ness et al., 2007; Strong et al., 2005; Tobias, Steer, Mattocks, Riddoch, & Ness, 2007). Participation in physical activity, particularly vigorous activity, is positively correlated with cardiorespiratory fitness (Dencker et al., 2006), which, itself, is a powerful marker of health (Ortega et al., 2008). Therefore the identification of key correlates of physical activity and cardiorespiratory fitness is important to facilitate development of strategies to improve children's health.

Fundamental movement skills represent one potential key determinant of physical activity and fitness (Stodden et al., 2008; Welk, 1999). Positive but weak associations have been found between fundamental movement skills and physical activity in older children (Hume et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). While two studies have found that competence in motor skills is associated with higher levels of fitness (Okely et al., 2001a; Reeves et al., 1999). However, the results of these studies may have been confounded by limitations in research design surrounding the methods used to assess motor skills, physical activity and fitness (see Section 2.4.7) and more research is needed to determine the strength of these associations. Given the potential importance of fundamental movement skills to children's physical activity and fitness, it is also important to monitor the prevalence of proficiency. Previous research on this topic has been based largely on Australian and North American children and adolescents (Hume et al., 2008; Ulrich, 2000; van Beurden et al., 2002). No recent evidence is available on the prevalence of skill proficiency in UK children, and descriptive research is urgently needed.

Welk (1999) proposes that movement skills can *enable* children to be physically active but likely exert an indirect influence on physical activity through increasing perceptions of physical competence (physical self-perceptions), which *predispose* children to be an active lifestyle. The literature on children and adolescents has generally supported the notion that physical self-perceptions are positively associated with physical activity and fitness (Biddle et al., 1993; Crocker et al., 2000; Hagger et al., 1998; Raudsepp et al., 2002; Raustorp et al., 2005; Welk & Eklund, 2005; Whitehead, 1995), with perceptions of sports competence and physical condition emerging as particularly influential. However, the strength of associations has varied across studies, and by gender, and more research is needed in children which utilises objective measures of physical activity and direct measures of fitness.

According to Harter (1978; 1985a), actual competence and social support inform perceptions of physical competence. It seems plausible that children who are proficient in fundamental movement skills will have higher perceptions of motor competence. Yet the available evidence suggests that although 9-11 year old children can assess their own physical competence, assessments have questionable accuracy (Raudsepp & Liblik, 2002; Rudisill et al., 1993; Ulrich, 1987). More investigation is needed, using matched motor competence tasks and perceived competence items, before firm conclusions on the accuracy of older children's competency beliefs can be made (Ulrich, 1987).

Differences in actual and perceived competence may partially explain why overweight children participate in less physical activity than non-overweight children (Riddoch et al., 2007; Trost et al., 2001). For example, there is some evidence that overweight children have lower perceptions of competence than non-overweight children (Raustorp et al., 2005; Southall et al., 2004; Welk & Eklund, 2005). Further, several studies have documented weak-to-moderate negative associations between markers of obesity (BMI, waist circumference and skin fold thickness) and motor skill competence (McKenzie et al., 2002; Okely et al., 2004; Wrotniak et al., 2006), though one study found that BMI z-score was not related to proficiency in five movement skills (Hume et al., 2008). However, no study has used DXA to estimate percent total body fat, meaning the nature of the actual and perceived competence relationship with obesity is unclear.

The purpose of this study was to describe the physical self-perception profiles and fundamental movement skill competence among 9-10 year old children, and examine gender differences. Additionally, this study aimed to extend previous research and explore the associations of physical activity, cardiorespiratory fitness and body fat with (a) fundamental movement skills and (b) physical self-perceptions. Limitations of previous research will be avoided by the use of an objective measure of physical activity, a direct measure of fitness ($\dot{V}O_{2\,peak}$), a comprehensive process-orientated fundamental movement skill assessment tool, and the use of DXA to measure body fatness. This study represents the baseline assessment of children included in "The A-CLASS Project".

3.2 Methods

3.2.1 Participants and settings

Following ethical approval from the University Ethics Committee (Ethics number 05138), government-funded schools within a large urban city (population c.436,000) situated in the north-west of England were assessed for eligibility to participate in the study. Schools were identified as eligible to participate based on school size (student enrolment >400 primary school; >250 junior school), current afterschool club provision (limited), school sport facilities available for use (bi-weekly) and socioeconomic status of the area (a deprivation score >40). Socioeconomic status was quantified using the Index of Multiple Deprivation (IMD; Noble et al., 2004) for the school postcode. The IMD provides a measure of deprivation, ranking areas based on calculations of several domains including income, employment, health, education, housing and crime.

Sixteen primary schools were identified as eligible to participate and invited to a meeting at the university which gave an overview of the project. Following the meeting, all invited schools consented to participate in the study. Due to limited capacity with the project design, 8 schools were randomly selected to take part. After fully informed consent from head teachers, all children from Year 5 (aged 9-10 years old) were given the opportunity to participate. Children were shown a DVD which contained video footage of an overview of the study. Following this children were given a letter containing a medical form, participant information sheet, and consent form to be completed by their parent/carer (Appendix A). Medical exclusion criteria included current use of prescription medication, any motor or co-ordination difficulties, any personal history of asthma or respiratory problems, heart, or vascular conditions, or a family history of early sudden death. Children also signed assent forms following a verbal explanation of all procedures and were reminded that they could refrain from taking part in any of the procedures at any time.

In total, 491 children were assessed for eligibility in the study. Informed consent was received from 292 children (59% response rate). 140 children (48%) were excluded for not meeting the inclusion criteria or for medical reasons, or because they either left school or were withdrawn by their school prior to baseline measurement. Therefore the final sample included 152 children (90 girls, 62 boys).

3.2.2 Measures

Anthropometry

All anthropometric assessments were conducted by a researcher trained (level 1) to the standards of the International Society for the Advancement of Kinanthropometry (Marfell-Jones et al., 2006). Children were assessed whilst wearing light clothing and with shoes removed. Following instrument calibration, sitting height and stature were measured (to the nearest 0.1 cm) using a stadiometer (Leicester Height Measure, Seca ltd., Birmingham, UK) and body mass was measured (to the nearest 0.01 kg) using digital scales (Seca ltd. Birmingham). From these BMI was calculated (mass [kg]/stature [m]^2). Additionally measures of girth were taken around the waist and gluteals (hip) using a tape measure (Lufkin W606PM, Cooper Tools Inc. UK). Three girth measurements were taken at each site and the median value recorded.

Body fatness: DXA

Percent total body fat was assessed by means of dual-energy x-ray absorptiometry (DXA: Hologic QDR series Discovery A, Bedford, Massachusetts) which provides information on three components of body composition: fat mass, fat-free mass and bone mineral content, and is widely considered a laboratory reference method (Plank, 2005). The assessment of body composition using DXA has been validated against 4-compartment models in children (Sopher et al., 2004; Wells et al., 1999). Participants were scanned in the supine position and wore lightweight t-shirt and shorts during the assessment. The calibration for body composition variables was performed weekly using a step phantom supplied by manufacturers. All scans were carried out by a trained researcher and analysed after each assessment and stored in data files. The technical error of measurement for the researcher was calculated using the coefficient of variation (CV). The CV (mean baseline, mid- and post-test measures) for repeated body fat (%) measures was 0.25%.

Maturation

Predicted years from peak height velocity, which is a somatic indicator of physical maturity, was calculated. For this, stretch stature and sitting height were entered into maturity offset calculations for boys and girls (Mirwald et al., 2002). The calculations were validated against longitudinal follow-ups of actual age of peak height velocity in children and adolescents from the Saskatchewan Growth and Development Study and the Leuven Longitudinal Twin Study.

Fundamental movement skills

The eight skills assessed included the vertical jump, sprint run, hop and dodge (locomotor skills) and the kick, catch, overarm throw and strike (object-control skills). The skills were selected as they were considered suitable for the participant age range and varied enough to eliminate gender bias (Hands & Larkin, 1997). Additionally the test battery represented skills which were perceived as important to successful participation in mainstream team sports such as football, netball, cricket and basketball. The skills were assessed using process-orientated measures, which focus on the way the skill is performed. Process-based measures were used to identify technical proficiency and thus offer useful guidance on the skill components that should be targeted during the intervention programme (Knudson & Morrison, 1997). Assessment procedures involved using video analysis to check each performance of the skills against a checklist of components specific to each skill (see Appendix B). These checklists were derived from an existing Australian resource: "Get Skilled, Get Active" (New South Wales Department of Education and Training, 2000). This booklet details assessment procedures for 15 skills. The catch, overarm throw, kick, forehand strike, sprint run, leap, dodge and vertical jump tests were validated in an earlier version of the manual (Victoria Department of Education, 1996) with acceptable alpha reliability coefficients (α = 0.70 or greater) for all skills except the leap and run (α = 0.13 and α = 0.17, respectively). In a subsequent study, the hop and static balance tests were validated and found to have good reliability for young children (Okely & Booth, 2000). Despite the reliability issues surrounding the run and leap tests, this assessment tool was used as it was the only validated process-orientated measure for use in both children and adolescents, and to enable comparisons with recent research (Booth, Macaskill, Phongsavan, McLellan, & Okely, 1998; Salmon et al., 2005; ; van Beurden et al., 2003; Victoria Department of Education, 1998). Further, the tool was selected as checklists that list key descriptive components for each skill are useful for consistent scoring (Payne & Isaacs, 2008). Finally, the resource represented a functional test battery which could be adopted and implemented by primary educational professionals in future.

The task and skill component criteria for the assessment of each of the eight skills are shown in Table 2. Tests were conducted either in the school playground (weather permitting) or school gymnasium by one researcher using the same èquipment at each site. Children were given a verbal description and single demonstration of the skill. Children were told to run, dodge and hop as fast as they could; to jump as high as they could; to catch as many balls as possible; and to throw, kick, and strike the ball with force rather than accuracy. Children performed each skill five times (except the sprint run and dodge, which was performed three times). The order of skill assessment was standardised throughout. Recordings of all participants were taken from identical angles and distances, with the video camera placed on a tripod during the testing. The data was then converted to DVD format for analysis. Videotaping skill assessments offers a number of advantages (Payne & Isaacs, 2008). Skills performed at high speed can be watched in slow-motion playback, which enables examiners more precision in analysis. Furthermore, children do not need to perform a large number of trials and so fatigue is unlikely to hinder performance. During the DVD analysis, if the skill component was checked as being present on four out of five trials (two out of three for sprint run and dodge) then the child was marked as possessing that skill component. A trained assessor conducted all fundamental movement skill assessments and subsequent video analysis. Before data collection, an observer reliability study was conducted in 20 children (10 boys, 10 girls) randomly selected from the sample. Intra-rater reliability was established using a one-week test-retest study with kappa of 0.87 (90% CI: 0.83 to 0.91). Although only one assessor completed the analysis in this study, inter-rater reliability between this assessor and another trained observer was checked on pairs of 96 scores and calculated with kappa as 0.77 (90% CI: 0.71 to 0.83).

Table 2 Fundamental movement skill test battery and assessment criteria

Skill	Task	Criteria
Hop	Hop as fast as you can over a distance of 15m	1. Support leg is bent in preparation and then straightens to push off 2. Takes off and lands on forefoot 3. Swing leg moves in rhythm with support leg 4. Able to hop on both right and left legs 5. Head and trunk stable with eyes focused forward 6. Arms bent and move to assist leg action
Vertical Jump	Jump and touch the wall as high as you can	1. Eyes focused forwards or upwards throughout the jump 2. Crouch with knees bent and arms behind the body 3. Forceful upward thrust of arms as legs straighten to take off 4. Legs straighten in the air 5. Contact ground with front part of feet and bend knees to absorb force of landing 6. Balanced landing with no more than one step in any direction
Dodge	Dodge through a series of cones placed in zig-zag formation, 3m apart	1. Bend knees during change of direction 2. Push off on outside of foot when changing direction 3. Body lowered during change of direction 4. Eyes focused in direction of travel 5. Can dodge to either side 6. Arms move to assist action
Sprint run	Run a distance of 30m as fast as possible	1. Lands on balls of feet 2. Eyes focused forward, head and trunk stable throughout the run 3. High knee lift (thigh almost parallel to the ground) 4. Knees bend at right angles during the recovery phase 5. Arms bent at least 90 degrees 6. Arms DRIVING forward and back in opposition to legs
Kick	Kick a size 4 football towards a target as hard as possible	1. Eyes are focussed on the ball throughout the kick 2. Forward and sideward swing of arm opposite kicking leg 3. Step forward with non-kicking foot placed near the ball 4. Hip extension and knee flexion of at least 90 degrees during preliminary kicking movement 5. Contact the ball with the top of the foot (a "shoelace" or instep kick) 6. Kicking leg follows through high towards the target after ball contact
Catch	Catch a tennis ball thrown underarm between 2-3m high, and from a distance of 10m	1. Eyes are focused on the ball throughout the catch 2. Feet move to put body in line with object 3. Hands move to meet ball 4. Hands and fingers positioned correctly to catch the ball 5. Catch and control the ball with hands only (well-timed closure) 6. Elbows bend to absorb force of the ball
Overarm Throw	Throw a tennis ball overarm as far as possible	1. Eyes are focused on the target throughout the throw 2. Stand side-on to the target 3. Arm moves in a down-ward and backward arc 4. Step towards the target with foot opposite throwing arm during the throw 5. Hip then shoulders rotate forward 6. Throwing arm follows through down and across the body
Strike	Using a t-ball stand and a foam baseball bat, hit a tennis ball as far as possible	1. Stand side-on to target 2. GRIP: hands next to each other, hand closest to handle end matches front foot 3. Front foot steps forward (weight transfers from back to front) 4. Hips then shoulders rotate forwards 5. Ball contact made on front foot with straight arms 6. Follow through with bat around body

Cardiorespiratory fitness

Peak oxygen uptake ($\dot{V}O_{2peak}$) was assessed on a treadmill (H P Cosmos, Traunstein, Germany) during a discontinuous incremental protocol to volitional exhaustion, adapted from Armstrong (2000). All tests were conducted by the same investigator under ambient conditions. Children were habituated to the laboratory and underwent a familiarization period of walking and running on the treadmill prior to the test. The protocol consisted of 3 minute stages, with a 30 second rest interval between each stage. The test started at an initial velocity of 4 $km \cdot h^{-1}$, which was increased by 2 $km \cdot h^{-1}$ for each subsequent stage. Treadmill gradient remained at 1.0% throughout the test. The test was terminated at the point of volitional exhaustion when the child was unable to continue despite strong verbal encouragement.

A paediatric facemask (Hans Rudolph, Kansas City) covering the nose and mouth was secured via an adjustable nylon harness prior to test commencement. During the test oxygen uptake ($\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) were measured breath-by-breath with an online system (Jaeger Oxycon Pro, Viasys Health Care, Warwick, UK). On all test days vanes were calibrated using known volumes of flow rate (0.2 and 2.0 $L \cdot s^{-1}$) and the gas analysers against known concentrations of gases (0.5% CO_2 and 20.5% O_2). Respiratory variables were averaged over 15 s epochs. Heart rate (HR) was monitored continuously (Polar, Kempele, Finland) and all participants wore a uni-axial accelerometer (GT1M model, Actigraph, Florida, USA), mounted on the right hip, which recorded data every 5 seconds.

VO_{2peak} was determined as the highest 15 s VO_2 value at steady state (between 120 s and 180 s of each stage). VO_2 was accepted as a maximal index when participants exhibited any of the following subjective indicators of maximal effort; unsteady gait, hyperpnea, facial flushing, sweating, which was confirmed by at least one of the following criteria being satisfied; a respiratory exchange ratio (RER) $\geq$ 1.00, or HR $\geq$ 195 $beats.min^{-1}$ (Armstrong & Welsman, 2000).

Physical activity

Physical activity was measured during waking hours over a period of seven consecutive days using a uni-axial accelerometer, which records movement in the vertical plane (GT1M model, Actigraph, Florida, USA). The actigraph has been shown to be a reliable and valid measure of physical activity in children and correlates reasonably well with doubly-labelled water derived energy expenditure (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006; Ekelund et al., 2001; Plasqui & Westerterp, 2007; Puyau et al., 2002; Trost et al., 1998). In order to capture the full nature of children's physical activity behaviour characterised by transient, intermittent short bursts of high intensity activity (Bailey et al., 1995; Baquet et al., 2007), the accelerometer was programmed to record physical activity data every 5 seconds. Children were issued with the monitors during school time where children became acquainted with the units. Children were asked to wear the monitor on the right hip using a tightly fitted elastic belt, during all waking hours except when swimming or bathing. A diary was given to children to record times when the accelerometer was put on or taken off, and corresponding reasons for removal. At the end of the data collection, all data were downloaded and checked for compliance using the Actilife Lifestyle Monitoring System (Version 2.1.8, Actigraph). Sustained 20 minutes periods of zero counts were deemed to indicate that the accelerometer had been removed and were deleted. For inclusion in the analyses, children were required to have produced counts for 9 hours a day for at least three days. Three days of physical activity measurement was used as the minimum criteria to maximise power, and is associated with an acceptable reliability coefficient of .7 (Mattocks et al., 2008).

Accelerometry data from the peak oxygen uptake test were used to determine individual thresholds for each child at the treadmill speeds of 4, 6, and 8 $km{\cdot}h^{-1}$. This process of individual calibration enabled physical activity to be described in terms of the time in minutes per included day spent above $4 km{\cdot}h^{-1}$ (PA>4),

$6km \cdot h^{-1}$ (PA>6), and $8km \cdot h^{-1}$ (PA>8). In addition, the total volume of total physical activity (average accelerometer counts/minutes of valid recording; CPM) were obtained for each valid day. The mean daily time spent above each threshold was calculated by dividing the total activity by the number of valid days and used for analyses. Three METs is equivalent to walking at $4km \cdot h^{-1}$ (Treuth et al., 2004; Department of Health, 2004), thus mean daily time in PA>4 was used as a crude indicator of time spent in MVPA.

Physical self-perceptions and self-esteem

Physical self-perceptions were assessed using the Children and Youth Physical Self-Perception Profile ((CY-PSPP) Whitehead, 1995). Whitehead (1995) reported good stability and internal consistency across subscales (Cronbach alpha = .79 to .92), and the CY-PSPP has recently been validated for use in young children (Welk & Eklund, 2005). The questionnaire comprises of 36 questions, representing six scales (6 items per scales): global self-esteem, the domain of physical-self worth, and subdomains sports competence, physical strength, body attractiveness and physical condition (see Appendix C). Each question consists of two statements and uses a structured alternative format. First the child must read the two statements and decide which "kid" is most like them. Next they must decide if it is "really true for me" or "sort of true for me" and then mark (X) the corresponding box. An example of a question for sports competence is shown in figure 3, whilst the full questionnaire is provided in the appendices. Every question is scored from one to four (1 meaning low self-perception, 4 meaning high self-perception). Scores for each sub-domain were summed - the maximum score of the six items for a sub-domain being 24, and the minimum 6. Children completed questionnaires independently during visits to the university laboratory. A researcher verbally described the questionnaire slowly and carefully to children to eliminate confusion, and was available to offer further assistance where necessary.

Figure 3 Example item in CY-PSPP to assess perceptions of sports competence

Really true for me	Sort of true for me				Sort of true for me	Really true for me
X		Some kids do very well at all kinds of sports	BUT	Other kids *don't* feel that they are very good when it comes to sports		

Eight further items were added to determine perceived competence in each of the assessed fundamental movement skills. This was done in order to include lower order facets/sub-facets of perceptions of competence which matched fundamental movement skill competence tasks. The additional items, which were based on those included by Southall et al. (2004) and written in a similar format to the other CY-PSPP questions, follow.

Some kids do well at games that involve kicking balls,

But other kids don't feel they do well at games that involve kicking balls.

Some kids do well at games that involve catching balls,

But other kids don't do well at games that involve catching balls.

Some kids wish they were able to run fast,

But other kids feel they are able to run fast.

Some kids do well at games that involve overhand throwing,

But other kids don't feel they do well at games that involve overhand throwing.

Some kids feel that they are not able to jump high,

But other kids feel they are able to jump high.

Some kids do well at games that involve striking (hitting) a ball, *But* other kids don't feel they do well at games that involve striking (hitting) a ball.

Some kids don't feel they are able to hop well,

But other kids feel they are able to hop well

Some kids do well at games that involve dodging,

But other kids don't feel they do well at games that involve dodging

Southall et al. (2004) reported the new items to be valid and reliable (α = .87), and that logical validity of the scale was confirmed by Harter in a personal communication to the authors (January, 2001). Perceived skill competence items were summed to create composite perceived total, locomotor and object-control skill competence scores.

3.2.3 Procedure

Assessments were conducted over a six week period from September to mid-October 2006. Children visited the university laboratories for one day during school time to undertake questionnaires and assessments of anthropometry, body composition, and cardiorespiratory fitness. Assessments of fundamental movement skills were undertaken at school, in the gym or playground, using a standardised sequential protocol. Physical activity monitors were distributed and collected at school, by one member of the research team. Children were issued with the same monitor that was worn in the fitness test in the laboratory.

3.2.4 Statistical analyses

To analyse fundamental movement skills, the number of components of each skill correctly demonstrated by each child was summed to give a score for each skill. A total skill score was created by summing the total number of skill components checked as present in each of the eight skills assessed (the index could hypothetically range from 0 to 48). Two further composite scores were created: locomotor skills (sum of components successfully demonstrated in the hop, vertical jump, sprint run and dodge; range 0 to 24) and object-control skills (sum of components successfully demonstrated in the catch, throw, strike and kick; range 0 to 24). Additionally, each skill was scored by creating a binary outcome variable of "proficient" (scored 1) versus "non-proficient" (scored 0). From this, "proficiency" was defined as demonstration of all or all but one of the listed skill components. Failure to achieve this standard was classed as "non-proficient".

Descriptive statistics were undertaken to compute the minimum, maximum, mean and SD for all continuous variables assessed. Frequency statistics were used to report the proportion of participants achieving proficiency for each skill. Initial descriptive analysis involved reporting the frequency of children who were classified as non-overweight or overweight according to Cole et al. (2000). Subsequent description involved ascertaining the proportion of children meeting the recommended guidelines for MVPA. That is, the percentage of children achieving an average of at least 60 minutes of daily PA>4 (indicator of MVPA).

All variables were checked for normality using the Shapiro-Wilk statistic, and by visual inspection of distribution charts. Univariate analyses included t-tests or Mann-Whitney U-tests (non-parametric variables only) to examine gender differences. Chi-square tests were used to calculate differences in prevalence of skill proficiency. ANCOVA's were used to calculate gender differences on locomotor and object-control skill composite scores, controlling for any differences on descriptive statistics (age, years to peak height velocity, total physical activity, % body fat, and perceived skill competence) which may confound, moderate, or mediate relationships.

The relationships between the dependent variables - physical activity, cardiorespiratory fitness ($\dot{V}O_{2peak}$) and body fat, and (a) fundamental movement skills and (b) physical self-perceptions were initially assessed via Spearman's rank correlations. Subsequently forced entry multiple regression analysis was used to examine whether (a) fundamental movement skill composite scores and (b) physical self-perception subscales predicted each of the dependent variables, whilst controlling for gender. Squared semi-partial correlations were calculated to indicate the unique variance attributed to each predictor. Finally, Spearman's rank correlations were used to explore associations between physical self-perceptions and fundamental movement skills. All analyses were carried out on SPSS statistical package 14.0 (SPSS Inc., Chicago, USA).

3.3 Results

Of the 152 children (62 boys, 90 girls) participating in the study, three children (2 boys, 1 girl) were absent on testing days and so did not attend university laboratories to complete anthropometric, fitness, and physical self-perception assessments. Of the 149 children who visited the laboratories: 2 girls did not complete the CY-PSPP questionnaire; 1 girl did not wish to undertake girth measures and so no data was recorded for waist circumference or waist/hip ratio; 3 boys were not scanned by DXA following requests from parents. In total 136 children (54 boys, 82 girls) met the criteria for $\dot{V}O_{2peak}$ and so were included in the analyses. Of the 13 children that attended the laboratory but had missing fitness data, reasons included failing to reach $\dot{V}O_{2peak}$ (n=9); obtaining an injury and not completing the test (n=1); requesting not to undertake the assessment (n=2); and a corrupt computer data file (n=1). Physical activity data was collected from 146 children (60 boys, 86 girls), although two children did not wear the accelerometer whilst undergoing the treadmill protocol and so do not have physical activity data for the thresholds of PA>4, PA>6 and PA>8. Of the six children with missing physical activity data, 4 children (2 boys, 2 girls) failed to meet the inclusion criteria, whilst 2 girls data files were removed due to higher values of physical activity than was deemed realistically possible. A total of 151 children (61 boys, 90 girls) completed the fundamental movement skill test battery, though one boy was absent from school and so was not assessed.

Table 3 Anthropometric, physical activity, fitness, physical self-perceptions and fundamental movement skills data (n = 152)

	N	Min	Max	Mean	SD
Anthropometry					
Age (years)	149	9.1	10.3	9.7	0.3
Peak height velocity	149	-4.3	-1.9	-3.3	0.5
Stature (m)	149	1.2	1.5	1.4	0.1
Mass (kg)	149	21.9	73.0	36.6	8.4
BMI (kg/m^2)	149	12.7	31.9	18.9	3.2
Sitting height (cm)	149	63.9	81.5	73.0	3.4
Waist circumference (cm)	148	49.2	89.5	62.9	7.4
Waist/hip ratio	148	0.7	0.9	0.8	0.0
Body fat (%)	146	13.3	44.7	27.6	6.5
Physical activity and fitness					
$\dot{V}O_{2peak}$ ($mlO_2 \cdot kg^{-1} \cdot min^{-1}$)	136	26.2	63.7	47.1	7.5
Physical activity (cpm/day)	146	285.8	926.6	554.9	137.9
Physical activity >4$km \cdot hr^{-1}$ (mins/day)	144	26.2	153.6	81.4	28.1
Physical activity >6$km \cdot hr^{-1}$ (mins/day)	144	2.8	95.3	29.5	17.1
Physical activity >8$km \cdot hr^{-1}$ (mins/day)	144	0.7	47.0	7.8	7.0
***Physical self-perceptions* (α)**					
Sports competence (.70)	147	8	24	18.2	3.5
Physical condition (.70)	147	9	24	18.1	3.4
Body attractiveness (.81)	147	7	24	17.1	4.0
Physical strength (.71)	147	7	24	17.0	3.6
Physical self-worth (.71)	147	8	24	17.8	3.5
Self-esteem (.79)	147	10	24	18.9	3.6
PSPP total	147	57	144	107.0	17.7
Total FMS competence	147	13	32	24.3	4.3
Locomotor competence	147	6	16	11.5	2.5
Object-control competence	147	7	16	12.9	2.3
Fundamental movement skills					
Hop	151	0	6	4.0	1.2
Vertical jump	151	2	6	4.0	0.8
Sprint run	151	1	6	3.5	1.1
Dodge	151	0	6	2.8	1.4
Kick	151	1	6	3.5	1.5
Catch	151	0	6	3.4	1.8
Throw	151	0	6	3.3	1.7
Strike	151	0	6	3.4	1.5
Locomotor skills	151	7	22	14.4	3.3
Object control skills	151	4	24	13.7	5.0
Total skill score	151	14	43	28.1	7.1

SD = Standard Deviation, α = Cronbach's Alpha

Table 4 Gender differences in anthropometric variables, physical activity, fitness, physical self-perceptions, and fundamental movement skills

	Boys			Girls			
	N	Mean	SD	N	Mean	SD	*P*
Anthropometry[†]							
Age (years)	60	9.7	0.3	89	9.7	0.3	.882
Peak height velocity	60	-3.2	0.5	89	-3.3	0.4	.215
Stature (m)	60	1.4	0.1	89	1.4	0.1	.473
Mass (kg)	60	36.9	8.8	89	36.4	8.1	.711
BMI (kg/m^2)	60	18.9	3.3	89	18.9	3.1	.967
Sitting height (cm)	60	73.5	3.5	89	72.6	3.3	.134
Waist circumference (cm)	60	63.9	7.9	88	62.2	6.9	.182
Waist/hip ratio	60	0.9	0.0	88	0.8	0.0	**.000****
Body fat (%)	57	24.9	6.9	89	29.4	5.7	**.000****
Physical activity and fitness[†]							
$\dot{V}O_{2peak}$ ($mlO_2 \cdot kg^{-1} \cdot min^{-1}$)	54	51.4	6.8	82	44.3	6.5	**.000****
Physical activity (cpm)	60	606.8	145.1	86	518.7	120.9	**.000****
Physical activity >4km hr^{-1} (mins)	59	85.1	29.1	85	78.9	27.3	.200
Physical activity >6km hr^{-1} (mins)	59	33.4	18.2	85	26.8	15.8	**.023***
Physical activity >8km hr^{-1} (mins)	59	10.8	8.7	85	5.7	4.5	**.000****
Physical self-perceptions[#]							
Sports competence	60	18.7	4.1	87	17.8	3.0	.072
Physical condition	60	18.7	3.7	87	17.7	3.2	.065
Body attractiveness	60	17.4	4.5	87	16.8	3.5	.215
Physical strength	60	17.4	4.2	87	16.7	3.1	.130
Physical self-worth	60	18.3	3.9	87	17.5	3.2	.164
Self-esteem	60	19.2	4.1	87	18.6	3.3	.163
PSPP total	60	109.7	21.1	87	105.2	14.8	**.046***
Total FMS competence	60	25.4	4.4	87	23.6	4.2	**.000****
Locomotor competence	60	12.0	2.6	87	11.1	2.5	.070
Object-control competence	60	13.4	2.3	87	12.5	2.3	**.010***
Fundamental movement skills[#]							
Hop	61	4.2	1.2	90	3.9	1.2	.057
Vertical jump	61	4.0	0.9	90	4.0	0.8	.978
Sprint run	61	3.5	1.2	90	3.5	1.0	.950
Dodge	61	3.3	1.4	90	2.5	1.4	**.000****
Kick	61	4.5	1.4	90	2.9	1.1	**.000****
Catch	61	4.4	1.4	90	2.7	1.6	**.000****
Throw	61	4.7	1.2	90	2.4	1.4	**.000****
Strike	61	4.4	1.2	90	2.8	1.2	**.000****
Locomotor skills	61	15.1	3.4	90	14.0	3.1	**.024***
Object control skills	61	18.0	3.7	90	10.8	3.5	**.000****
Total skill score	61	33.2	6.0	90	24.7	5.6	**.000****

SD = Standard deviation, [†] independent t-test, [#] Mann-Whitney U-test, * *P* = <0.05, ** *P* = < 0.01

Anthropometric characteristics, cardiorespiratory fitness score, physical activity, physical self-perceptions, and FMS data are shown in for the entire sample in Table 3, and by gender in Table 4

3.3.1 Anthropometry and physical characteristics

The sample (40% male) was aged approximately 9.6 years. As shown in Table 4, no gender differences were observed for age, years from peak height velocity, stature, mass, sitting height, BMI or waist circumference. Using age and gender-specific BMI cut-off points (Cole et al., 2000), 38% of girls and 38% of boys were classified as overweight or obese. Contrary to BMI and waist circumference data, boys had significantly lower % total body fat and waist/hip ratio compared to girls.

3.3.2 Physical activity and cardiorespiratory fitness

In total, 140 children completed the stages of $4km \cdot hr^{-1}$, $6km \cdot hr^{-1}$, and $8km \cdot hr^{-1}$ on the treadmill as part of the fitness protocol (136 reached $\dot{V}O_{2peak}$). Table 5 shows the percentage $\dot{V}O_2$ peak at each treadmill speed. Moderate intensity physical activity equates to 40-60% of $\dot{V}O_{2peak}$ (Treuth et al., 2004). Percentage $\dot{V}O_{2peak}$ at $4km \cdot hr^{-1}$ was approximately 38% and 41% in boys and girls, supporting the use of PA>4 as an indicator of time spent in MVPA. The mean accelerometer counts at this threshold equated to approximately 1564±509 counts per minute. Using this criteria, 71% of boys (42/59) and 69% of girls (59/85) achieved more than 60 minutes of PA>4. Further, 47% of boys (28/59) and 27% girls (23/85) participated in more than 90 minutes of PA>4 on average per day. Boys participated in significantly more total physical activity (cpm) than girls, and spent more minutes in PA>6 and PA>8, but no gender distinction was found for PA>4 (Table 4). Boys had significantly higher $\dot{V}O_{2peak}$ than girls, with a mean score approximately $7ml \cdot kg^{-1} \cdot min^{-1}$ above that of the girls.

Table 5 Percentage VO_{2peak} at treadmill speeds (mean ± S.D)

	Boys (n=57)	Girls (n=83)
$\%\dot{V}O_{2peak}$ at 4 km·h^{-1}	38.3 ± 4.5*	40.6 ± 5.5*
$\%\dot{V}O_{2peak}$ at 6 km·h^{-1}	54.9 ± 6.2**	58.5 ± 6.6**
$\%\dot{V}O_{2peak}$ at 8 km·h^{-1}	78.3 ± 7.0**	85.2 ± 6.1**

boys vs girls; *$P < 0.05$, **$P < 0.01$

3.3.3 Physical self-perceptions, self-esteem and perceived FMS competence

Cronbach's alpha coefficients for each of the CY-PSPP subscales ranged from 0.70 to 0.81 (see Table 3), indicating acceptable internal consistency. As shown in Table 4, boys and girls had relatively high physical self-perceptions and self-esteem, with mean scores higher than the median value (15) across all subscales. Boys had significantly higher PSPP total score than girls, though no significant differences were found for any subscales or for global self-esteem. However, there was a trend for boys to have higher perceptions of sports competence and body attractiveness compared to girls. With regards to perceptions of skill ability, boys had significantly higher perceived total FMS competence and object-control skill competence than girls, whilst there was a trend for higher perceptions of locomotor competence too.

3.3.4 Fundamental movement skills

The prevalence of FMS components for each individual skill can be found in Appendix D. Table 4 shows gender differences in the mean number of skill components checked as present for each skill (minimum 0, maximum 6), and for the FMS composite variables – FMS total skill score (all eight skills), locomotor skills (hop, vertical jump, dodge, sprint run) and object-control skills (kick, catch, throw, strike). With regards to individual object-control skills, boys demonstrated significantly more skill components than girls in the kick, catch, throw and strike.

Concerning specific locomotor skills, boys performed better at the dodge than girls, but no differences were found in the vertical jump, sprint or hop. Boys scored highest in the four object control skills, which were girls' lowest scoring skills. Girls performed best at locomotor skills including the hop, vertical jump and sprint run, with the latter two skills amongst boys' lowest scores. The dodge was the worst skill for both boys and girls. For both boys and girls, no mean skill scores were above the skill proficiency barrier, defined as over 5 skill components. In girls, the vertical jump was the only skill with a mean score above 4, whilst boys surpassed this in six of the eight assessed skills. Significant gender differences, favouring boys, were observed for total skill score, locomotor skills and object-control skills composite scores. However, following adjustments for differences in age, maturation (years from peak height velocity), physical activity (cpm), body fat (%), and perceived skill ability, boys only scored significantly higher in object-control skills (see Figure 4). There was virtually no difference in locomotor skills.

Figure 4 Gender differences in locomotor and object-control skills (adjusting for age, maturation, body fat (%), physical activity (cpm), and perceived skill ability). Note. Boys vs girls ** P <0.01

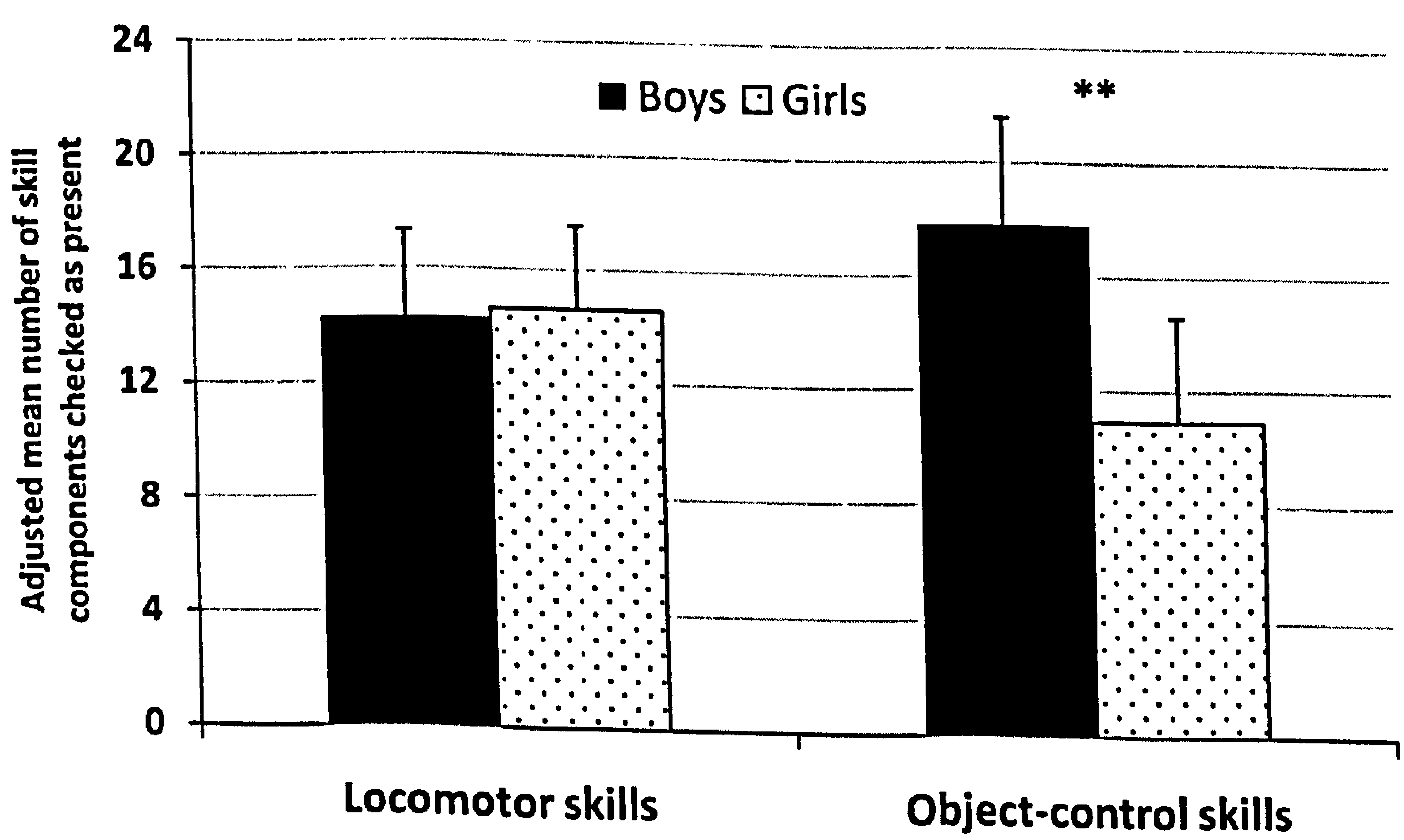
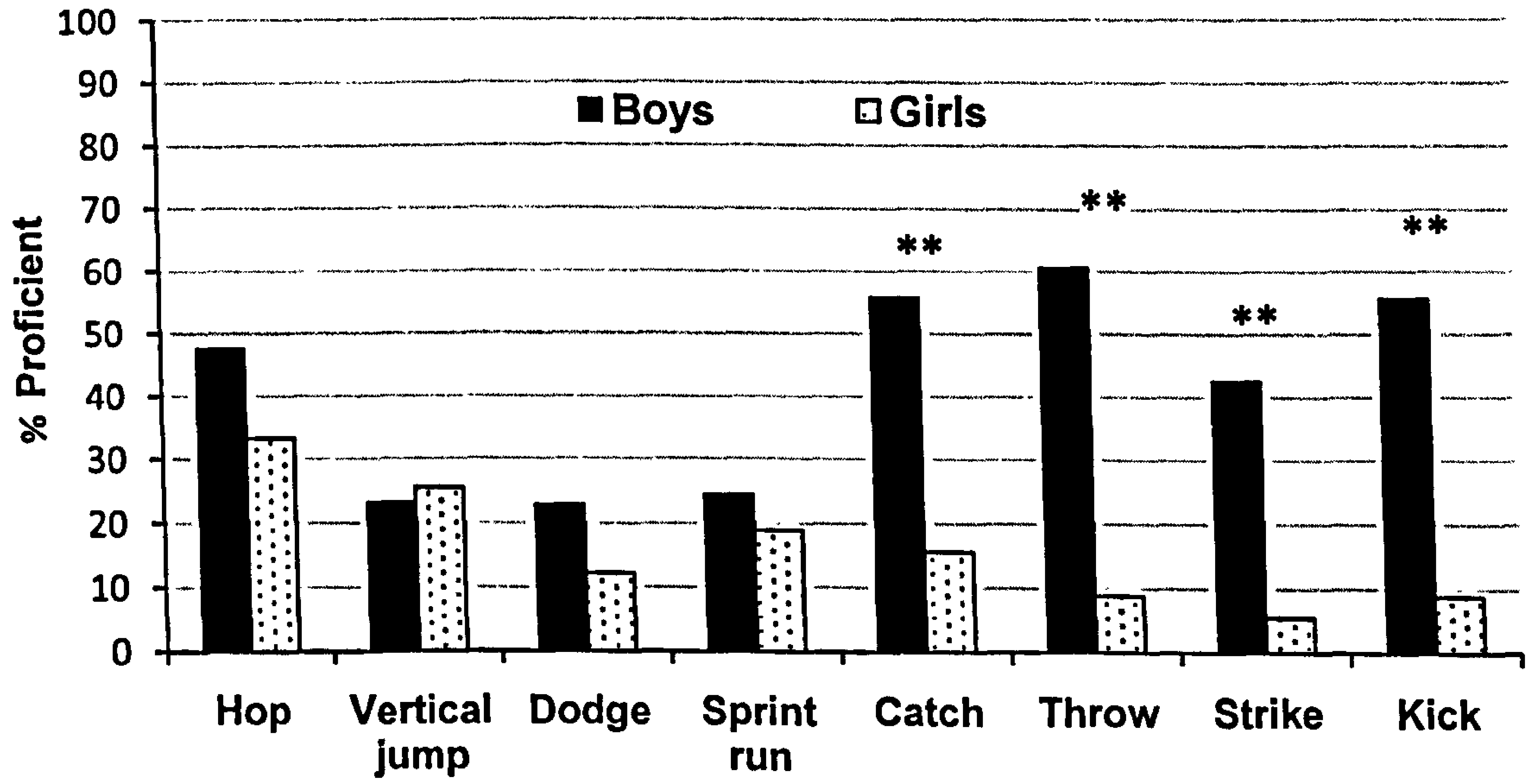


Figure 5 shows the prevalence of proficiency (possessing all, or all but one, required components of a skill) at FMS for boys and girls. Overall, boys were significantly more proficient than girls (42% vs. 16%). Boys were more advanced than girls in seven out of the eight skills; however these differences were only significant ($P < .001$) in the four object control skills – the catch ($\chi^2 = 25.3$), overarm throw ($\chi^2 = 44.1$), strike ($\chi^2 = 28.4$) and kick ($\chi^2 = 37.4$).

Figure 5 Prevalence (%) of proficiency at fundamental movement skills among boys (n=61) and girls (n=90). *Note.* boys vs girls ** $P<0.01$



Prevalence of proficiency amongst girls was very low. Only one-third of girls were rated as proficient in the hop, yet this represented their highest rated skill. The next best assessed skill was the vertical jump, with just 25% proficiency. Girls performed worst at the overarm throw, strike and kick, with over 9 out of 10 girls being classified as poor. Prevalence of proficiency was higher in boys. Over half of boys were classed as proficient in the overarm throw, kick, and catch. However boys performed worst in the vertical jump, sprint and dodge, with over 75% rated as poor.

Table 6 Relationships[#] between fundamental movement skills and physical activity, fitness and body fat in boys and girls

	Total PA (CPM)	PA >4km·hr^{-1} (mins)	PA >6km·hr^{-1} (mins)	Peak VO_2 (ml·kg^{-1}·min^{-1})	Body fat (%)
Hop					
Boys	.109	.236	.218	**.355****	**-.427****
Girls	.090	.189	.208	**.443****	**-.511****
V.Jump					
Boys	**.497****	**.437****	.222	**.294***	**-.303***
Girls	**.339****	**.308****	**.254***	.168	-.019
Sprint					
Boys	.063	.173	.074	.160	**-.330***
Girls	**.277****	**.218***	**.288****	.136	-.028
Dodge					
Boys	.251	**.306***	.205	**.371****	**-.567****
Girls	**.229***	.195	.202	.198	**-.231***
Kick					
Boys	.222	**.324***	**.278***	**.272***	**-.296***
Girls	.082	.013	.122	.071	.005
Catch					
Boys	-.068	.162	.010	.164	.069
Girls	.118	**.222***	.077	.029	-.007
Throw					
Boys	.163	.113	.151	**.385****	**-.249***
Girls	.201	.084	.086	-.054	-.005
Strike					
Boys	-.088	-.023	.082	-.055	-.031
Girls	.127	.046	.145	.171	-.058
Locomotor skills					
Boys	**.274***	**.384****	.235	**.417****	**-.584****
Girls	**.334****	**.294****	**.335****	**.380****	**-.320****
Object-control skills					
Boys	.103	.246	.210	.171	-.189
Girls	.186	.133	.184	.060	-.021
Total skill score					
Boys	.233	**.364****	**.264***	**.338***	**-.449****
Girls	**.307****	**.236***	**.311****	**.291****	**-.238***

[#] Spearman's rank correlations, * $P = < 0.05$, ** $P = < 0.01$

3.3.5 Relationships between FMS and physical activity, fitness and body fat

Table 6 shows bivariate correlations between FMS and physical activity, fitness and body fat variables in boys and girls. Total skill composite score showed weak-to-moderate associations with all physical activity, fitness and body fat variables. Locomotor skills composite score was positively related (r = .27 to .42) to fitness, total physical activity (cpm), PA>4 and PA>6 in boys and girls, whilst higher percent body fat was associated with lower competence in locomotor skills, particularly in boys (r = .58). No significant associations were found between object-control composite score and physical activity, fitness or body fat variables in boys or girls, however there was a trend for object-control skills score to be positively related to PA>4 and PA>6 in boys.

With regards to individual locomotor skills, competence in the hop was inversely related to percent body fat and positively associated with fitness in boys and girls, whilst there was also a trend for an association with PA>6. Vertical jump performance was negatively associated with body fat in boys, and showed weak-to-moderate positive associations across genders for total physical activity and PA>4; with PA>6 in girls; and with fitness in boys. The sprint run was positively correlated with total physical activity, PA>4 and PA>6 in girls, but not boys, though percent body fat was inversely related to boys' sprint run competence. Fitness was unrelated to sprint run performance in either boys or girls. The ability to dodge had moderate and small negative associations with body fat in boys and girls, respectively. The dodge skill was also significantly and positively associated with total physical activity (cpm) in girls, whilst there was a trend for a relationship with PA>4 and PA>6. In boys, significant weak-to-moderate positive correlations were found between dodge competence and PA>4 and fitness, whilst there were also trends for associations with total physical activity and PA>6.

In terms of object-control individual skills, in boys, competence in the kick was related to higher levels of fitness and more time spent in participation in physical activity at PA>4 and PA>6, though no associations were found in girls. The catch, throw and strike showed limited associations with physical activity and fitness variables across genders. There was a weak correlation between PA>4 and the catch in girls, whilst throwing competence was positively associated with fitness in boys. Only boys' ability to kick and throw was inversely related to percent body fat, no associations were found for individual object-control skills and adiposity in girls.

3.3.6 Does competence in fundamental movement skills predict physical activity, fitness and body fat?

Results of the standard multiple regression examining skill composite scores as predictors of physical activity, fitness and body fat are shown in Table 7 Controlling for gender, total skill score significantly ($P<.01$) predicted 11% of unique variance in PA>4; 6.2% in total physical activity (cpm); 6.5% in physical fitness; and 9.2% in percent body fat. Specifically, a 1 unit increase in total skill score is associated with a 0.35% decrease in body fat (95% CI: -.52 to -.18); a 0.33ml.kg^{-1}.min^{-1} increase in fitness score (95% CI: .14 to .53); a 1.63 minute increase in time spent in physical activity >4km^{-1} (95% CI: .86 to 2.40); and a 6 unit (cpm) increase in total physical activity (95% CI: 2.34 to 9.66).

When the total skill score variable was removed from the regression model and replaced with the composite variables of locomotor skills and object-control skills, only locomotor skills significantly predicted PA>4km^{-1}, total physical activity, and physical fitness – object-control skills were not related. Controlling for gender, locomotor skills significantly ($P< .01$) predicted 7.7% of unique variance in PA>4; 5.6% in total physical activity; 13.4% in physical fitness; and 23.7% in percent body fat. Specifically, a 1 unit increase in locomotor skills score was associated with a 1.08% decrease in total body fat (95% CI: -1.38 to -

.78); a 0.96ml·kg^{-1}·min^{-1} increase in fitness score (95% CI: .59 to 1.31); a 2.64 minute increase in time spent in PA>4 (95% CI: 1.16 to 4.12); and a 11 unit (cpm) increase in total physical activity (95% CI: 3.99 to 18.01). Object-control skills weakly predicted 2% of unique variance in percent body fat (*P*=.036):- a 1 unit increase in object-control score was associated with a 0.29% increase in percent body fat.

Table 7 Results from linear regressions with fundamental movement skills as predictors of physical activity, fitness, and body fat (adjusting for gender).

Predictor	β	SE	95% CI	*P*	r^2	sr_i^2
DV: ***Physical activity >4km·hr^{-1}***						
Total skill score	**1.63**	0.39	0.86 to 2.40	.000	12.1%	11%
Locomotor skills	**2.64**	0.75	1.16 to 4.12	.001	13.6%	7.7%
Object-control skills	0.73	0.69	-0.63 to 2.09	.288		0.7%
DV: ***Physical activity (cpm)***						
Total skill score	**6.00**	1.85	2.34 to 9.66	.002	16.1%	6.2%
Locomotor skills	**11.05**	3.57	3.99 to 18.10	.002	17.7%	5.6%
Object-control skills	1.54	3.27	-4.92 to 8.01	.638		0%
DV: ***Physical fitness (ml·kg^{-1}·min^{-1})***						
Total skill score	**0.33**	0.1	0.14 to 0.53	.000	28.2%	6.5%
Locomotor skills	**0.96**	0.18	0.59 to 1.31	.000	35.8%	13.4%
Object-control skills	-0.18	0.16	-0.50 to 0.13	.257		0.6%
DV: ***Body fat (%)***						
Total skill score	**-0.35**	0.09	-0.52 to -0.18	.000	20.3%	9.2%
Locomotor skills	**-1.08**	0.15	-1.38 to -0.78	.000	35.1%	23.7%
Object-control skills	**0.29**	0.14	0.02 to 0.56	.036		2%

β = unstandardised regression coefficient, SE = standard error for β coefficent,
DV = dependent variable, 95% CI = 95% confidence intervals for regression coefficient,
r^2 = total variance explained by gender and skill predictor variables (either total skill score or both locomotor skills and object-control skills)
sr_i^2 = squared semi-partial correlation coefficient, unique variance explained by predictor

3.3.7 *Relationships between physical self-perceptions and self esteem and fitness, physical activity and body fat in boys and girls.*

Table 8 shows the relationships between physical self-perceptions and self-esteem, and physical activity, fitness, and percent total body fat. In girls, perceptions of physical condition and body attractiveness showed weak-to-moderate positive associations with VO_{2peak}. Percent body fat was inversely related to perceived physical condition, whilst there were also trends for higher body fat to be associated with lower body attractiveness and self-esteem. No associations were found between CY-PSPP variables and total physical activity, PA>4 and PA>6.

Table 8 Relationships# between physical self-perceptions and physical activity, physical fitness, and percent total body fat in boys and girls

	Total PA (CPM)	PA >4km·hr^{-1} (mins)	PA >6km·hr^{-1} (mins)	Peak VO_2 (ml.kg^{-1}.min^{-1})	Body fat (%)
Sports competence					
Boys	-.095	**.296***	**.413****	.205	-.164
Girls	-.054	.052	-.073	.017	-.127
Physical condition					
Boys	-.187	.191	**.314***	**.355****	**-.301***
Girls	-.117	-.028	-.033	**.248***	**-.233***
Body attractiveness					
Boys	.058	.172	**.335***	**.274***	-.141
Girls	.033	.175	.093	**.232***	-.198
Physical strength					
Boys	-.012	**.303***	**.381****	.187	-.011
Girls	-.151	.014	.005	-.157	-.023
Physical self-worth					
Boys	-.083	.133	**.267***	.205	-.183
Girls	.004	.072	.040	.230	-.161
Self-esteem					
Boys	-.102	.195	**.370****	**.343***	-.204
Girls	.099	.093	.058	.139	-.198
PSPP total					
Boys	-.104	.244	**.398****	**.325***	-.213
Girls	-.030	.086	.033	.157	-.184

Spearman's rank correlations, * *P* = < 0.05, ** *P* = < 0.01

Compared to girls, boys' physical self-perceptions and self-esteem were more strongly related to physical activity, fitness and body fat variables. Perceived sports competence was positively associated with PA>4 and PA>6, and there was also a trend for a relationship with fitness. Perceptions of physical condition, body attractiveness and global self-esteem showed weak to moderate positive relationships with PA>6 and fitness. Perceived physical condition was negatively associated with percent body fat, whilst there was also a trend for higher body fat to be associated with lower self-esteem. Perceptions of strength was associated with PA>4 and PA>6. Perceived physical self-worth was positively related to PA>6, whilst there was a trend for a positive association with fitness and also a negative relationship with body fat. Similarly to girls, total physical activity was not significantly associated with physical self-perceptions or global self-esteem.

3.3.8 *Do physical self-perceptions predict physical activity, fitness and body fat?*

Table 9 shows the results of the multiple regression examining physical self-perception sub-scales as predictors of fitness and percent total body fat, adjusting for gender. The regression models with PA>4 and total physical activity as dependent variables were not significantly different from zero - the physical self-perception subscales and did not significantly predict activity. Gender and physical self-perceptions explained 32.4% of the total variance in physical fitness, though physical self-perception scales weakly predicted fitness. Only perceived physical condition and physical strength subscales were associated with fitness scores, predicting 3.2% and 3.8% of unique variance in fitness, respectively. Specifically, a 1 unit increase in perceived physical condition was associated with a $0.52 ml \cdot O_2 \cdot kg^{-1} \cdot min^{-1}$ increase in fitness (95% CI: 0.10 to 0.94, P=.016), whilst a 1 unit increase in perceived physical strength was associated with a $0.56 ml \cdot O_2 \cdot kg^{-1} \cdot min^{-1}$ decrease in fitness (95% CI: -.98 to -.15, P=.008).

Gender and physical self-perceptions explained 22.5% of the total variance in percent body fat, though physical self-perceptions were weak predictors. Only perceived physical condition and physical strength subscales were significantly associated with percent body fat, predicting 4.3% and 3.5% of unique variance in percent body fat, respectively. Specifically, a 1 unit increase in perceived physical condition was associated with a 0.53% decrease in body fat (95% CI: -.91 to -.15; P=.007), whilst a 1 unit increase in perceived physical strength was associated with a 0.48% increase in percent body fat (95% CI: .10 to .86).

Table 9 Results from linear regressions with physical self-perceptions as predictors of fitness and percent total body fat, adjusting for gender.

Predictor	β	SE	95% CI	P	r^2	sr_i^2
DV: ***Physical fitness*** ***($ml.kg^{-1}.min^{-1}$)***					32.4%	
Sports competence	-0.03	0.24	-0.50 to 0.45	.911		0.01%
Physical condition	**0.52**	**0.21**	**0.10 to 0.94**	**.016**		**3.16%**
Body attractiveness	0.39	0.20	0.00 to 0.77	.051		2.07%
Physical strength	**-0.56**	**0.21**	**-0.98 to -0.15**	**.008**		**3.78%**
Physical self-worth	0.21	0.25	-0.29 to 0.72	.403		0.38%
DV: ***Body fat (%)***					22.5%	
Sports competence	-0.04	0.22	-0.48 to 0.39	.849		0.02%
Physical condition	**-0.53**	**0.19**	**-0.91 to -0.15**	**.007**		**4.25%**
Body attractiveness	-0.20	0.17	-0.54 to 0.15	.260		0.72%
Physical strength	**0.48**	**0.19**	**0.10 to 0.86**	**.014**		**3.51%**
Physical self-worth	-0.22	0.23	-0.67 to 0.23	.331		0.54%

β = unstandardised regression coefficient, SE = standard error for β coefficent,
DV = dependent variable, 95% CI = 95% confidence intervals for regression coefficient,
r^2 = total variance explained by gender and physical self-perception subscales
sr_i^2 = squared semi-partial correlation coefficient, unique variance explained by predictor

3.3.9 *Is there a relationship between fundamental movement skills and perceptions of competence and self-esteem in older children?*

Table 10 shows bivariate correlations between fundamental movement skills and physical self-perceptions, self-esteem and perceived skill competence. In boys, total skill score showed significant weak-to-moderate positive associations (r =.28 to .30) with perceptions of sports competence, physical condition and physical strength. In girls, only self-esteem was significantly associated with total skill score. In terms of sub-groups of skills; girls' locomotor skills composite score was significantly and positively associated with perceptions of sports competence (r = .23), physical self-worth (r = .27) and self-esteem (r = .39), whilst there was a trend for body attractiveness also (r = .20). In boys, no self-perception variables were significantly associated with locomotor skills score, although there was a trend for perceived physical condition (r = .23). Object-control skills were not related to girls' self-perceptions but significant associations were found in boys. Positive weak-to-moderate correlations (r =.23 to .37) were found between boys' object-control skills composite score and perceptions of sports competence, physical condition and physical strength, whilst a trend was found for physical self-worth.

With regards to individual skills, in girls, independent object-control skills were not associated with self-perceptions. Significant weak-to-moderate associations (r = .22 to .35) were found between several CY-PSPP subscales and three out of four locomotor skills. Performance in the hop was associated with increased perceptions of attractiveness, physical self-worth and self-esteem. The dodge was positively associated with perceived sports competence, physical self-worth and self-esteem, whilst the latter was also associated with the sprint run.

In boys, no significant associations were observed between self-perceptions and individual locomotor skills, though there was a trend found between sprint run competence and perceived physical condition (r = .24). Some positive associations were found in boys between CY-PSPP subscales and individual object-control skills (r = .20 to .37). The kick was moderately associated with higher perceptions of sports competence, physical condition and physical strength, whilst there was a trend in physical self-worth (r = .24). The catch was also moderately associated with higher perceptions of sports competence and physical strength. There were also trends found between competence in the strike and perceived physical condition (r = .21) and physical strength (r = .20).

Table 10 Relationships[#] between fundamental movement skills and physical self-perceptions

	Sports competence	Physical condition	Body attractiveness	Physical strength	Physical self-worth	Self-esteem	PSPP total	Perceived skill ability[a]
Hop								
Boys	.031	.119	-.031	.070	.037	.137	.085	.050
Girls	.170	.176	**.219***	-.057	**.231***	.300	**.227***	**.241***
V.Jump								
Boys	.069	.124	.049	.141	-.016	.070	.082	-.114
Girls	.080	.042	-.042	.097	.121	.078	.076	-.125
Sprint								
Boys	.175	.253	-.018	.136	.066	.142	.133	-.006
Girls	.116	-.073	.112	-.005	.141	**.285****	.131	.011
Dodge								
Boys	.048	.166	-.082	.049	.030	.065	.052	.146
Girls	**.286****	.098	.186	.151	**.275***	**.346****	**.280****	-.007
Kick								
Boys	**.372****	**.262***	.106	**.373****	.241	.188	**.287***	**.287***
Girls	-.049	.006	-.083	-.143	-.127	-.040	-.087	.126
Catch								
Boys	**.319***	.189	.033	**.293***	.178	.081	.200	.235
Girls	.061	-.019	.106	-.093	.059	.139	.092	.049
Throw								
Boys	.104	.064	.124	.062	.005	.019	.063	.116
Girls	.110	-.080	.102	-.002	.127	.120	.090	.027
Strike								
Boys	.143	.211	-.129	.198	.169	.087	.116	.118
Girls	.082	-.098	.014	-.116	.050	.003	-.004	-.026
Locomotor skills								
Boys	.100	.230	-.047	.124	.036	.133	.112	.069
Girls	**.229***	.065	.200	.037	**.267***	**.387****	**.258***	.152
Object-control skills								
Boys	**.372****	**.275***	.042	**.363****	.228	.158	**.259***	**.319***
Girls	.027	-.099	.045	-.168	.025	.079	.002	.035
Total skill score								
Boys	**.285***	**.293***	-.002	**.283***	.159	.175	.220	.228
Girls	.160	.010	.152	-.067	.175	**.299****	.172	.104

[a] like-for-like comparison with relevant FMS, [#] Spearman's rank correlations, * $P = < 0.05$, ** $P = < 0.01$

In terms of perceptions of skill ability, like-for-like comparisons with corresponding skills showed that both boys and girls lack accuracy in assessing competence in most skills. In boys, only the kick was associated with perceived kicking ability, though there was a trend for boys to competently self-judge catching competence. In girls, only the hop was significantly associated with perceived ability.

3.4 Results summary

- 38% of girls and 38% of boys were classified as overweight or obese.
- 69% of girls and 71% of boys achieved at least 60 minutes of PA>4 per day, an indication of time spent in MVPA.
- Mean physical self-perceptions were relatively high across subscales in boys and girls, indicating positive psychological profiles.
- Prevalence of proficiency at fundamental movement skills was low-to-moderate, with girls' levels of proficiency particularly low.

3.4.1 *Gender differences*

- Compared to boys, girls were fatter, less fit and participated in lower amounts of total physical activity and high intensity physical activity (PA>6 and PA>8). However no gender difference was found for PA>4.
- No significant gender differences were found for CY-PSPP subscales, though there was a consistent trend for boys to score higher. Boys had significantly higher perceptions of total fundamental movement skill competence, and locomotor skill competence than girls.
- For fundamental movement skills, boys demonstrated significantly more skill components than girls in the dodge, kick, catch, throw, and strike, and had significantly greater skill composite scores. However, following adjustments for covariates, gender differences were only found for object-control skills, not locomotor skills.

- Prevalence of proficiency was higher in boys than girls, with significant differences found for each of the four object-control skills assessed.

3.4.2 *Relationships between fundamental movement skills and physical activity, cardiorespiratory fitness and body fatness*

- Total skill score was found to have weak-to-moderate associations with physical activity, fitness and body fat. Regression results indicate that total skill score explained 11% of unique variance in PA>4; 6.2% of total physical activity; 6.5% of cardiorespiratory fitness; and 9.2% of body fat.
- Locomotor skill score was found to have weak-to-moderate positive associations with fitness, and physical activity, and moderate negative correlations with percent body fat. Regression results found that locomotor skill score explained 7.7% of unique variance in PA>4; 5.6% in total physical activity; 13.4% in cardiorespiratory fitness; and 23.7% in percent body fat.
- Object-control skill score was not significantly associated with physical activity, cardiorespiratory fitness or percent body fat.
- Skill competence in the hop and dodge was negatively associated with percent body fat in boys and girls.
- The vertical jump was the strongest correlate of physical activity variables in boys and girls.
- The kick had important associations with PA>4 and PA>6 in boys but not girls. Conversely, the sprint run was positively correlated with total physical activity, PA>4 and PA>6 in girls but not boys.
- In boys, competence in the hop, jump, dodge, kick and throw was positively correlated with cardiorespiratory fitness. In girls, only the hop was associated with fitness.
- The catch, throw and strike showed weak associations with variables.

3.4.3 *Relationships between physical self-perceptions and physical activity, cardiorespiratory fitness, and body fatness*

- In boys, all CY-PSPP subscales were related to PA>6, whilst perceived sports competence and strength was correlated with PA>4, though no associations were found with total physical activity. In girls, no associations were found between subscales and physical activity.
- Regression results found that CY-PSPP subscales were not significant predictors of physical activity.
- Cardiorespiratory fitness was positively associated with perceptions of physical condition and body attractiveness in boys and girls, and with self-esteem in boys, whilst there was a trend for higher perceptions of physical self-worth across genders.
- Regression results found that the subscales perceived physical condition and strength were significant but weak predictors of cardiorespiratory fitness, explaining 3.2% and 3.8% of unique variance, respectively.
- Body fat was negatively correlated with perceptions of physical condition in boys and girls, whilst there was a trend for negative associations with self-esteem and body attractiveness (girls only).
- Perceptions of physical condition and strength were significant but weak predictors of percent body fat, explaining 4.3% and 3.5% of unique variance, respectively.

3.4.4 *Relationships between actual and perceived skill competence*

- Actual competence was significantly correlated with perceived competence in only one skill in boys (kick) and girls (hop), though there was a trend for boys in catching.
- In boys, kicking and catching represented the fundamental movement skills most related to CY-PSPP subscales, with positive associations found with perceptions of sports competence, physical condition (kick only) and strength.

- In girls, the dodge and hop represented the skills most related to CY-PSPP subscales and were associated with positive perceptions of physical self-worth and self-esteem, and perceived sports competence (dodge only) and body attractiveness (hop only).
- In boys, total skill score and object-control skill score was significantly associated with perceptions of sports competence, physical condition and physical strength. No associations were found for locomotor skills.
- In girls, locomotor skill score was significantly correlated with perceived sports competence, physical self-worth and self-esteem, which was also associated with total skill score. Object-control skills were not related to physical self-perceptions.

3.5 Discussion

This study aimed to investigate the prevalence of skill proficiency and levels of perceived competence in UK children, and additionally sought to examine the associations of fundamental movement skill competence and physical self-perceptions with children's physical activity, cardiorespiratory fitness, and percent body fat. The fundamental movement skill results indicate that the prevalence of skill proficiency among this population was low-to-moderate, with boys more skilful than girls in object-control skills but not locomotor skills. Further, skill competence was a significant predictor of cardiorespiratory fitness, physical activity, and percent body fat. The findings from physical self-perceptions indicate positive psychological profiles within this sample. No significant gender differences were found across CY-PSPP subscales, although there was trend for boys to have more positive self-perceptions. Physical self-perceptions did not predict physical activity participation, but perceived physical condition and physical strength were weak predictors of cardiorespiratory fitness and percent body fat.

3.5.1 Prevalence of proficiency at fundamental movement skills

In boys, prevalence of skill proficiency was low-to-moderate (ranging from 23% to 61%) and did not exceed 60% in any skill except the overarm throw. In girls prevalence of skill proficiency in girls was low (ranging from 6% to 33%), and only the hop had over 30% rated as proficient, whilst 9 out of 10 girls were rated as non-proficient in the throw, strike and kick. The large proportion of children rated as non-proficient in this sample is similar to results from studies of Australian children, including the "Switch-Play" (Hume et al., 2008), "Move it Groove it" (MIGI; (van Beurden et al., 2002), and "NSW SPANS 2004" (Booth et al., 2006) studies, which assessed skills using a similar assessment tool. The results suggest that there is significant potential to improve fundamental movement skill competence.

No recent information on the skill profiles of UK children is currently available; however comparisons on prevalence of skill proficiency can be drawn with the aforementioned Australian studies. Compared with similar aged children in the "Switch-Play" study (Hume et al., 2008), children in this study had similar levels of proficiency in the vertical jump and sprint run (both genders), lower proficiency in the strike and kick (both genders), and higher proficiency at the throw in boys, but similar findings in girls. Of the five possible skill comparisons with Grade 4 children in the MIGI study, A-CLASS girls had lower levels of proficiency in the hop, vertical jump, kick, catch and throw, whilst A-CLASS boys had similar levels of proficiency with the exception of the vertical jump which was lower. Finally, compared with NSW SPANS 2004 children (Booth et al., 2006), proficiency at the vertical jump and sprint run was higher than that found in A-CLASS (across genders). A-CLASS boys had higher levels of proficiency in the kick and throw, though no difference was found in catch. In girls, no difference was found between studies on kick and throw, but A-CLASS children had lower prevalence of proficiency in the catch. These comparisons suggest that there are interesting cross-cultural differences in skill proficiency between studies. However, all comparisons should be treated with caution due to the different methodologies employed to assess fundamental movement skills (for example, video analysis by experts vs direct observation by trained observers) and the likely cultural differences between Australian and UK children on the perceived value of various skills (van Beurden et al., 2002; Wright & Okely, 1997). There is a need for further research to be conducted to examine whether this data provides an accurate indication of the skill proficiency of UK children.

The low prevalence of skill proficiency is worrying given that children should master most fundamentals by 8 years of age (Gallahue & Ozmun, 1998; Payne & Isaacs, 2008). However, the development of fundamental movement skills is not automatic, in order to develop, skills need to be taught and practiced. Instruction time necessary to develop skill proficiency can range from 240-600 minutes, depending on the skill and developmental capability of the child (NSW Department of Education, 2000). It may be that children were not sufficiently active and so lacked the opportunities to develop these skills. However, an examination of the physical activity data reveals that 71% of boys and 69% of girls participated in at least 60 minutes of PA>4 per day, which suggests that the majority of children in the sample were sufficiently active. Alternatively, the physical activity experiences that children were engaged in may have lacked the quality to facilitate improvements in such skills. For example, children may not have received the quantity or quality of coaching within physical education or sport necessary to reach proficiency in these skills. The training provided to primary school teachers in physical education has significantly declined (Caldecott, Warburton, & Waring, 2006a, 2006b), whilst OFSTED reported that teachers have a weak understanding of progression and assessment in PE (Office-for-Standards-in-Education, 1998). Further, schools are being asked to focus on literacy and numeracy, and so limited attention is paid to the provision of quality early learning experiences in physical education that will foster development in fundamental movement skills. This supports the need for after-school programmes to provide an opportunity for enhancing such skills (Raudsepp & Päll, 2006). On the other hand, skill competence may be low as children were recruited into the project from deprived wards. Children from higher socioeconomic backgrounds have been associated with increased levels of skill proficiency (Booth et al., 1999; Booth et al., 2006; Okely et al., 2004). Such children may have greater access to facilities and be more likely to own sports equipment and therefore have increased opportunities to develop these skills.

3.5.2 Gender differences in fundamental movement skills

The skills selected for assessment were considered age-appropriate and free from gender bias (Hands & Larkin, 1997). However, overall, boys possessed more skill components and were more proficient than girls. Similar to previous studies which used similar methods (Booth et al., 1999; Okely & Booth, 2004; van Beurden et al., 2002), more prevalent proficiency and skill competence was found in object-control skills (catch, throw, strike and kick) among boys, and for three of the four locomotor skills (vertical jump, hop, and sprint run) among girls. Gender differences were significant in object control skills (boys better), but not locomotor skills. The observed gender differences in object-control skills may reflect the different sports and activities in which children typically participate in at this age. More boys play football, basketball and cricket than girls and so have further opportunities to develop and practice object control skills such as kicking, catching and throwing (Okely & Booth, 2004). Conversely girls are more likely to participate in activities such as dance or gymnastics which do not reinforce object-control skills. Differences are also formulated in unstructured settings such as school playtime. Boys are significantly more likely to participate in ball games whereas girls prefer sedentary play, skipping or hopscotch (Blatchford et al., 2003). This explanation supports the view that gender differences are environmentally and culturally induced, rather than biological (Thomas, 2000). If similar opportunities for instruction, practice, encouragement, and feedback are provided to both boys and girls then observed gender differences can be reduced (Okely & Booth, 2004).

3.5.3 Fundamental movement skills and percent body fat

Overweight and obese children suffer from bullying, name-calling and teasing, and may seek to avoid overt victimisation by withdrawing from physical activity (Faith et al., 2002; Gray, Janicke, Ingerski & Silverstein, 2008; Griffiths, Wolke, Page & Horwood, 2006; Janssen, Craig, Boyce & Pickett, 2004; Storch et al., 2007; Zabinski, Saelens, Stein, Hayden-Wade & Wilfley, 2003), which, in turn, may limit their opportunities to develop skill competence. The results revealed weak-to-moderate negative associations between skill competence and percent body fat. Specifically, total skill score showed weak-to-moderate negative correlations with percent body fat in boys (r = -.45) and girls (r = -.24). The associations are stronger than those found between product-assessed motor skills and the mean of two skin folds in young children (McKenzie et al., 2002), and alike to those found between motor proficiency and BMI z-score in similar-aged children (Wrotniak, et al., 2006), but in contrast to one study which found no relationship between skill index score and BMI (Hume et al., 2008). After controlling for gender, total skill score predicted 9.2% of the variance in percent total body fat, suggesting that the association between movement skills and body fat is weak to moderate. However, experimental research is required to determine whether skill competence is causally related to body fat.

When skills were partitioned into locomotor skills and object-control skills, only locomotor skills were associated with percent body fat, with stronger correlations observed compared to total skill score in boys (r = -.58) and girls (r = -.32). Locomotor skills significantly predicted 23.7% of variance in percent total body fat, signifying a moderate association. This finding of a unique influence for locomotor skills is supported by two other recent studies which classified children as overweight using BMI (Cole et al., 2000). Southall et al. (2004) found that overweight children, as classified by BMI, had lower competence in locomotor skills than their non-overweight peers but no difference was found for object-control skills. Whilst Okely et al. (2004) found that non-overweight boys and girls were two to three times more likely to possess more advanced locomotor skills than overweight boys and girls, though object-control skills were virtually unrelated to body composition. The results from Southall et al. (2004), a much smaller study but including a broader range of skills and Okely et al. (2004), a very large sample but with fewer skills in their test battery - complement the findings from this study.

Locomotor skills may be more related to obesity than object-control skills for several reasons. Firstly, object-control skills require less movement of body mass from one place to another than locomotor skills, and so may be less difficult to perform for overweight children. Riddiford (2000) showed that obese children had greater difficulty moving their greater body mass against gravity when rising from a chair compared to non-obese children. Secondly, obese children can demonstrate abnormal gait patterns (McGraw, McClenaghan, Williams, Dickerson, & Ward, 2000), which increases the energy cost of locomotion and may cause early fatigue, thus limiting time spent practising locomotor skills. Further, overweight and obesity is often associated with orthopaedic conditions such as flat-footedness and increased plantar pressure at the forefoot which may cause pain or discomfort during physical activities and cause locomotor movement complications (Dowling, Steele, & Baur, 2001, 2004; Hills, Hennig, Byrne, & Steele, 2002; Mickle, Steele, & Munro, 2006a, 2006b; Riddiford-Harland, Steele, & Storlien, 2000). Okely and colleagues (2004) hypothesize that the relationship between skill competence and overweight maybe reciprocal. Thus, children who are overweight participate in less physical activity, and so have less opportunity to practice and develop proficiency in motor skills, *or* children who are less skilled have fewer opportunities to engage in physical activity and gain less enjoyment from participation which may cause overweight. Taken together, the results suggest that improving locomotor skills may be a plausible intervention strategy to reduce adiposity in children; however experimental research is needed to determine the causal nature of this relationship.

3.5.4 Fundamental movement skills and physical activity

The results of the present study indicate that fundamental movement skills may have an important influence on physical activity behaviour. Total skill composite score showed weak-to-moderate associations with total physical activity (cpm) in boys and girls, and, after adjusting for gender, explained 6.2% of unique variance. This is marginally smaller than the finding of Wrotniak and colleagues (2006), who found that product-assessed motor skills explained 8.7% of additional variance in total physical activity in similar aged children. In contrast, pedometer-determined total physical activity was not related to select motor skills in 11-13 year old children (Reed et al., 2004). Skill competence had a stronger influence on MVPA (PA>4) than total physical activity (cpm), explaining 11% of unique variance. Further, observed correlation coefficients of .36 in boys and .24 for girls were higher than those found in a similar study of Australian youth (Hume et al., 2008). It may be that it is easier for children who are moderately or highly skilled to participate in physical activity at higher intensities, as more efficient movement patterns may result in less energy expenditure and lower levels of fatigue (Wrotniak et al., 2006). Alternatively, MVPA could include sport participation which may offer opportunities to enhance such skills. However, Okely et al. (2001b) found that adolescents' movement skills explained only 3% of time spent in self-reported organised physical activity. The results of this and other research likely differ due to differences in the age range of participants (children vs adolescents), and methodologies employed to assess motor skills (product vs process) and physical activity (instrument, accelerometer epoch: 1 min vs 5 *s*). Taken together, the research provides support for a positive association between fundamental movement skills and physical activity in children.

3.5.5 Fundamental movement skills and cardiorespiratory fitness

Another important result of the present study was an association between skill competence and cardiorespiratory fitness, with total skill score predicting 6.5% of variance in fitness. This supports previous findings from cross-sectional research in young children and adolescents that used indirect measures of fitness (Okely et al., 2001a; Reeves et al., 1999). As Stodden et al. (2008) propose - children with higher skill competence will have more opportunities to participate in physical activity, which will increase fitness and allow further improvement and refinement of motor skills. Similarly, children who are more fit will be able to persist in activities for longer, and continue to develop motor skill competence. Thus cardiorespiratory fitness likely mediates the relationship between physical activity and movement skills. Cardiorespiratory fitness is a key factor in children's health (Ortega et al., 2008), yet fitness levels in youth are declining (Stratton et al., 2007). Improving children's movement skills may be one strategy to promote higher levels of fitness, but intervention research is needed to document a cause-and-effect relationship.

3.5.6 Important influence of locomotor skills

Similar to the findings for body fat and movement skills; locomotor skills significantly predicted cardiorespiratory fitness (13.4% variance), total physical activity (5.6%), and MVPA (7.7%) but object-control skill composite score did not. It is interesting that only locomotor skill composite score was associated with physical activity and this may reflect the nature of children's physical activities at this age, which may be centred around 'play' rather than structured activity. Activities including tag, hopscotch and other playground games do not require competence in manipulative skills as a prerequisite to participation, nor do they require equipment. Children may find it easier to play such games to be active and likely develop locomotor skills and fitness when doing so. It may be that as these children move into adolescence object-control skills become more important as youth physical activity participation becomes more structured and engagement in recreational sport and organised competition are the main contributors to physical activity. One longitudinal study reported that children's proficiency in object-control skills was associated with levels of physical activity and fitness in adolescence, yet locomotor skills did not predict future behaviour (Barnett et al., 2008a, 2008b). There was evidence that select object-control skills were associated with physical activity and fitness. As stated earlier, boys are significantly more likely to participate in ball games in the playground than girls (Blatchford, Baines, & Pellegrini, 2003), which may explain why the kick and throw was important in boys' physical activity and fitness. Catching is an important skill for the traditional girls game of netball, which may explain why it is associated with girls' MVPA. As locomotor skills had important associations with physical activity, it is unsurprising that such skills were important predictors of cardiorespiratory fitness. Children who were proficient in locomotor skills participated in more physical activity, which, in turn, may have improved fitness. Additionally, it seems logical that locomotor skills (for example hopping), which involve moving the body from one point to another, would be more related to fitness than object-control skills, which are more static in nature (e.g. catching). It is possible that higher movement skill competence facilitates increased participation in physical activity, which in turn, improves cardio-respiratory fitness and this is consistent with the model proposed by Stodden et al. (2008).

3.5.7 Physical self-perception profiles of 9-10 year old children

The physical self-perception results suggest that 9-10 year old boys and girls in this sample had relatively high physical self-perceptions. This is encouraging, as low physical self-perceptions could negatively impact self-esteem. The data is similar to other studies of physical self-perceptions in children from Canada (Crocker et al., 2000) and USA (Welk & Eklund, 2005), although comparisons should be treated with caution due to the wider age range assessed within these samples. Notably, two studies examining physical self-perceptions in 13-14 year old UK children (Gilson et al., 2005; Hagger et al., 1998) found lower self-perceptions compared to the 9-10 year old children assessed in this study, suggesting a decline into adolescence. This could suggest that the transition from childhood to early adolescence is a critical period for physical self-perceptions, which may need to be targeted if positive self-perceptions from late childhood are to be maintained.

3.5.8 Gender differences in physical self-perceptions

There was a strong trend for gender differences in physical self-perceptions, with boys scoring higher on global self-esteem, the domain of physical self-worth and the sub-domains of sports competence, physical condition, body attractiveness and physical strength. The finding of a trend for gender differences is consistent with other research. Whitehead (1995) found 11-13 year old boys had higher perceived self-esteem, physical self-worth, body attractiveness, sport competence and physical strength than same-aged girls. Crocker et al. (2000) also observed more positive perceptions of strength, sport skills and physical self-worth in boys than girls, whilst Welk and Eklund (2005) found that young boys perceptions were significantly higher than girls' in all CY-PSPP constructs but body attractiveness. However, Hagger et al. (1998) found differences *only* existed in body attractiveness for 13-14 year old children, whilst Gilson and colleagues (2005) found no gender differences.

Reasons for gender differences are unclear. Perceptions of competence can stem from actual competence or social support (Harter, 1978, 1985a). Boys in the project were more competent than girls in some measured outcomes i.e. boys possessed better fundamental movement skills, fitness, and had lower levels of body fat. This may explain higher perceptions of sports competence, physical condition, and body attractiveness. However, Welk and Eklund (2005) suggest that perceptions of competence are likely to be conceived by comparisons with peers of the same-sex, rather than the opposite sex. They argue that reasons for gender differences may be based on social and cultural factors. Boys tend to value physical competence more than girls, and have greater expectations for success in physical activity and sport (Eccles et al., 1993). Boys also receive more encouragement than girls from parents to be physically active (Brustad, 1993). These social pressures could explain higher perceived physical competence. Conversely, girls may not see themselves as "the sporty type", they place little value on physical competence and so have lower self-perceptions. Further, gender differences may simply be due to girls being more modest, whilst boys exaggerate competence (Mullan et al., 1997).

3.5.9 Physical self-perceptions and physical activity

In boys, weak to moderate associations were found between MVPA (PA>4) and perceived sports competence and physical strength, whilst all CY-PSPP subscales were positively associated with PA>6. However girls physical self-perceptions were not related to physical activity variables. Some studies have reported similar relationships across genders between self-reported physical activity and physical self-perceptions (Crocker et al., 2000; Raudsepp et al., 2002). Yet another study ,which also used an objective measure of physical activity, showed fair correlations in boys but weak correlations in girls (Raustorp, et al., 2005), supporting the findings of this study. Despite evidence of weak to moderate correlations in boys, after adjusting for gender physical self-perceptions did not significantly predict participation in total physical activity, or MVPA. This is in contrast to other studies which have found that physical self-perceptions, particularly perceived sports competence and physical condition, predict 20-29% of the variance in physical activity in boys and 4-27% of the variance in physical activity in girls (Crocker et al., 2000; Raudsepp et al., 2002; Raustorp et al., 2005). This study used accelerometers to measure physical activity and included slightly younger children, which may explain the discrepancy between findings of this study and others.

3.5.10 Physical self-perceptions and cardiorespiratory fitness

Previously, children's performance in fitness tests, such as shuttle run protocols and mile-run times, have been found to be positively associated with perceptions of sports competence, physical condition and body attractiveness (Biddle et al., 1993; Raudsepp et al., 2002; Welk et al., 1997; Welk & Eklund, 2005; Whitehead, 1995). In this study, fair-to-moderate associations were found between cardiorespiratory fitness and perceived physical condition and body attractiveness in boys and girls, whilst fitness was also positively associated with self-esteem in boys. These results, obtained using a direct measure of fitness, lend support to previous work; however, associations were slightly weaker in this study - results from the multiple regression found that only perceived physical condition and physical strength significantly predicted fitness, explaining 3.2% and 3.8% of unique variance, respectively. These findings suggest that physical self-perceptions are only weakly associated with fitness.

3.5.11 Physical self-perceptions and percent body fat

Perceptions of physical condition and physical strength also significantly predicted some variance in percent body fat, explaining 4.3% and 3.5%, respectively. Negative associations between body fat and perceived physical condition have been reported elsewhere (Raustorp et al., 2005; Welk & Eklund, 2005). Further, Southall et al. (2004) reported that overweight children had significantly lower actual and perceived physical competence than non-overweight children. However, our findings, observed using a DXA measure of body fatness, suggest that physical self-perceptions do not substantially influence obesity. It is possible that a consequence of childhood obesity may be more negative perceptions of the physical self rather than *vice versa*. For example, Franklin and colleagues (2006) found that obesity negatively impacted children's perceptions of athletic competence and global self-worth, with a stronger negative influence of obesity found in girls. Similarly, Raustorp et al.

(2005) found stronger inverse relationships for specific physical self-perceptions in girls.

3.5.12 Relationships between actual and perceived competence

The results of the multiple linear regression analyses in this study suggest that physical self-perceptions are weak predictors of physical activity, fitness and body fat. The finding that fundamental movement skill competence is a stronger predictor of physical activity, fitness and fatness than physical self-perceptions in this sample of 9-10 year old children is consistent with the model proposed by Stodden et al. (2008), but disagrees with Welk's (1999) views that perceptions of competence are more important than actual competence. Perceptions of competence may be less related at this age because children's ability judgements are generally high and lack accuracy. The results show that boys and girls of this age group do not have the ability to accurately assess competence in fundamental movement skills – actual competence was only related to perceived competence in one skill for boys and girls. Similarly, observed correlations between perceived physical condition and fitness were not as strong as would be expected, suggesting that many children do not have a sound judgment of their fitness level. Other studies have also reported that children can lack accuracy in assessing actual competence (Rudisill et al., 1993; Raudsepp & Liblik, 2002), whilst others have found that young children have a fairly accurate sense of their physical status (Sollerhed et al., 2007).

The lack of accuracy in children's self-perceptions suggests that their sources of competence information are not accurate enough. Young children rely on skill mastery and social reinforcement from adults for competence information (Harter, 1978; 1985a). Significant adults should offer appropriate reinforcement and performance contingent praise to enhance perceptions of competence (Horn, 1985), non-reinforcement or in-contingent praise is likely to be detrimental to perceptions of competence. As children become older the emphasis shifts to peer comparison as a means of judging personal competence (Weiss & Ferrer-Caja, 2002), which can have a negative impact. Children also become better at assessing competence with age. Consequently, the perceived competence and health-related fitness relationships may strengthen with age.

3.5.13 Strengths and limitations of the study

The strengths of this study lie in its strong scientific methodologies, including 1) the use of accelerometers to objectively assess physical activity, 2) a five second epoch for recording physical activity data, 3) a direct measure of cardiorespiratory fitness, 4) the assessment of body composition with DXA, and 5) the use of video analysis and process-orientated checklists to assess fundamental movement skills.

Limitations of the study include the relatively small sample size, which limits the generalisability of the findings. Further, the use of PA>4 as a crude indicator of MVPA meant that far more children were classified as having met the recommended guidelines than the 5.1% of boys and 0.4% of girls found in the ALSPAC study, which defined MVPA as 3600 counts per minutes and used a 1 minute epoch (Riddoch et al., 2007). It is recommended that calibration studies, which aim to define accelerometer cut-off points, should include a range of activities that represent children's typical free-living activities (Reilly et al., 2008). Unfortunately, for time and practical reasons this was not possible in this study and so a treadmill protocol was employed. It could be argued that the use of a treadmill to individually calibrate children's physical activity thresholds was a limitation of the study as biomechanics of movement differ between treadmill and non-treadmill movement (Freedson et al., 2005). That is, children's counts are lower in treadmill movement than in non-treadmill movement (Freedson et al., 2005). This means that using a treadmill for the purposes of individual calibration during walking at $4 km \cdot h^{-1}$ may underestimate the accelerometer counts produced at that intensity in non-treadmill walking, thus classifying lower intensity activity as MVPA. However, it should be noted that PA>4 corresponded with approximately 40% of $\dot{V}O_{2peak}$ in both boys and girls, which represents moderate intensity activity. Additionally, the physical activity data is similar to that produced within the SPEEDY study, which used 2000 counts per minute to define MVPA and a 5 second epoch and found that 69% of children were sufficiently active. Finally, the large standard deviation around the mean accelerometer counts at PA>4 (1564±509) highlights the variation in counts across children at a standardised intensity, supporting the use of individual calibration to define physical activity thresholds.

3.5.14 Summary of findings

In summary, the findings of this cross-sectional study corroborate those from other studies examining fundamental movement skills in children. Prevalence of proficiency in skills was low-to-moderate, suggesting that there is great potential to improve such skills. It is especially important that children develop movement skills as competence was positively associated with physical activity and cardiorespiratory fitness, and inversely related to percent total body fat. Locomotor skills, in particular, should be targeted to positively influence such health behaviours. Physical self-perceptions profiles of children were positive, whilst observed gender differences support findings from previous studies. However, self-perceptions were weak predictors of dependant variables, suggesting that actual competence rather than psycho-social determinants are more important predictors of behaviour in this age range. Researchers should examine the effectiveness of interventions on these determinants to examine whether a cause-and-effect relationship is present.

Chapter 4

Study 2

The effects of a 9-week intervention on fundamental movement skills, physical self-perceptions and body mass index in 8-9 year old children: An exploratory trial

4.1 Introduction

Fundamental movement skills are the foundation for participation in popular types of physical activities and sports (Burton & Miller, 1998; Haywood & Getchell, 2005; Payne & Isaacs, 2002). Childhood is a sensitive learning period for motor skill development (Gallahue & Donnelly, 2003). In order to develop, these skills need to be taught and practiced (Payne & Isaacs, 2002), with between 240 and 600 minutes of instruction time required to reach proficiency (NSW Dept. of Education and Training, 2000). Children's skills emerge within a dynamic system that is affected by interactions between the task, the learner and the environment (Newell, 1986). Personal characteristics, motivation, prior experience, community and cultural values, and other factors can combine to affect the learning of fundamental movement skills (Gallahue & Ozmun, 1998).

Cross-sectional research suggests that mastery of fundamental movement skills is associated with important health benefits. For example, skill competence is positively correlated with physical activity in children and adolescents (Fisher et al., 2005; Okely et al., 2001b; Sääkslahti et al., 1999; Ulrich, 1987; Wrotniak et al., 2006). Failure to master such skills may prevent participation in physical activity and sport during childhood and later in life (Gallahue & Donnelly, 2003). Increased proficiency in the skills is also positively correlated with cardio-respiratory fitness (Okely et al., 2001a), and inversely related to obesity (Okely, Booth, & Chey, 2004; Southall et al., 2004; Wrotniak et al., 2006).

Mastery of movement skills is thought to influence perceptions of physical competence (Weiss, 2000). Competence motivation theory posits that perceptions of physical competence influence children's motivation to participate in physical activity (Harter, 1978; Weiss, 2000). Children who perceive themselves to be highly competent in an activity or skill will be more likely to enjoy, persist and continue to attempt skill mastery, whilst children who have low perceived competence will not continue and lose interest (Harter, 1978; Ulrich, 1987). Several studies have documented that physical self-perceptions (perceived physical competence) are positively related to physical activity behaviour in children and adolescents (Crocker et al., 2000; Daley, 2002; Gilson et al., 2005; Raudsepp et al., 2002; Raustorp et al., 2005; Welk & Eklund, 2005). As motor skill competence (actual competence) correlates with perceived competence (Raudsepp & Liblik, 2002; Rudisill et al., 1993), increasing skill proficiency may enhance children's physical self-perceptions and self-esteem, which in turn, may increase children's participation in physical activity. A small pilot study (Cliff et al., 2007) found that overweight and obese 8-12 year old children (n=13) increased fundamental movement skill competence and perceived athletic competence following 10 weeks of a skill-development physical activity programme, with improvements were maintained at 9 months follow-up. However, no studies including non-overweight children have been conducted and more research is needed.

Recent descriptive research has raised concerns regarding low levels of motor skill competence in children (Booth et al., 1999; Okely & Booth, 2004; van Beurden et al., 2002). Yet more research is needed to examine what should be done to increase skill proficiency. Interventions usually involve changes to physical education programmes and some have been successful. The "Move it Groove it" intervention (van Beurden et al., 2003) involved 1,045 Australian children (aged 7 to 10 years). The 12-month programme delivered significant improvements in proficiency in each of the 8 skills assessed when compared to the control group. In a sample of 545 Scottish pre-school children, a 6-month nursery intervention programme produced similar findings (Reilly et al., 2006), however no effect was found on body mass index (BMI). While in a small study of Greek young children (n=55), a 12 week programme involving self-testing activities significantly improved movement skills when compared to a control group that followed standard physical education programmes (Karabourniotis, Evaggelinou, Tzetzis, & Kourtessis, 2002).

Out of-school programmes may provide a conducive environment for acquiring movement skills in children (Raudsepp & Päll, 2006). However, little is known about the efficacy of fundamental movement skill interventions in non-curricular settings. Therefore, the purpose of this exploratory study was to examine the efficacy of an after-school multi-skill club designed to increase fundamental movement skill proficiency. A secondary aim of the study was to investigate the effect of the nine-week multi-skill club intervention on perceived physical competence and overweight/obesity (BMI).

4.2 Methods

4.2.1 Participants and settings

Following ethical approval from the University Ethics Committee, two primary schools in northwest England were invited to participate in the study. Selection criteria included school size (number of children enrolled >400), availability of school sports facilities (accessible to intervention), and current after-school club provision (no current programmes for year 4 children). Both schools were located in areas of high deprivation - levels of unemployment were significantly higher than the national average, and over 30% of children at each school were eligible for free school meals. One school was randomly assigned to each condition and, therefore, the equivalence of groups at baseline is not secure. To address this threat to validity, the selected schools were matched for each of the above characteristics as closely as possible (Varnell, Murray, & Baker, 2001).

All children from year 4 (aged 8-9) were invited to participate in the study via a letter of information and an informed consent form sent home to parents. Children who agreed to participate were selected if they were healthy and had no known medical conditions that could affect motor proficiency. Sixty-one children consented to participate in the study, with 47 children meeting the selection criteria and 14 excluded for medical reasons. The intervention condition comprised 26 children, with 21 children in the control. At post-test, the intervention and control group had lost 7 and 6 children, respectively. Reasons for the losses at follow up included absence from school on testing days due to illness or holidays. Children who took part in the baseline and follow up examination were included in this study. This final sample represented 72% of the original group. Therefore the control group had 15 children ((9 girls, 6 boys) *M* age=9.1 yrs., SD=.3yrs)) and the intervention group included 19 children ((12 girls, 7 boys) *M* age=9.2 yrs., SD=.3 yrs). The sample data were not separated by gender due to the small sample size, and as preliminary analysis revealed no significant gender interaction with the effects of the intervention programme.

4.2.2 Measures

Fundamental Movement Skills

The seven fundamental movement skills assessed were the vertical jump, leap, sprint run, kick, catch, throw, and static balance. The skills were considered age-appropriate and varied enough to eliminate gender bias (Hands & Larkin, 1997). The skills were assessed by one trained researcher according to the procedures outlined in the **Study 1** and using a process-orientated assessment tool (NSW Department of Education and Training, 2000). Table 11 shows the tasks and criteria used to assess each skill. Children were told to balance for as long as possible; to run as fast as they could; to jump and leap as high as they could; and to kick, throw and strike with force rather than accuracy.

Body mass index

Anthropometric procedures were conducted at the university by a researcher trained to the standards of the International Society for the Advancement of Kinanthropometry (Marfell-Jones et al., 2006; IMOD, 2010). Children were assessed whilst wearing light clothing and with shoes removed. Stature was measured (to the nearest 0.1 cm) using a stadiometer (Leicester Height Measure, Seca ltd., Birmingham, UK). Body mass was measured (to the nearest 0.01 kg) using digital scales (Seca ltd. Birmingham). From these body mass index (BMI) was calculated (mass [kg]/stature $[m]^2$).

Table 11 FMS Assessment task and criteria

Skill	Task	Criteria
Vertical Jump	Jump and touch the wall as high as you can	1. Eyes focused forwards or upwards throughout the jump 2. Crouch with knees bent and arms behind the body 3. Forceful upward thrust of arms as legs straighten to take off 4. Legs straighten in the air 5. Contact ground with front part of feet and bend knees to absorb force of landing 6. Balanced landing with no more than one step in any direction
Leap	Run to marker and leap as far as possible	1. Eyes focused forward throughout leap 2. Knee of take-off leg bends 3. Legs straighten during flight 4. Arms held in opposition to legs 5. Trunk leans slightly forward 6. Land on ball of foot and bend knee to absorb landing
Sprint run	Run a distance of 30m as fast as possible	1. Lands on balls of feet 2. Eyes focused forward, head and trunk stable throughout the run 3. High knee lift (thigh almost parallel to the ground) 4. Knees bend at right angles during the recovery phase 5. Arms bent at least 90 degrees 6. Arms DRIVING forward and back in opposition to legs
Kick	Kick a size 4 football towards a target as hard as possible	1. Eyes are focussed on the ball throughout the kick 2. Forward and sideward swing of arm opposite kicking leg 3. Step forward with non-kicking foot placed near the ball 4. Hip extension and knee flexion of at least 90 degrees during preliminary kicking movement 5. Contact the ball with the top of the foot (a "shoelace" or instep kick) 6. Kicking leg follows through high towards the target after ball contact
Catch	Catch a tennis ball thrown underarm between 2-3m high, and from a distance of 10m	1. Eyes are focused on the ball throughout the catch 2. Feet move to put body in line with object 3. Hands move to meet ball 4. Hands and fingers positioned correctly to catch the ball 5. Catch and control the ball with hands only (well-timed closure) 6. Elbows bend to absorb force of the ball
Overarm Throw	Throw a tennis ball overarm as far as possible	1. Eyes are focused on the target throughout the throw 2. Stand side-on to the target 3. Arm moves in a down-ward and backward arc 4. Step towards the target with foot opposite throwing arm during the throw 5. Hip then shoulders rotate forward 6. Throwing arm follows through down and across the body
Static balance	Balance on one leg for 15 seconds	1. Support leg is still, foot flat on the floor 2. Non-support leg bent, not touching support leg 3. Can balance on either leg 4. Head and trunk stable and upright 5. Arms still, may extend or come out to side of body to correct readjust 6. Eyes focused forward

Physical self-perceptions

Physical self-perceptions (perceived physical competence) were assessed using the Children and Youth Physical Self-Perception Profile ((CY-PSPP) Whitehead, 1995) according to the procedures outlined in **Study 1**.

4.2.3 Procedure

This study used a pre-test - post-test experimental design. Assessments were conducted at baseline (mid-April 2006) and immediately following the intervention (late June 2006). The two schools were randomly allocated to either intervention or control groups, using the computer equivalent of a coin flip.

4.2.4 Description of intervention

Multi-skill club

The 9-week multi-skill club intervention consisted of a twice-weekly after-school club, located within the intervention school. Each one-hour session focused on improving two fundamental movement skills from the vertical jump, leap, sprint run, kick, catch, throw, and static balance. Contact time therefore totalled 18 hours, with each skill being covered in 2 sessions. Three sessions included a multi-skill circuit, which offered activity stations to improve all the skills. Each session was delivered by experienced coaches who held several sports coaching qualifications and had attended Sports Coach UK workshops on delivering multi-skill clubs prior to the intervention programme.

The intervention programme was planned using activity resources designed by the Youth Sports Trust (Hanford, Haskins, Hawkins, Haydn-Davies, Morley & Stevenson, 2005), with each session designed to maximise participation and enjoyment, consisting of a variety of games, drills and self-learning activities offering numerous opportunities for practice. Skill components were taught to the children using simple learning cues (in kicking "eyes on the ball" was used to try to get the children to keep their eyes on the ball during the kicking action), and skill questions were used to develop purposeful feedback (for example - where did your throwing arm finish when you released the ball?). Children attended on average 80% of the sessions (range 72-100%).

Control group

The control group (CON) were given leaflets containing information from the British Heart Foundation on heart health and did not receive the after-school multi-skill club intervention. All children were asked to follow their normal routines and not engage in additional sport programs during the intervention period. The school agreed not to alter their current after-school club programme or to enhance their curricular programme for fundamental movement skills.

4.2.5 Statistical analyses

Preliminary analyses indicated no significant or substantial gender by intervention interactions; therefore, boys and girls were merged into a single group for the primary analysis. Descriptive statistics (means, standard deviations) for physical characteristics and CY-PSPP scales were calculated for the intervention and control group at baseline and post-test. Analysis of covariance (ANCOVA) was conducted to evaluate the effect of the 9-week intervention on BMI and physical self-perceptions (CY-PSPP scales). The independent variable was the type of intervention (control/multi-skill club); and the dependent variable the change score (post-test minus baseline). Baseline score was inputted as a covariate to control for chance imbalances across groups at baseline (Vickers and Altman, 2001).

Minimum Practically Important Difference (MPID)

The primary strategy for the interpretation of an intervention effect was an estimation approach (Curran-Everett *et al.*, 1998), presenting the mean effects of the intervention (versus control) on the primary outcome, together with 90% confidence intervals as suggested by Sterne and Smith (2001). A traditional null-hypothesis analysis framework is also presented. Adjusted mean intervention effects were evaluated for their practical significance by pre-specifying the minimum clinically importance difference (MCID) (Batterham and Hopkins, 2006). For the purpose of this study MCID was termed the minimum "practically" important difference (MPID), in recognition of the use of non-clinical measures of fundamental movement skills and physical self-perceptions. In the absence of a robust practical anchor, the MPID is defined conventionally using a distribution-based method as a Cohen's *d* (difference in the change scores between groups) of 0.2 between subject standard deviations (Cohen, 1988). The standard deviation (SD) of the pooled baseline scores was used for this purpose, as the post-test SD may be exaggerated by individual differences in responses to the intervention. The MPID was interpreted as 'positive' or 'negative' according to the direction of the effect on the intervention for a given variable. Using the mean intervention effect, together with its uncertainty, the probability that the true population effect was as least as large as the MPID was calculated using an online spreadsheet (Hopkins, 2007 [http://newstats.org/xcl.xls]), and subsequently described as either "*most likely*" (>99.5% chance that the true population effect was at least as large as MPID), *"very likely"* (99-99.5%), *"likely"* (75-99%), or *"possibly"* (25-75%). This process requires the calculation of a *t* statistic for the intervention effect (for more information, see Batterham & Hopkins, 2006; Froehlich, 1999; Shakespeare et al., 2001). For example, a 71% chance of a positive (MPID) effect would be determined "possibly" positive. If there is a greater than 5% chance of a substantial positive effect and a >5% chance of a negative effect then the effect is termed "*unclear*". Effect statistics were also qualitatively described in terms of their magnitude, with thresholds of 0.2, 0.6, 1.2 and 2 between-subject standard deviations corresponding with small, moderate, large and very large effect magnitudes (Hopkins et al., 2009). Mean intervention effects and their magnitude were reported. For the purpose of this exploratory study, this included all 'possible' intervention effects as they were considered as important for informing a subsequent definitive trial.

To analyse movement skills, each skill was scored by creating a binary outcome variable of "proficient" (scored 1) versus "non-proficient" (scored 0). Specifically, the number of components of each skill correctly demonstrated by each child was summed to give a score for each skill. From this, "proficiency" was defined as demonstration of all or all but one of the listed skill components. Failure to achieve this standard was classed as "non-proficient". Frequency statistics were used to report the proportion of participants achieving proficiency for each skill at baseline and post-test. Binary logistic regression analysis techniques were used to calculate the effects of the intervention on attainment of proficiency at post-test for each skill. The post-test outcome (1=proficient, 0=non-proficient) was entered as the dependent variable, with group and baseline coding (to control for baseline differences between groups) as independent variables (Everitt & Pickles, 2004).This method provides an odds ratio for the effect of the intervention (compared to control) adjusted for any baseline imbalance. To aid interpretation, adjusted odds ratios were converted to relative risk estimates together with their associated 90% confidence intervals using the formula provided by Zhang & Yu (1998). An estimation approach was again preferred; following van Beurden et al. (2003), the smallest practically important effect was defined as a 10% increase in the proportion attaining proficiency at post-test. This effect size approximates to an odds ratio of 1.5, a relative risk of 1.2, and a standardised mean effect (Cohen's d) of 0.2 between-subject standard deviations (Chinn, 2000). This smallest practically worthwhile effect thus represents a 'small' effect size according to (Cohen, 1988) scale of magnitudes, whilst a relative risk of 1.9, 3, and 5.7 correspond with thresholds for 'moderate', 'large' and 'very large' effect sizes (Hopkins et al., 2009). All data analyses were conducted using SPSS version 14.0 (SPSS Inc., Chicago, USA) and alpha set at .05. In line with the recommendations of (Perneger, 1998), Bonferroni corrections for multiple outcomes were not applied.

4.3 Results

Physical characteristics and CY-PSPP scale results at pre- and post-test are displayed in Table 12. No group differences were found for age, stature, mass or waist circumference at post-test. ANCOVA results revealed that participants' BMI increased significantly more in the multi-skill club than the control group (adjusted mean difference (AMD): 0.48kg/m^2, 90% CI: 0.1 to 0.9; $P = .040$), a possible small negative effect.

Table 12 Physical characteristics and CY-PSPP scale means at baseline and post-test.

	CONTROL (n = 15)				MSC* (n = 19)			
	Baseline		Post-test		Baseline		Post-test	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Physical characteristics								
Age (yrs)	9.2	(0.4)	9.4	(0.3)	9.2	(0.3)	9.4	(0.3)
Stature (cm)	134.5	(6.1)	136.0	(5.6)	135.0	(6.1)	137.2	(6.4)
Mass (kg)	36.3	(12.8)	36.8	(13.2)	32.1	(7.4)	33.5	(8.1)
BMI (kg/m^2)	19.7	(5.6)	19.6	(5.8)	17.4	(2.8)	17.6	(2.9)
Waist (cm)	63.8	(13.9)	63.1	(13.8)	59.5	(8.9)	60.5	(8.2)
CY-PSPP scale								
Sports competence	19.1	(4.0)	18.9	(4.8)	17.7	(3.0)	17.8	(3.5)
Physical condition	18.6	(3.5)	19.6	(3.8)	18.2	(3.2)	18.7	(3.2)
Body attractiveness	19.9	(3.6)	20.0	(3.4)	16.7	(3.0)	16.9	(4.6)
Physical strength	16.3	(4.9)	17.4	(3.6)	16.1	(3.1)	16.9	(3.7)
Physical self-worth	19.8	(3.3)	20.0	(3.5)	17.9	(3.0)	18.8	(3.7)
Self-esteem	20.9	(3.4)	20.3	(3.7)	19.5	(2.9)	19.5	(3.5)

SD, Standard deviation; CY-PSPP, Children and Youth Physical Self-Perception Profile
*MSC, Multi-skill club

The effect of the multi-skill club on physical self-perceptions and self-esteem is shown in Table 13. No significant intervention effects were observed for any CY-PSPP scales. However, using a marker of 0.2 between-subject standard deviations for potentially practically important effects, it was found that participation in the multi-skill club was *possibly* associated with small negative effects on perceived physical condition (MPID: ±0.65, 64.1% probability that the true population effect is as large as the MPID; Hopkins, 2007) and body attractiveness (MPID: ±0.71; 67.2%), compared to CON.

Table 13 ANCOVA mean changes in CY-PSPP scales from baseline to post-test, adjusting for baseline differences.

CY-PSPP scale	CON Adjusted Mean Δ	MSC* Adjusted Mean Δ	Difference MSC vs CON	(90% CI)	*P*
Sports competence	0.43	0.20	-0.23	(-2.0 to 1.5)	.827
Physical condition	1.63	0.58	-1.05	(-2.9 to 0.8)	.346
Body attractiveness	1.15	-0.27	-1.42	(-4.1 to 1.3)	.376
Physical strength	1.26	1.02	-0.25	(-2.0 to 1.5)	.810
Physical self-worth	0.66	0.76	0.10	(-1.8 to 2.0)	.927
Self-esteem	0.24	-0.15	-0.39	(-2.3 to 1.5)	.726

Δ = baseline to post-test change
90% CI, Confidence intervals for adjusted mean difference between groups
MSC, Multi-skill club

Table 14 shows the proportion of children in each group that attained proficiency in the skills at baseline and post-test. At baseline, the proportion of children in both groups achieving proficiency was lowest in the static balance, kick, throw and catch. The vertical jump and sprint run represented the skills with the highest proportion of children rated as proficient.

Table 14 Proportion (%) of participants achieving ratings of proficiency* in fundamental movement skills at baseline and post-test

	CONTROL (n = 15)		MSC** (n = 19)	
Skill	**Baseline**	**Post-test**	**Baseline**	**Post-test**
Balance	33.3	40.0	36.8	89.5
Leap	46.7	53.3	42.1	63.2
Vertical Jump	73.3	80.0	84.2	89.5
Sprint Run	86.7	60.0	68.4	57.9
Kick	6.7	13.3	31.6	52.6
Catch	0.0	26.3	26.7	63.2
Throw	6.7	20	21.1	42.1

* Demonstration of all or all but one skill components
** MSC, multi-skill club

Table 15 shows the results of the binary logistic regression, controlling for differences in baseline proportions of proficiency. The findings indicate that being in the multi-skill club significantly increased the likelihood of attaining proficiency at post-test in only one skill – static balance (P = 0.005). Specifically, children who participated in the intervention programme were on average over twice as likely to attain proficiency as those children who were in the control group, a moderate intervention effect. There were no other statistically significant group effects.

However, whilst in the majority of fundamental movement skills there was no statistically significant group effect, by definition this exploratory trial is not powered to define small effects precisely, and our findings may have some meaningful practical relevance. Using a relative risk value of 1.2 as a marker of the smallest practically important effect, the results show that in addition to static balance the point estimate of the relative risk surpassed this value for the kick, overhand throw, and catch skills. These findings indicate the multi-skill club may have practically important implications, particularly for manipulative skills.

Table 15 Binary Logistic Regression Analyses, adjusting for baseline differences between groups

Skill	β	SE	OR	RR	90% CI	P
Balance	2.56	0.92	12.92	2.24	1.64 - 2.44	.005*
Leap	0.41	0.7	1.51	1.19	0.66 - 1.59	0.56
Vertical Jump	0.64	1.01	1.89	1.1	0.74 - 1.22	0.53
Sprint Run	0.3	0.78	1.35	1.12	0.59 - 1.47	.70
Kick	1.63	0.98	5.09	3.29	1.01 - 5.99	.097
Catch	1.01	0.79	2.75	1.87	0.80 - 2.98	.20
Throw	0.78	0.96	2.18	1.76	0.51 - 3.63	0.42

β, regression coefficient; SE, standard error; OR, adjusted odds ratio; RR, adjusted relative risk; 90% CI, confidence intervals for RR

4.4 Discussion

This appears to be the first exploratory study to examine the effects of an after-school multi-skill club on the development of fundamental movement skills. The findings indicate that, compared to the control group, nine weeks training in the multi-skill club significantly increased the likelihood of attaining proficiency at post test in only one skill – static balance. It was also observed performance improvements of potential practical importance in the kick, throw, and catch skills – and these findings await confirmation in a subsequent definitive trial. It appears that a 9-week after-school multi-skills club can produce modest improvements in several skills; however the results may have been limited by, *inter alia*, the relatively short duration of the intervention.

4.4.1 Prevalence of proficiency at fundamental movement skills

With the exception of the vertical jump and sprint run, the results revealed worryingly low levels of proficiency in each skill at baseline. The 2002 Health Survey for England (Sproston & Primatesta, 2003) found that only 70% of boys and 61% of girls met the recommended guidelines for participation in physical activity. More recently, in a large, representative cohort of children, only 5.1% of boys and 0.4% of girls achieved the recommended guidelines for physical activity, as assessed by accelerometers (Riddoch et al., 2007). It is possible that children in this study may not have participated in sufficient amounts of physical activity to practice and nurture these skills, which may explain their low levels of proficiency. Further, pre-school programmes can foster skill development (Reilly et al., 2006) thus opportunities to develop such skills in children's early years may have been limited. In addition, poor skill development could also suggest that the provision and quality of teaching of fundamental movement skills within physical education is not sufficient to reach proficiency. This appears to support the need for additional opportunities for movement skill acquisition in children (Raudsepp & Päll, 2006).

4.4.2 Influence of the multi-skill club on fundamental movement skills

Balance is a stability motor skill that forms the basis for all other fundamental movement skills (Gallahue & Donnelly, 2003). Being able to maintain stability affects the quality and accuracy in performance of many skills, and also the ability to undertake everyday tasks. Participation in the multi-skill club significantly improved performance of this skill, with participants over twice as likely to reach proficiency as their control counterparts. Stability skills are the most basic of the three categories of movement skills (Gallahue & Donnelly, 2003), which may explain why significant improvements were found in balance but not the locomotor or object-control skills. As balance forms an integral part of any skill, such improvements may assist in the development of other categories of movement skills in the longer term.

Participation in the multi-skill club was associated with potentially important practical benefits in three manipulative skills – the kick, overhand throw and catch. This finding compares favourably with a 6 month physical education programme which significantly improved performance of the catch and throw, but not the kick (McKenzie et al., 1998). These positive improvements are encouraging given the low levels of proficiency in each of these skills at baseline and likely reflect meaningful relationships between instruction, practice and performance. However, locomotor skills such as the leap, sprint run and vertical jump were not associated with performance improvements. The "Move it Groove it" intervention (van Beurden et al., 2003) delivered substantial improvements in all 8 skills assessed, including the sprint run, side gallop, jump and hop, following a year-long programme. Locomotor skills are complex total body movements and these results suggest that an after-school multi-skill club would need to run for a longer period in order to benefit all forms of fundamental movement skills.

4.4.3 Influence of the multi-skill club on BMI and perceived physical competence

A secondary aim of the study was to examine the influence of the multi-skill club on physical self-perceptions (perceived physical competence) and overweight/obesity (BMI). On average, the multi-skill club participants increased

BMI compared to their control counterparts. This is somewhat surprising given that the bi-weekly multi-skill club provided an extra opportunity for participants to engage in physical activity, and that children in the control group did not participate in any school-based extra-curricular programmes during the study. It may be that differences between groups in habitual physical activity or diet may have contributed to the results, and future research should consider the inclusion of such measures.

Motor proficiency has been reported to be inversely related to BMI (Okely et al., 2004; Wrotniak et al., 2006), yet increases in BMI were observed in the multi-skill club participants despite improvements in object-control skills and balance. Similarly, Reilly et al. (2006) significantly increased fundamental movement skills in preschool children following a six-month nursery intervention but no effect was found on BMI or physical activity. Two studies have documented that locomotor skills more strongly relate to overweight and obesity than object-control skills (Okely et al., 2004; Southall et al., 2004). The multi-skill club did not improve proficiency in locomotor skills, which may partially explain our findings. However, the use of BMI as a surrogate marker of obesity has several limitations (Prentice & Jebb, 2001) in growing children and may have confounded the results. BMI is a measure of body weight and does not measure body fatness. Further, BMI does not account for skeletal size, muscle mass or amount of body water – all factors which could result in children being misclassified as healthy weight or overweight.

The finding that participation in the multi-skill club possibly negatively impacted children's perceptions of physical condition and body attractiveness was not anticipated and more data is needed to confirm the findings. It is difficult to ascertain the key causal agents for these possible negative changes. Cross-sectional studies have reported an inverse relationship between BMI and perceptions of body attractiveness and physical condition (Raustorp et al., 2005; Welk & Eklund, 2005). Children in the multi-skill club intervention increased BMI, which could explain more negative feelings of attractiveness and physical condition. In a 3-year longitudinal study of adolescent girls, Crocker et al. (2006) found that although self-reported BMI slightly increased, this change was not associated with changes in perceptions of body attractiveness, however perceived physical condition did decline. It is possible that children's fitness declined during the intervention, which may provide another explanation for lower perceptions of physical condition. Fitness data would be useful in determining whether children's physical condition *per se* did decrease. The lack of training effect on perceived physical self-worth and global self-esteem suggests that more negative feelings of physical condition and body attractiveness did not generalise upwards. Nevertheless, these possible negative findings suggest that greater consideration needs to be given by deliverers towards creating an appropriate atmosphere and motivational climate within the multi-skill club that fosters positive perceptions of body attractiveness and physical condition for participants. A mastery motivational climate can also facilitate learning of fundamental movement skills, as demonstrated following a 6 week physical education intervention in US kindergarten children (Martin et al., 2009).

No intervention effect was observed for perceived physical strength, which was expected as the multi-skill club did not include activities to develop this aspect of fitness. As actual and perceived motor competence are correlated (Raudsepp & Liblik, 2002; Rudisill et al., 1993), it was interesting to note that participation in the multi-skill club increased proficiency in 4 skills but perceptions of sports competence did not increase. In Fox's hierarchical model of the physical self (Fox, 1997), self-perceptions vary from one level to another, and repeated mastery experiences generalise upwards and increase competence beliefs (see Section 2.3.3). The CY-PSPP subdomain of sports competence (athletic ability, ability to learn sport, confidence in sport) represents a middle order construct in the model which is thought less amenable to change than lower order facets (e.g. catching ability), which may explain the lack of an intervention effect.

4.4.4 Recommendations for future research

This research supports the contention that after-school multi-skill clubs could complement school curricular programmes by allowing additional opportunities for fundamental movement skill development. The implementation and delivery of the intervention programme was completed successfully, and the club was well attended. It is recommended that a subsequent definitive trial of a longer term intervention be conducted in a larger, more representative sample. This would enable the potential practical importance of the intervention to be estimated more precisely.

A number of lessons can be learned from this exploratory trial to inform the design of a subsequent experimental trial. Firstly, the inclusion of habitual physical activity and cardiorespiratory fitness data would offer a greater insight into the effectiveness of the intervention and help researchers to better understand the complex inter-relationships between physical activity, fitness, obesity, skill, and perceived competence. Further, assessment of physical activity would enable researchers to understand physical activity patterns outside of the intervention programme. Secondly, the use of BMI as a surrogate marker of obesity may have confounded some findings. It is recommended that a more precise measure of body fatness, such as dual energy x-ray absorptiometry, is used to estimate change in body fat, and children's maturational status is calculated so findings can be adjusted accordingly. Thirdly, the addition of items to the CY-PSPP which specifically address perceptions of competence in fundamental movement skills (subfacet level) should provide researchers with the sensitivity to detect any intervention effect, and determine whether skill competence is causally linked to perceived skill competence. Finally, in line with other successful studies (van Beurden et al., 2003; Reilly et al., 2006), the multi-skill club should be conducted over a longer period to determine whether the intervention can improve all forms of movement skills.

4.4.5 Conclusion

In conclusion, this exploratory study found that a 9 week multi-skill club was associated with potentially practically meaningful improvements in four of the eight fundamental movement skills assessed. An after school multi-skill club may offer a viable opportunity for movement skill acquisition, but any programme would need to run for longer to identify if this type of activity could benefit all skills. Compared to children in the control group, participation in the multi-skill club was associated with higher BMI and possibly more negative perceptions of body attractiveness and physical condition. It is recommended that future studies include measures of physical activity and fitness measures to better understand the key causal mechanisms of such changes.

Chapter 5

Study 3

The effects of a group-randomised 12 month intervention on fundamental movement skills, physical self-perceptions, physical activity, fitness and body fatness in 9-10year old children: The A-CLASS Project

5.1 Introduction

Study 1 revealed low-to-moderate prevalence of skill proficiency in 9-10 year old children from North-West England, a significant finding given that the results also highlighted the importance of fundamental movement skills to children's physical activity, cardiorespiratory fitness and body fatness. These findings highlight the need for motor skill interventions in older children.

Since 2003, the UK Government has invested substantial funds in out of school hours multi-skill clubs in an attempt to provide children with an opportunity to improve skill competence (DfES/DCMS, 2003). Foweather et al. (2008) investigated the effectiveness of such clubs and found that participation in a 9-week multi-skill club increased proficiency at the static balance, kick, overarm throw and catch. However, locomotor skills did not improve. In contrast, the "Move it Groove it" physical education intervention significantly benefitted both locomotor and object-control skills following a 12 month programme (van Beurden et al., 2003). Further, German children increased performance in lateral jumping at 20 and 48 months post-test following a primary school intervention, with gains in balancing backwards also reported at 4 years post-test (Graf et al., 2005; Graf et al., 2008). These findings suggest that a multi-skill club may need to run for longer to improve *all* forms of movement skills.

Multi-skill clubs aim to foster skill development through the provision of developmentally appropriate tasks and equipment, and opportunities for practice, instruction, and feedback from qualified coaches. A direct-instruction model is thought to be the best approach to improve such skills (Silverman, 1991; Sweeting & Rink, 1999), and is the strategy typically implemented in motor skill interventions (van Beurden et al., 2003; Salmon et al., 2008; McKenzie et al., 1998). However, other forms of programmes may impact the development of such skills. For example, a school-based behaviour-modification programme, which included healthy lifestyle education but no structured exercise classes, enhanced Australian girls' skill competence (Salmon et al., 2008). Through the National Healthy School Programme and the Physical Education and Sport Strategy for Young People, the UK Government is encouraging schools to target children's physical activity and fitness in PE lessons and extra-curricular activities in order to help children achieve public health recommendations. It is important to establish whether prioritising health outcomes is at the expense of motor skill development. To date, the comparison of an after-school multi-skill club with a physical activity/fitness after-school club or a lifestyle programme on fundamental movement skill development has not been attempted.

According to competence motivation theory (Harter, 1978; Weiss, 2000), perceived physical competence is an important determinant of children's physical activity. However, in Study 1 self-perceptions were not significant predictors of physical activity, though the sub-domains of strength and condition accounted for weak variance in children's fitness, while perceived physical condition weakly predicted body fatness. Whilst these findings do not suggest that physical self-perceptions are important for children's physical activity, this is in contrast to other studies involving 10-14 year old children (Crocker et al., 2000; Raudsepp et al., 2002; Raustorp et al., 2005; Welk & Eklund, 2005). Further, a longitudinal study of young adolescent girls found that changes in physical self-perceptions predicted changes in physical activity participation (Crocker et al., 2003). This suggests that physical self-perceptions warrant further investigation. Change analysis is necessary to establish causal links between physical activity and physical self-perceptions (Crocker et al., 2003), yet few controlled experimental trials have been conducted to clarify the nature of this relationship (Fox & Wilson, 2008). Prior interventions have included adolescent girls (Burgess et al., 2006; Lindwall & Lindgren, 2005; Schneider et al., 2008), overweight children (Goldfield et al., 2007) and American elementary school children (Walters & Martin, 2000). There is scant evidence of the effectiveness of interventions on physical self-perceptions in UK primary school aged children, though the results from Study 2 indicated that participation in the

9-week multi-skill club was *possibly* associated with small negative effects on perceived physical condition and body attractiveness. Given that increasing skill mastery has been proposed as a possible intervention strategies for enhancing perceptions of sports competence (Whitehead & Corbin, 1997), this finding requires confirmation in a definitive experimental trial. In addition, it has been recommended that future studies should evaluate the effects of different types of interventions on physical self-perceptions (Lindwall & Lindgren, 2005).

The A-CLASS Project was established to measure the impact of afterschool programmes on children's health. In addition to fundamental movement skills and physical self-perceptions, which are the primary outcomes within this thesis, the interventions also aimed to benefit children's physical activity, fitness, cardiovascular health, bone health, and body composition. Due to the multi-faceted outcomes within the project, two further interventions were included for investigation alongside the afterschool multi-skill club for a one year trial. A high-intensity physical activity afterschool club was incorporated to promote fitness and positively impact cardiovascular health, bone health and body composition. In addition, a behaviour-modification intervention was included to examine the impact of a cost-effective lifestyle programme, which did not require paid coaching staff, on children's physical activity and sedentary behaviour.

Therefore, the purpose of the current study was to assess the effects of one year bi-weekly fundamental movement skill (FMS) or high intensity physical activity (HIPA) after-school clubs, and a lifestyle intervention (PASS) on fundamental movement skills and perceived physical competence in primary school children, compared to a control-comparison group (CON). Additionally the impact of these interventions on children's physical activity, cardiorespiratory fitness and percent body fat were examined to contextualise intervention effects on movement skills and physical self-perceptions.

5.2 Methods

5.2.1 Participants and settings

Participants and settings were as described in the cross-sectional study (see section 3.2.1). Briefly, eight schools were randomly-selected to take part in the project. All children in Year 5 (aged 9 to 10 years) were invited to participate in the study via letters of informed consent to parents. Informed consent was received from 292 children (59% response rate). At baseline, 152 children met the inclusion criteria and commenced the study. At mid-test (nine months) 149 children continued to participate; 2 children had left school, whilst 1 child withdrew from the project. After twelve months (post-test) 145 children remained, representing a 5% attrition rate from baseline. The flow of schools and participants through the project is shown in Figure 6.

5.2.2 Measures

Measures of anthropometry, body fat, cardiorespiratory fitness, physical activity, fundamental movement skills and physical self-perceptions were taken at baseline, mid-test and post-test following methods and procedures outlined in the **cross-sectional study** (Chapter 3).

5.2.3 Procedure

Using a computer generated procedure and a two-schools-per-group design; schools were randomly allocated to one of four conditions:

1) Physical Activity Signposting Scheme (PASS)
2) Fundamental movement skills (FMS)
3) High-intensity physical activity (HIPA)
4) Control-comparison (CON)

Figure 6 School and participant flow through the project (CONSORT)

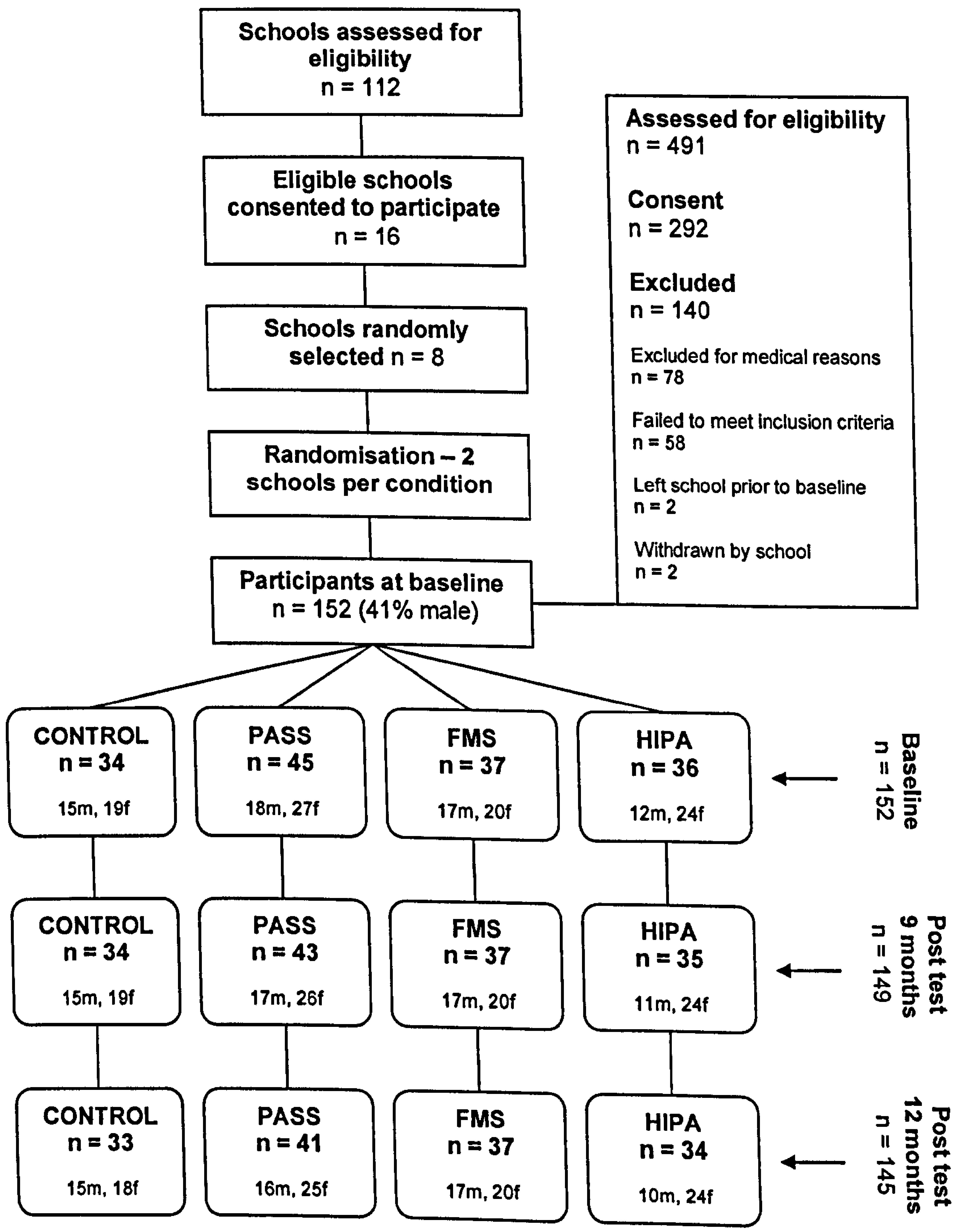


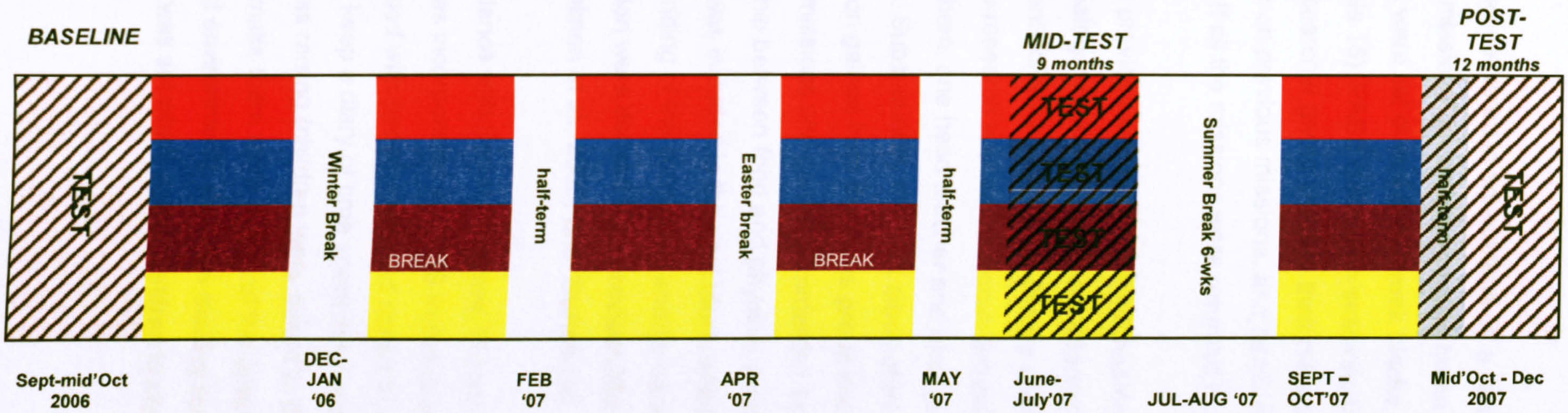
Figure 7 displays a schematic overview of the A-CLASS Project. Assessments were conducted over six week periods at baseline (September to mid-October 2006), 9 months mid-intervention (Mid-test: June to mid-July 2007), and at 12 months immediately following the intervention (Post-test: mid-October-November 2007). Children visited the university laboratories for one day during school time to undertake questionnaires and assessments of anthropometry, body composition, and cardio-respiratory fitness. Assessments of fundamental movement skills were undertaken at school in the gymnasium or playground, using a standardised sequential protocol. Physical activity monitors were distributed and collected at school by one member of the research team. The intervention ran over a period of 12 months, although no intervention was given during school holidays, which included breaks for Christmas (2 weeks), February half-term (1 week), Easter (2 weeks), May half-term (1 week), and summer (6 weeks).

5.2.4 Description of the Interventions

Physical Activity Signposting Scheme (PASS)

PASS was a lifestyle intervention which focused on increasing habitual physical activity and reducing time spent in sedentary behaviours (for a detailed overview of PASS, see Hepples & Stratton, 2007). There is a need to develop successful lifestyle interventions as the majority of children's physical activity is unstructured (Trost et al., 2002), thus children need to learn how to be active and make healthy choices when organised activities are not available. Additionally, the promotion of a healthy lifestyle appears to be a cost-effective and sustainable method to reduce obesity, compared with the provision of structured programmes (Bar-Or & Baranowski, 1994).

Figure 7 A-CLASS Project overview



CON: Control-comparison group. This group did not receive any intervention, and only participated in testing

PASS: Physical Activity Signposting Scheme intervention. The A-CLASS PASS coach visited school to deliver PASS missions and encourage participation in physical activity and reductions in sedentary behaviour

FMS: Fundamental Movement Skill intervention. A-CLASS coaches delivered a bi-weekly after-school multi-skill club (2 x 1hr) focusing on improving eight fundamental movement skills.

HIPA: High Intensity Physical Activity intervention. A-CLASS coaches delivered a bi-weekly high intensity after-school club (2 x 1hr) focusing on vigorous weight-bearing activity incorporated into games and circuits.

PASS was delivered in school time by a researcher, and comprised of weekly "healthy missions" for children to take home and complete. A total of twenty missions were set over 4 x 4-6 week blocks, each separated by a 6 week break (see Table 16). PASS classroom sessions lasted for 30 minutes and consisted of the researcher giving children their missions, discussing and providing feedback on previous missions, and administering stickers for every returned mission. If all the missions were returned in a block, a prize was presented.

Table 16 provides an overview of the healthy missions which children were set. Each "healthy mission" in the PASS intervention was designed based on components of Social Cognitive Theory (Bandura, 1986) and developed using an action-research approach. Focus groups were conducted with all children and teachers, one head teacher and nine parents following each block of missions. Subsequently the next block of missions were designed based on information gained from the focus group data. For example, following the first block of missions one parent commented that children were not aware of the relationship between food and physical activity. Following this feedback, a mission was included in the next block which planned to improve children's understanding of the concept of energy balance. Additionally, parts of the intervention were derived from previous lifestyle interventions such as "Switch-Play" (Salmon et al., 2005) and "Switch-Off, Get-Active" (Harrison et al., 2006).

In accordance with Social Cognitive Theory (Bandura, 1986), behaviour change techniques incorporated in PASS included self-monitoring (for example children were issued with pedometers and asked to record daily step counts, and were asked to keep a diary of time spent in sedentary behaviours); education and awareness raising (children were asked to draw a map of their neighbourhood in order to make them more aware of the opportunities for physical activity within their local environment); decision making (e.g. a mission entitled "intelligent viewing" was set which asked children to choose which television programmes

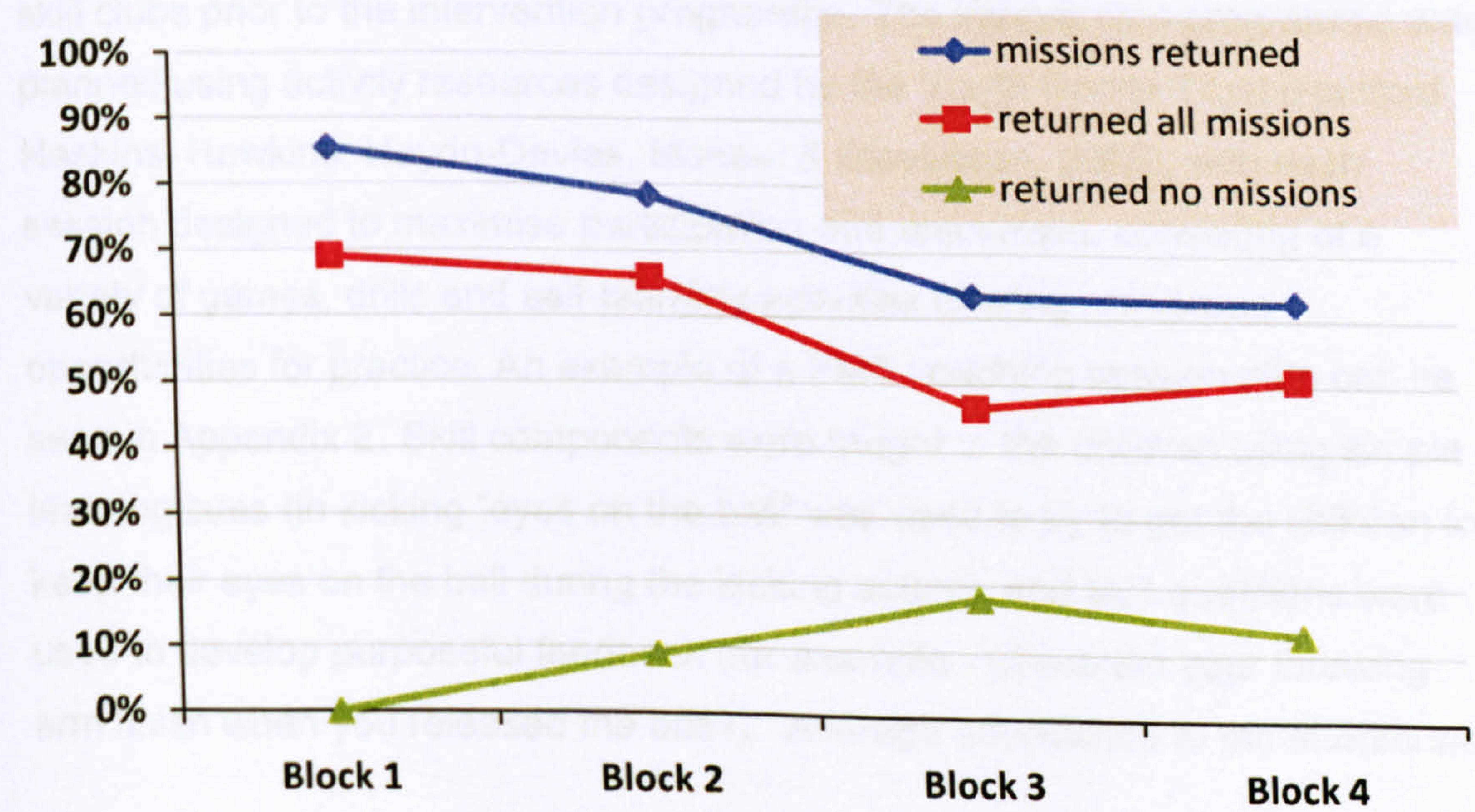
Table 16 Overview of PASS healthy missions

Mission	Outline of mission
	Block 1. Oct 06 – Dec 06
Map drawing	*Draw a map of the local area and house*
Pedometer challenge	*Write down how many steps that they had achieved each day*
New activities	*Think of activities that they could do around the house*
TV monitoring	*Monitor how much television that they watched in a day*
Intelligent viewing	*Reduce their television viewing to two hours a day*
Replacing TV with activity	*Replace television viewing with physical activity and also to reintroduce pedometer challenge*
Break. Dec 06 – Feb 07	**Focus groups with parents and teachers were undertaken**
	Block 2. Feb 07 – April 07
Photograph challenge	*Disposable camera's were issued to take pictures of active places*
New game	*To design own game and take pictures of this game.*
Active Transport	*Encouraging the children to use active transport*
Energy balance	*Children rated food they ate and activity they did, and asked does it balance?*
Reducing screen-watching	*The children were asked to reduce computer use as well as TV watching*
Break. Apr 07 – June 07	**Focus groups with parents and teachers were undertaken**
	Block 3. June 07 – July 07
60 minutes of activity	*Points were given for each minute of activity that was undertaken.*
Fitness Challenge	*Children timed themselves doing physical activity tasks*
Scavenger Hunt	*To find certain household items in the quickest time they could*
Whatever	*Children were told that they could do whatever they wanted*
Decisional balance	*Choice between being active or sedentary in different situations*
Break. Jul 07 – Sept 07	**Focus groups with parents and teachers were undertaken**
	Block 4. Sept 07 – Oct 07
Design own mission to increase activity x2	*Children were issued with a few rules to design their own missions for 2 weeks*
Design own mission to decrease sedentary behaviour	*Children were issued with a few rules to design their own missions*
Advocacy poster	*Children were asked to draw a poster based on their choice between physical activity and sedentary behaviour*

they wanted to watch in advance and only watch those programmes); social support (missions were aimed at the whole family - children were asked to show received weekly feedback from the visiting researcher). The missions also sought to increase children's self-efficacy by setting missions that were challenging but achievable. This aimed to provide children with the confidence and belief that they can be more active and can reduce sedentary behaviours.

Figure 8 shows the compliance and return rate of PASS missions. In block 1, children on average returned 85% of missions, whilst 69% of participants returned all missions. All children returned at least one mission. In blocks 2 and 3 return rates declined steadily. In the final block children returned on average 63% of missions, whilst 51% returned all missions. 13% of children did not return a mission. The return rate is comparable to that of home tasks returned by children in the Switch-Play intervention (57-62%, Salmon et al., 2005). Initially children appeared to be motivated to return missions "for the prize" or "because you told us to". When asked at the end of block 4 why they returned missions children stated it was "to be healthy" or because they "got them active".

Figure 8 Compliance and return rate of PASS healthy missions



Fundamental Movement Skills (FMS)

The FMS intervention was based on the Youth Sport Trusts (YST) multi-skill club programme. Such clubs can take place in numerous settings including a child's primary school, at a local secondary school, or within a local authority leisure centre. YST multi-skill clubs are run as an out of hours, open access and regular session in which children aged 7-11 can increase their fundamental movement skills and general sport skills (for more information see www.youthsporttrust.org). The FMS intervention consisted of a twice-weekly after-school club, located within the intervention schools. The after-school club took place in either the school playground (weather permitting) or the gymnasium.

Each one-hour session focused on improving two fundamental movement skills from the vertical jump, hop, sprint run, dodge, kick, catch, overarm throw, and strike. In total there were 70 sessions; contact time therefore totalled 70 hours, with each skill being covered in 15 sessions. Ten sessions included a multi-skill circuit, which offered activity stations to improve all the skills. Each session was delivered by experienced coaches who held several Level 2 sports coaching qualifications and had attended Sports Coach UK workshops on delivering multi-skill clubs prior to the intervention programme. The intervention programme was planned using activity resources designed by the Youth Sports Trust (Hanford, Haskins, Hawkins, Haydn-Davies, Morley, & Stevenson, 2005), with each session designed to maximise participation and enjoyment, consisting of a variety of games, drills and self-learning activities offering numerous opportunities for practice. An example of a FMS coaching session plan can be seen in Appendix E. Skill components were taught to the children using simple learning cues (in kicking "eyes on the ball" was used to try to get the children to keep their eyes on the ball during the kicking action), and skill questions were used to develop purposeful feedback (for example - where did your throwing arm finish when you released the ball?). Average attendance to the afterschool club was 68% (78% boys, 60% girls) and ranged from 2.85% to 100%. 27 out of 37 children attended over 70% of the sessions.

High-Intensity Physical Activity (HIPA)

The HIPA intervention consisted of a twice-weekly after-school club, located within the intervention schools. The after-school club took place in either the school playground (weather permitting) or the gymnasium. Previous research has found that vigorous high intensity activity can be beneficial in reducing body fat, and improving bone strength, cardiovascular function and fitness (Gutin et al., 2002; Ruiz et al., 2006). Consequently HIPA sessions were designed to impact these variables; with each sixty minute session consisting of whole body muscular activity which aimed to keep children moving and maintain children's heart rates above 80% of their maximum (~155 beats·min^{-1}). During the sessions children took part in fun multi-activities such as circuits, dance and games. These game-based coaching strategies were chosen ahead of more traditional fitness activities such as continuous running or cycling to keep children motivated and engaged within a varied, stimulating, enjoyable, and fun environment. Each session was delivered by experienced coaches who held several sports coaching qualifications. An example of a HIPA coaching session plan can be seen in Appendix E.

Twenty randomly-selected children wore heart rate monitors (Team Polar, Kempele, Finland) once a month to determine the intensity of the sessions. Mean heart rate for sessions was greater than 70% heart rate maximum (150.9 ±25.4 beats·min^{-1}), and children spent on average 66.6% of the session in activity at intensity greater than 50% of heart rate reserve. This represents data from a "real world" coaching session – including heart rate data collected during activities within the session but also encompassing periods of administration and organising/setting up coaching drills. Average attendance of the 70 sessions was 64% (64% boys, 64% girls) and ranged from 0% to 95.7%. 22 out of 34 children attended over 70% of sessions.

Control-comparison (CON)

Children in CON participated in their usual school curriculum, and did not receive any intervention with the exception of leaflets produced by the British Heart Foundation providing information on heart health. At the time of the study, all children in English government-funded schools were required to participate in two hours of physical education and school sport per week, both within and beyond the curriculum (DfES/DCMS, 2003). For ethical and practical reasons it was not possible to restrict or control the physical activity, physical education or school sport programmes schools offered by CON schools.

5.2.5 Reward scheme

A reward scheme was incorporated to enhance adherence to the intervention. A t-shirt (10 sessions), water bottle (25 sessions), pedometer (40 sessions) and baseball cap/music CD (60 sessions) were used as incentives for FMS and HIPA participants to attend coaching sessions. PASS children received a pedometer at the start of the intervention, whilst a t-shirt (block 1), water bottle (block 2), baseball cap (block 3) and music CD (block 4) were used to reward children for returning all missions. CON participants were rewarded for compliance in baseline testing and physical activity monitoring with a t-shirt and water bottle, respectively. All groups were rewarded with a yo-yo, frisbee and beach ball for attendance at post-test assessment.

5.2.6 Statistical analysis

Prior to the intervention analyses several composite scores were created. Firstly, to investigate the effect of the interventions on fundamental movement skill competence, three skill composite scores were created. The number of skill components checked as present in each of the 8 skills was summed to create a "Total skill score". Additionally two further skill summary variables - "Locomotor skills" (sum of components checked as present in the hop, vertical jump, sprint run and dodge) and "Object-control skills" (sum of components checked as present in the catch, throw, kick and strike) were formed to investigate whether the interventions had differential effects on distinct categories of movement skills. Secondly, to analyse the effect of the interventions on perceived skill competence, the perceived skill competence items added to the CY-PSPP to assess perceived ability in the hop, vertical jump, sprint run, dodge, kick, catch, throw, and strike were summed to create a "Perceived skill score".

Descriptive statistics (means, standard deviations) were calculated for continuous primary (fundamental movement skills and physical self-perceptions) and secondary (age, years from peak height velocity, physical activity, fitness and percent body fat) outcome variables for each of the experimental groups (PASS, FMS, HIPA and CON) at baseline, mid- and post-test. Data were checked for normality by visual inspection of histograms for skewness and kurtosis, and examined for the presence of outliers with box plots. Two outliers were identified within baseline physical activity data as the accelerometer counts per minute recorded were considered impossibly high (over 3 standard deviations above the mean). Consequently these 2 girls were removed from the physical activity dataset.

Analysis of covariance (ANCOVA) was used to examine the effectiveness of interventions on all continuous outcome variables. Multivariate analysis of covariance were not employed in order to avoid the risk of multi-collinearity amongst dependant variables, which can severly hinder statistical power (Tabachnick & Fidell, 2007). The mid- or post-test outcome value was entered as the dependent variable in the ANCOVA with experimental group and gender as the independent variables. Additionally, the baseline value was entered as a covariate to control for chance imbalances across groups at baseline (Vickers and Altman, 2001). Interactions between covariates including maturation (Years from Peak Height Velocity), physical self-perceptions, physical activity, fundamental movement skills, fitness and percent body fat were explored but removed if they did not significantly influence the model. If significant gender by intervention interactions were found then boys and girls data were reported separately. Non-uniformity of variance was checked by examining plots of the residuals of the dependant variable for evidence of heteroscedasticity (Hopkins et al., 2009), and using the Levene's Test for Equality of Variances. An intention-to-treat analysis approach was implemented and children with missing data for individual outcomes were excluded from the respective analysis.

Minimum Practically Important Difference (MPID)

The principal strategy for the interpretation of an intervention effect was an estimation approach (Curran-Everett et al., 1998), presenting the mean effects of the intervention (versus control) on the primary outcome, together with 90% confidence intervals as suggested by Sterne and Smith (2001). A traditional null-hypothesis analysis framework is also presented. Adjusted mean intervention effects were evaluated for their practical significance by pre-specifying the MPID. The strategy for this approach was as described in **Study 2** (page 117). However, for the purpose of this study, effect statistics were deemed as practically important if the chance that the true population effect was at least as large as the MPID was greater than 75%, which is qualitatively described as a "likely" effect by Hopkins et al. (2009). Additionally, thresholds of 0.2, 0.6, 1.2, and 2 between-subject standard deviations translate to small, moderate, large and very large effect sizes and adjusted mean differences (intervention vs. CON) were qualitatively described in this way to enable inferential assertions about the magnitude of the effects (Hopkins et al., 2009).

To analyse changes in movement skill proficiency, each skill was scored by creating a binary outcome variable of "proficient" (scored 1) versus "non-proficient" (scored 0). Specifically, the number of components of each skill correctly demonstrated by each child was summed to give a score for each skill. From this, "proficiency" was defined as demonstration of all or all but one of the listed skill components. Failure to achieve this standard was classed as "non-proficient". Frequency statistics were used to report the proportion of participants in each group achieving proficiency for each skill at baseline and post-test.

Binary logistic regression analysis techniques were used to calculate the effects of the intervention on attainment of proficiency at post-test for each skill. For this, the post-test outcome (1 = proficient, 0 = non-proficient) was entered as the dependent variable, with group and baseline coding (to control for baseline differences between groups) as independent variables (Everitt & Pickles, 2004). To facilitate interpretation, adjusted odds ratios were converted to relative risk estimates together with their associated 90% confidence intervals using the formula provided by Zhang & Yu (1998). An estimation approach was again preferred; following van Beurden et al. (2003), the smallest practically important effect was defined as a 10% increase in the proportion attaining proficiency at post-test. This effect size approximates to an odds ratio of 1.5, a relative risk of 1.2, and a standardised mean effect (Cohen's d) of 0.2 between-subject standard deviations (Chinn, 2000). This smallest practically worthwhile effect thus represents a 'small' effect size according to (Cohen, 1988) scale of magnitudes, whilst a relative risk of 1.9, 3, and 5.7 correspond with thresholds for 'moderate', 'large' and 'very large' effect sizes (Hopkins et al., 2009). Again, for the purpose of this study the effect was reported as practically important if the chance that the true population effect was at least as large as the MPID was greater than 75%, as calculated using an online macro (macro on http://newstats.org/xcl.xls, accessed 4th August 2008).

All data analyses were conducted using SPSS version 15.0 (SPSS Inc., Chicago, USA) and alpha set at .05. In line with the recommendations of (Perneger, 1998), Bonferroni corrections for multiple outcomes were not applied. The main weakness of adjusting for multiple tests is that the interpretation of a finding depends on the number of other tests performed. Further, the likelihood of type II errors is also increased (Perneger, 1998).

5.3 Results

Table 17 shows the number of children that successfully completed data collection in project measures at all three timepoints. Of the 145 children still participating in the project at post-test, 97 completed all measures at all time points. In terms of successful completion of individual measures at baseline, mid- and post-test:- 134 children were scanned by DEXA; 121 children had valid physical activity data; 114 children met the criteria for Peak VO_2 fitness, 141 children undertook the FMS assessment protocol; and 135 children completed the CY-PSPP questionnaire.

Table 17 Number of children with complete data in DEXA, physical activity, fitness, fundamental movement skills, and physical self-perceptions.

Group (n at post-test)	DEXA	PA	FITNESS	FMS	PSPP	ALL MEASURES
CONTROL (n=33)						
Group	29	30	24	31	31	22
Boys	12	13	11	14	14	9
Girls	17	17	13	17	17	13
PASS (n=41)						
Group	39	33	35	40	40	27
Boys	14	13	12	16	15	8
Girls	25	20	23	24	25	19
FMS (n=37)						
Group	33	28	27	36	32	23
Boys	16	14	14	16	16	12
Girls	17	14	13	20	16	11
HIPA (n=34)						
Group	33	30	28	34	32	25
Boys	10	10	8	10	10	8
Girls	23	20	20	24	22	17

5.3.1 Fundamental movement skills – did the intervention increase the number of skill components checked as present (skill competence)?

Individual skill competence

As the focus of results for individual skills was on increasing the likelihood of attaining proficiency; changes in the number of skill components checked as present are presented in the appendices. Appendix F shows raw means for the number of skill components checked as present, whilst Appendix G shows the effects of the interventions on competence in individual skills at mid-test and post-test.

Table 18 Total skill score, locomotor skills and object-control skills at baseline, mid-test and post-test, by group.

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Total skill score												
Baseline	34	27.3	6.1	45	28.2	7.5	36	28.8	7.3	36	28.3	7.3
Mid-test	32	28.1	5.9	41	29.3	7.0	36	32.5	5.3	34	28.6	7.3
Δ Baseline - Mid-test	32	1.3*	3.3	41	1.2*	3.5	36	3.8**	3.8	34	1.0	4.4
Post-test	33	28.9	6.2	41	29.3	7.1	37	35.2	6.4	34	30.2	7.1
Δ Baseline - Post-test	33	1.4*	3.5	41	1.4**	3.4	36	6.3**	4.3	34	2.6**	4.0
Locomotor skills												
Baseline	34	14.2	2.7	45	14.1	3.5	36	14.9	3.2	36	14.6	3.6
Mid-test	32	13.8	2.6	41	15.1	3.2	36	16.2	2.3	34	14.5	3.6
Δ Baseline - Mid-test	32	-0.2	2.3	41	1.0**	2.0	36	1.3**	2.2	34	0.2	2.6
Post-test	33	14.6	2.7	41	14.9	3.2	37	17.5	2.6	34	15.6	3.6
Δ Baseline - Post-test	33	0.3	2.7	41	0.9**	2.0	36	2.5**	2.4	34	1.2**	2.6
Object-control skills												
Baseline	34	13.2	4.7	45	14.0	4.9	36	13.8	5.5	36	13.7	5.3
Mid-test	32	14.3	4.4	41	14.2	5.1	36	16.3	4.2	34	14.1	5.2
Δ Baseline - Mid-test	32	1.5**	2.4	41	0.2	2.7	36	2.5**	3.0	34	0.8	2.7
Post-test	33	14.3	4.6	41	14.4	5.1	37	17.7	4.5	34	14.6	4.8
Δ Baseline - Post-test	33	1.1*	2.6	41	0.6	2.7	36	3.8**	3.2	34	1.4*	3.1

Within-group significant difference from baseline, * P = <0.05 ** P = <0.01 (Paired t-tests)

5.3.2 Skill composite scores

No significant gender by intervention interactions were observed so results are presented by group. Table 18 shows raw skill composite scores at baseline, mid-test and post-test. Appendix H lists similar tables for boys and girls.

***Total skill score* (MPID = 1.41)**

Figure 9 shows the effects of the interventions on results total skill score, adjusting for baseline differences. At mid-test all groups increased from baseline, with FMS increasing by the largest margin. Consequently, the FMS group possessed significantly more skill components than CON at mid-test and was associated with a small positive effect (Adjusted Mean Difference (AMD): 2.9 units, 90% CI 1.5 to 4.3; P = 0.01). No significant differences were found between either HIPA or PASS, and Control.

At post-test, skill competence in the FMS and HIPA groups had continued to increase from mid-test, whilst CON and PASS skill gains appeared to plateau. Compared to CON, the FMS intervention was associated with a moderate positive effect on total skill score (AMD: 5.5 units, 90% CI, 4.0 to 6.9; $P = .000$), whilst HIPA was associated with a small positive effect (AMD: 2.05 units, 90% CI, 0.5 to 3.6; $P = .028$). PASS and control groups improved marginally over the project and were not significantly different at 12 months post-test.

***Locomotor skills* (MPID = 0.66)**

Figure 10a shows the intervention effects on locomotor skill scores, adjusting for baseline differences. At mid-test, FMS, PASS and HIPA all increased from baseline, whereas the control group had showed a slight decline. PASS and FMS interventions were associated with small positive intervention effects compared to CON. Specifically, the effect of the FMS and PASS interventions on locomotor skill score was a mean benefit of 1.8 units (90% CI, 0.9 to 2.6; P = .001) and 1.18 units (90% CI, 0.4 to 2.0; P = .017), respectively.

At post-test the FMS group had continued to increase linearly, with HIPA improving from mid-test to post-test at a similar rate to FMS. PASS showed a small decline from mid-test to post-test, finishing with a score marginally higher than at baseline. CON increased from mid-test, representing a minor increase from baseline to post-test. Significant differences were found between the FMS and HIPA interventions, and CON at post-test. The effect of the FMS intervention on locomotor skill score (compared to CON) was a mean benefit of 2.5 units (90% CI, 1.6 to 3.4; $P = .000$), a moderate positive effect. The effect of the HIPA intervention was a mean benefit of 1.3 units (90% CI, 0.3 to 2.2; $P = .026$), a small positive effect. There was no difference between PASS and CON.

Object-control skills **(MPID= 1.01)**

Figure 10b shows the intervention effects on object-control skill scores, adjusting for baseline differences. At mid-test, the FMS showed a large increase in object-control skill score from baseline, whilst the control, PASS and HIPA groups showed small gains. There were no differences between groups at mid-test though there was a possible trend for the FMS intervention to be associated with small benefits.

At post-test, all groups scored significantly higher in object-control skills than at baseline. FMS had improved further from mid-test, whilst skill improvements for PASS and HIPA were small. Control object-control skills decreased from mid-test to post-test, with the post-test score being similar to PASS. FMS possessed significantly more object control skill components than CON at post-test. The effect of the FMS intervention on object-control skills score (compared to CON) was a mean benefit of 3.1 units (90% CI, 2.1 to 4.2; $P = .000$), a moderate positive effect. There were no differences between HIPA and PASS, and CON at post-test.

Figure 9 ANCOVA total skill score means at baseline, mid test, and post-test, adjusting for baseline differences.

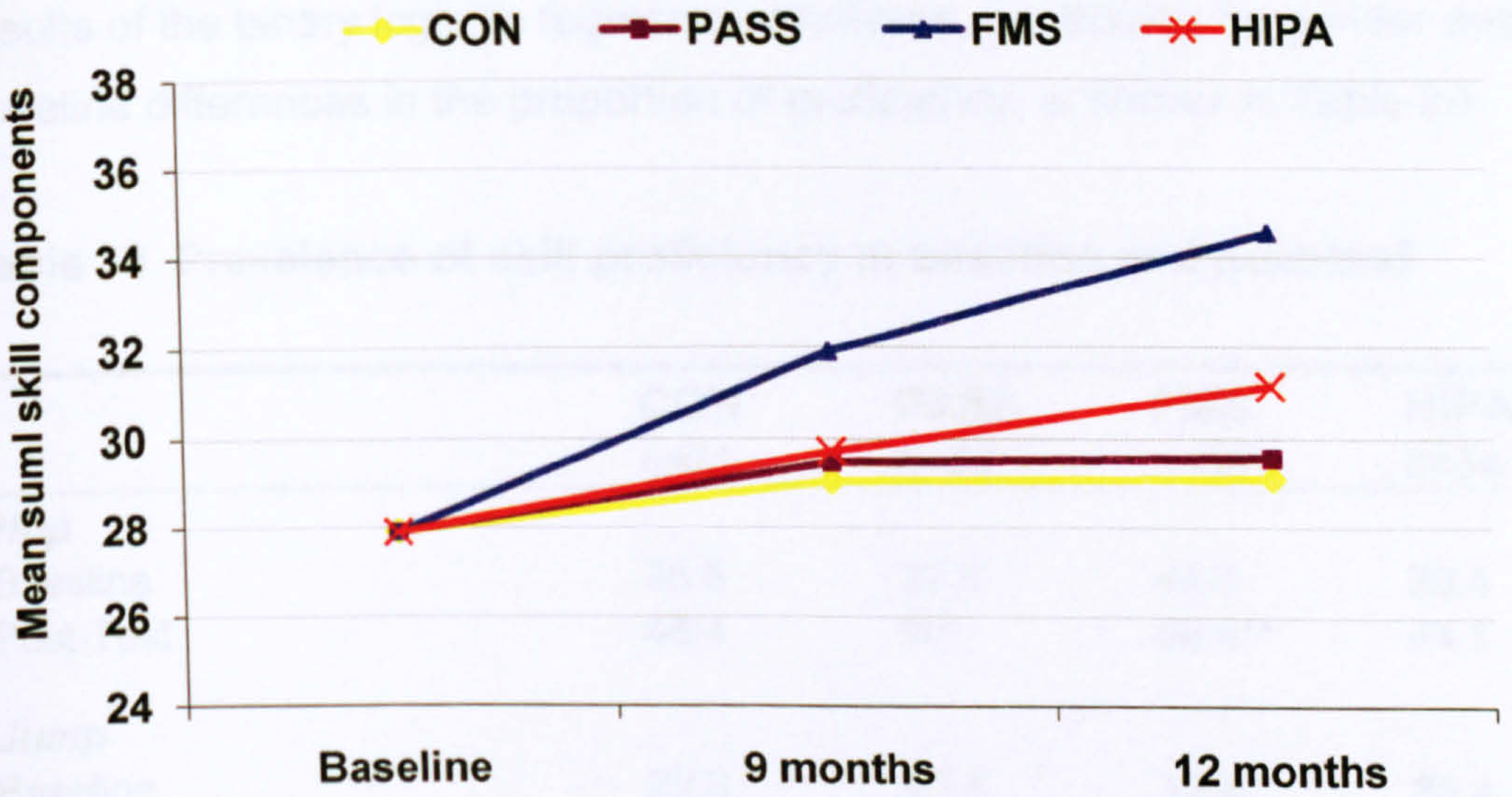
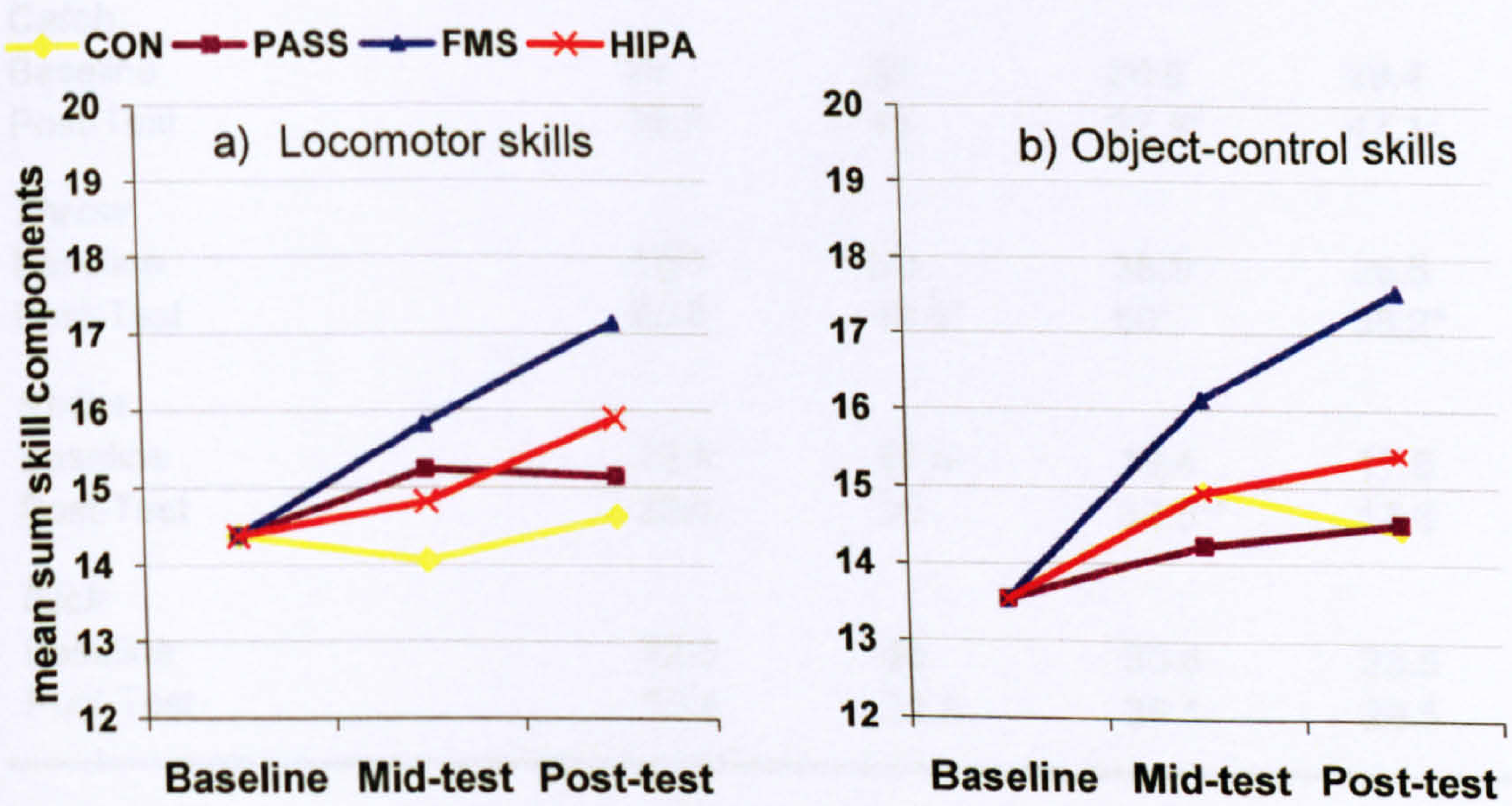


Figure 10 ANCOVA locomotor (a) and object-control skills (b) means at baseline, mid-test and post-test, adjusting for baseline differences.



5.3.3 Did the intervention increase skill proficiency?

The prevalence (%) of skill proficiency (demonstrating all or all but one required components of a skill) at baseline and post-test is shown in Table 19. The results of the binary logisitic regression analyses, controlling for gender and baseline differences in the proportion of proficiency, is shown in Table 20.

Table 19 Prevalence of skill proficiency at baseline and post-test

	CON n=31	PASS n=40	FMS n=36	HIPA n=34
Hop				
Baseline	35.5	37.5	44.4	29.4
Post-Test	48.4	50*	80.6**	44.1
Jump				
Baseline	22.6	27.5	19.4	29.4
Post-Test	25.8	30	72.2**	38.2
Dodge				
Baseline	9.7	15	22.2	17.6
Post-Test	3.2	22.5	30.6	38.2*
Sprint				
Baseline	22.6	17.5	22.2	14.7
Post-Test	16.1	12.5	16.7	8.8
Catch				
Baseline	29	30	30.6	29.4
Post-Test	35.5	45	52.8*	47.1
Throw				
Baseline	16.1	30	38.9	26.5
Post-Test	25.8	42.5*	50*	38.2*
Strike				
Baseline	25.8	17.5	19.4	17.6
Post-Test	22.6	20	52.8**	17.6
Kick				
Baseline	22.6	30	30.6	23.5
Post-Test	19.4	32.5	36.1	26.5

note. Within-group difference * P <0.05, ** P < 0.01 (Wilcoxon Signed Rank Test)

Table 20 Binary Logistic Regression Analyses on the likelihood of attaining proficiency at post-test compared to CON children, adjusting for gender and baseline differences between groups

Skill	β	SE	OR	90% CI	RR	P
Hop						
PASS	0.07	0.55	1.07	0.44 to 2.64	1.04	0.90
FMS	1.62	0.61	5.06	1.85 to 13.83	**1.71†**	0.01
HIPA	0.00	0.56	1.00	0.40 to 2.53	1.00	1.00
V.Jump						
PASS	0.14	0.61	1.15	0.42 to 3.16	1.11	0.82
FMS	2.50	0.63	12.14	4.31 to 34.19	**3.13†††**	0.00
HIPA	0.61	0.63	1.84	0.66 to 5.14	1.51	0.33
Dodge						
PASS	2.45	1.16	11.53	1.70 to 77.9	**8.63††††**	0.04
FMS	2.69	1.16	14.79	2.20 to 99.26	**10.26††††**	0.02
HIPA	3.46	1.17	31.69	4.62 to 217.63	**15.99††††**	0.00
Sprint						
PASS	-0.12	0.77	0.89	0.25 to 3.16	0.91	0.88
FMS	0.09	0.75	1.10	0.32 to 3.78	1.08	0.90
HIPA	-0.45	0.87	0.64	0.15 to 2.64	0.67	0.60
Catch						
PASS	0.62	0.58	1.86	0.72 to 4.79	1.42	0.28
FMS	0.97	0.60	2.65	0.99 to 7.07	**1.67†**	0.10
HIPA	0.95	0.61	2.57	0.95 to 7.01	**1.65†**	0.12
Throw						
PASS	1.18	0.95	3.26	0.69 to 15.49	**2.06††**	0.21
FMS	2.02	1.10	7.54	1.24 to 45.94	**2.81††**	0.07
HIPA	1.59	1.05	4.91	0.88 to 27.53	**2.44††**	0.13
Strike						
PASS	0.90	1.03	2.45	0.45 to 13.24	1.85	0.38
FMS	3.89	1.15	48.98	7.34 to 326.69	**4.14†††**	0.00
HIPA	1.17	1.05	3.21	0.58 to 17.92	**2.14††**	0.26
Kick						
PASS	1.12	0.81	3.07	0.82 to 11.56	**2.19††**	0.16
FMS	1.30	0.82	3.67	0.96 to 14.08	**2.42††**	0.11
HIPA	1.15	0.87	3.16	0.76 to 13.21	**2.23††**	0.19

β, regression coeffecient; SE, standard error; OR, adjusted odds ratio; 90% CI, confidence intervals; RR, adjusted relative risk
Effect magnitude: †small, ††moderate, †††large, ††††very large

Locomotor skills

Hop

As shown in Table 19, at post-test, the prevalence of proficiency in FMS was 80.6%, representing a 36.2% increase in proficiency from baseline. Proficiency in CON (↑12.9%), PASS (↑12.5%) and HIPA (↑14.7%) increased from baseline to post-test at similar rates. Participants in the FMS group were on average 1.7 times more likely to attain proficiency in the vertical jump at post-test than CON counterparts, demonstrating a significant small positive effect (Table 20). There were no significant or practically meaningful differences between PASS and HIPA, and CON.

Vertical Jump

At post-test, prevalence of proficiency in the vertical jump was highest in FMS, representing an absolute gain of 52.8% from baseline. Post-test proficiency rates were much lower in CON, PASS and HIPA groups with prevalence of proficiency increasing from baseline by 3.2%, 2.5% and 8.8%, respectively (Table 19). Participants in FMS were on average over three times more likely to attain proficiency in the vertical jump at post-test than CON counterparts, demonstrating a significant large positive intervention effect (Table 20). There were no significant or practically meaningful differences between PASS and HIPA, and CON.

Dodge

At post-test, HIPA had increased proficiency rates by the largest amount from baseline (↑20.6%), whilst PASS and FMS had absolute gains in proficiency from of 7.5% and 8.4%, respectively (Table 19). Compared to CON, participation in PASS, FMS and HIPA was significantly associated with very large intervention effects (Relative risks > 5.7). Specifically, compared to children in CON, participants in PASS, FMS and HIPA were on average over 8, 10, and 15 times more likely to attain proficiency in the dodge at post-test, in that order (Table 20).

Sprint run

Prevalence of proficiency in the sprint run was low at post-test with absolute changes in proficiency from baseline to post-test similar across all groups - CON, PASS, FMS and HIPA proportions decreasing by 6.5%, 5%, 5.5% and 5.9%, respectively (Table 19). There were no significant or practically meaningful differences in the likelihood of attaining proficiency at post-test between the intervention groups and the CON (Table 20).

Object-control skills

Catch

The absolute increases in prevalence of proficiency at the catch from baseline to post-test in the CON, PASS, FMS and HIPA groups was 6.5%, 15%, 22.2%, and 17.7%, respectively (Table 19). Consequently at post-test, relative to children in CON, participants in FMS and HIPA were on average over 1.5 times more likely to attain proficiency at post-test, representing small but potentially practically important positive effects (Table 20). There were no significant or practically meaningful differences between PASS and CON.

Overarm Throw

Table 19 shows that absolute changes in proficiency at the catch from baseline to post-test were similar across all groups (9.7% – 12.5%). Whilst all groups showed similar absolute gains, the low prevalence of proficiency among CON participants at baseline meant they had the most potential for change. Consequently, in comparison to CON participants, children in the PASS, HIPA and FMS groups were on average over twice as likely to attain proficiency in the throw at post-test, indicating moderate, potentially practically important, positive effects (Table 20).

Strike

At post-test, 22.6% of CON participants were rated as proficient, representing an absolute decrease of 3.2% from baseline, whilst HIPA and PASS rates of proficiency showed little change (Table 19). In contrast, the prevalence of proficiency among FMS participants had increased over two fold from baseline, with an absolute increase of 33.4%. Compared to children in CON, participation in the FMS intervention was associated with a significant large intervention effect, with children on average over four times more likely to attain proficiency at post-test. Moderate potentially practically important intervention effects were also observed in HIPA, with participants on average over twice as likely to attain proficiency at post-test than children in CON (Table 20). There were no significant or practically meaningful differences between PASS and CON.

Kick

Participants in FMS were associated with the highest absolute increase in prevalence of proficiency from baseline to post-test (5.5%), whilst PASS and HIPA showed minor gains. In contrast, CON proficiency rates declined by 3.2% from baseline (Table 19). Compared to CON, PASS, FMS, and HIPA interventions were associated with moderate, potentially practically important positive effects. Specifically, in comparison to CON participants, children in the PASS, HIPA and FMS groups were on average over twice as likely to attain proficiency in the kick at post-test (Table 20).

5.3.4 Physical self-perceptions, self-esteem and perceived FMS competence

Significant gender by intervention interactions were found so boys and girls results are presented separately. Tables 21 and 22 show raw means in physical self-perceptions and self-esteem at baseline, mid-test and post-test for boys and girls, respectively. Group data can be found in Appendix I. The ANCOVA results on the effectiveness of the interventions on CY-PSPP subscales, self-esteem and perceived FMS competence are described below.

Table 21 Mean physical self-perceptions and self-esteem scores in <u>boys</u> at baseline, mid-test and post-test.

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Sports competence												
Baseline	15	19.8	5.2	17	18.3	3.8	16	18.9	3.6	12	17.8	3.5
Mid-test	14	18.4	4.0	17	19.1	3.7	17	19.6	3.7	11	19.2	2.4
Δ Baseline - Mid-test	14	-1.1	3.1	16	0.9	3.0	16	0.5	3.7	11	1.2	2.8
Post-test	15	18.7	4.8	16	17.8	3.9	17	20.1	3.7	10	19.5	3.5
Δ Baseline - Post-test	15	-1.1	3.3	15	-0.2	1.8	16	0.9	3.5	10	1.2	2.6
Physical condition												
Baseline	15	19.7	3.7	17	18.8	3.5	16	18.6	3.9	12	17.5	3.9
Mid-test	14	18.2	2.8	17	18.7	3.3	17	19.7	3.5	11	18.4	1.9
Δ Baseline - Mid-test	14	-1.7	3.3	16	-0.3	2.8	16	1.1	3.4	11	0.9	3.2
Post-test	15	18.7	3.5	16	18.0	4.2	17	19.7	3.7	10	19.0	3.9
Δ Baseline - Post-test	15	-1.1	3.6	15	-0.9	4.3	16	0.8	4.0	10	0.9	3.4
Body attractiveness												
Baseline	15	18.3	4.1	17	17.7	4.2	16	18.0	4.7	12	15.1	5.1
Mid-test	14	16.1	3.6	17	17.7	5.0	17	17.9	2.9	11	19.1	2.5
Δ Baseline - Mid-test	14	-2.3*	3.5	16	-0.3	4.7	16	-0.3	4.0	11	3.3*	4.1
Post-test	15	16.9	4.5	16	17.1	5.3	17	18.8	2.8	10	16.3	3.0
Δ Baseline - Post-test	15	-1.4	3.1	15	-0.8	5.2	16	0.6	3.5	10	0.4	5.6
Physical strength												
Baseline	15	18.4	3.8	17	17.9	4.4	16	17.4	4.4	12	15.6	4.1
Mid-test	14	17.9	3.5	17	17.9	5.0	17	17.7	3.4	11	18.4	3.4
Δ Baseline - Mid-test	14	-0.5	3.5	16	-0.3	4.3	16	0.3	3.2	11	2.2*	3.0
Post-test	15	18.3	4.7	16	17.4	5.1	17	17.5	4.2	10	19.2	3.4
Δ Baseline - Post-test	15	-0.1	4.1	15	-0.7	3.4	16	0.1	3.7	10	2.8*	3.3
Physical self-worth												
Baseline	15	19.7	3.7	17	18.7	4.0	16	18.4	3.5	12	15.8	3.9
Mid-test	14	17.5	3.0	17	18.7	4.9	17	18.7	3.4	11	20.1	3.5
Δ Baseline - Mid-test	14	-2.1*	3.6	16	-0.4	6.3	16	0.4	2.4	11	4.0*	4.0
Post-test	15	18.1	4.0	16	17.3	4.5	17	19.8	3.4	10	19.2	3.5
Δ Baseline - Post-test	15	-1.6	2.9	15	-1.5	5.4	16	1.1	3.0	10	2.9*	3.5
Self-esteem												
Baseline	15	20.8	3.1	17	19.5	4.1	16	19.6	4.1	12	16.3	4.4
Mid-test	14	18.9	3.4	17	19.1	4.4	17	20.1	3.5	11	21.3	2.9
Δ Baseline - Mid-test	14	-1.7	3.7	16	-0.7	6.0	16	0.4	3.9	11	4.4**	3.6
Post-test	15	19.7	3.9	16	17.9	3.2	17	20.5	3.7	10	19.9	2.7
Δ Baseline - Post-test	15	-1.1	4.3	15	-1.5	5.3	16	0.7	3.7	10	2.5	4.0

Table 22 Mean physical self-perceptions and self-esteem scores in girls at baseline, mid-test and post-test.

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Sports competence												
Baseline	19	17.6	2.9	27	18.0	3.4	18	17.8	3.1	23	17.7	2.9
Mid-test	18	18.2	3.0	26	17.2	4.1	18	17.2	3.3	24	18.3	3.5
Δ Baseline - Mid-test	18	0.5	3.7	26	-0.7	3.6	16	-1.1	2.8	23	0.6	3.2
Post-test	18	18.2	3.0	25	18.6	3.7	20	18.1	2.9	23	17.8	3.3
Δ Baseline - Post-test	18	0.8	3.4	25	0.7	3.5	18	0.0	2.7	22	0.2	2.2
Physical condition												
Baseline	19	18.2	3.3	27	16.4	2.8	18	19.0	2.7	23	17.9	3.5
Mid-test	18	18.7	3.0	26	16.7	2.7	18	18.4	2.5	24	18.0	3.3
Δ Baseline - Mid-test	18	0.3	2.6	26	0.3	3.3	16	-1.1	3.1	23	-0.1	3.6
Post-test	18	19.0	3.3	25	16.8	3.1	20	17.1	3.5	23	18.2	2.9
Δ Baseline - Post-test	18	0.9	3.8	25	0.4	3.4	18	-2.2**	2.8	22	0.5	3.7
Body attractiveness												
Baseline	19	16.8	4.3	27	16.5	2.9	18	17.1	1.9	23	17.0	4.5
Mid-test	18	17.0	3.5	26	15.7	3.7	18	16.1	2.8	24	17.1	4.5
Δ Baseline - Mid-test	18	0.0	3.8	26	-0.9	4.2	16	-1.5*	2.6	23	-0.2	5.2
Post-test	18	16.6	4.0	25	15.7	3.5	20	16.0	2.7	23	15.6	4.9
Δ Baseline - Post-test	18	-0.1	3.6	25	-0.7	4.3	18	-1.5*	2.8	22	-1.4	5.5
Physical strength												
Baseline	19	15.4	3.5	27	16.6	3.0	18	17.8	2.1	23	17.2	3.1
Mid-test	18	16.3	3.1	26	16.5	2.8	18	16.1	3.6	24	17.5	3.5
Δ Baseline - Mid-test	18	0.9	4.1	26	-0.1	3.9	16	-1.8	4.2	23	0.3	3.4
Post-test	18	17.1	3.1	25	17.2	3.9	20	16.1	2.2	23	17.5	3.5
Δ Baseline - Post-test	18	1.4	2.8	25	0.6	4.4	18	-1.8*	2.3	22	0.5	2.4
Physical self-worth												
Baseline	19	17.1	3.6	27	17.1	3.1	18	17.9	2.5	23	18.0	3.5
Mid-test	18	17.6	3.4	26	17.6	3.3	18	17.1	3.4	24	18.6	3.5
Δ Baseline - Mid-test	18	0.6	4.5	26	0.5	3.5	16	-0.6	3.3	23	0.6	3.2
Post-test	18	17.7	3.7	25	17.9	3.5	20	17.0	2.6	23	17.5	3.2
Δ Baseline - Post-test	18	0.9	3.3	25	0.6	3.5	18	-0.9	1.9	22	-0.5	2.9
Self-esteem												
Baseline	19	18.3	3.8	27	18.6	3.2	18	18.8	3.3	23	18.9	3.0
Mid-test	18	18.4	3.6	26	19.1	3.5	18	18.1	3.1	24	20.0	3.5
Δ Baseline - Mid-test	18	0.1	4.4	26	0.4	4.5	16	-0.8	3.6	23	0.9	3.4
Post-test	18	18.7	3.6	25	20.4	2.7	20	18.0	3.2	23	19.4	3.5
Δ Baseline - Post-test	18	0.6	4.2	25	1.7*	4.5	18	-1.1	2.5	22	0.3	3.7

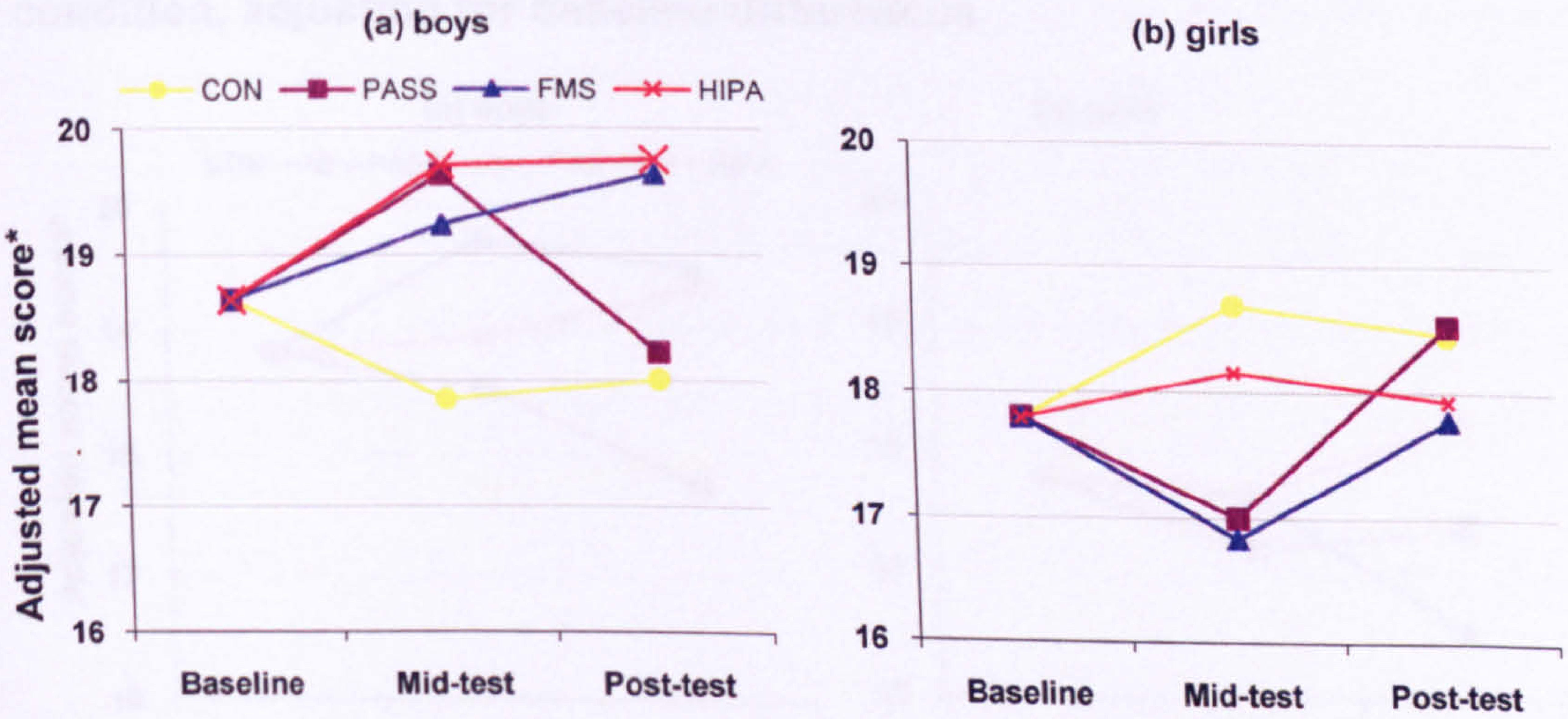
***Sports competence:* boys (MPID: 0.81)**

The effects of the interventions on perceptions of sports competence in boys can be seen in Figure 11a. At mid-test CON perceptions of sports competence decreased below baseline, whilst PASS, FMS and HIPA increased. PASS (AMD: 1.8 units, 90% CI: 0.1 to 3.4; *P* = .079) and HIPA (AMD: 1.9 units, 90% CI: 0.0 to 3.7; *P* = .098) interventions were associated with a small, potentially practically important, positive effect at mid-test, compared to CON. PASS scores declined from mid-test to post-test, whilst FMS values increased further. At post-test participation in FMS (AMD: 1.6 units, 90% CI: -0.2 to 3.3; *P* = .111) and HIPA (AMD: 1.7 units, 90% CI: -0.2 to 3.7; *P* = .132) was associated with a small, potentially practically important positive effect, compared to CON.

***Sports competence*: girls (MPID: 0.61)**

The effects of the interventions on perceptions of sports competence in girls can be seen in Figure 11b. PASS and FMS perceived competence decreased from baseline to mid-test, HIPA showed little change, whilst CON increased. At mid-test PASS (AMD: -1.7 units, 90% CI: -3.3 to -0.1; *P* = .077) and FMS (-1.9 units, 90% CI: -3.6 to -0.1; *P* = .079) were associated with small, potentially practically important, negative effects, compared to CON. PASS and FMS increased from mid-test to post-test and no differences were found between groups.

Figure 11 Intervention effects (ANCOVA) on perceptions of sports competence, adjusting for baseline differences



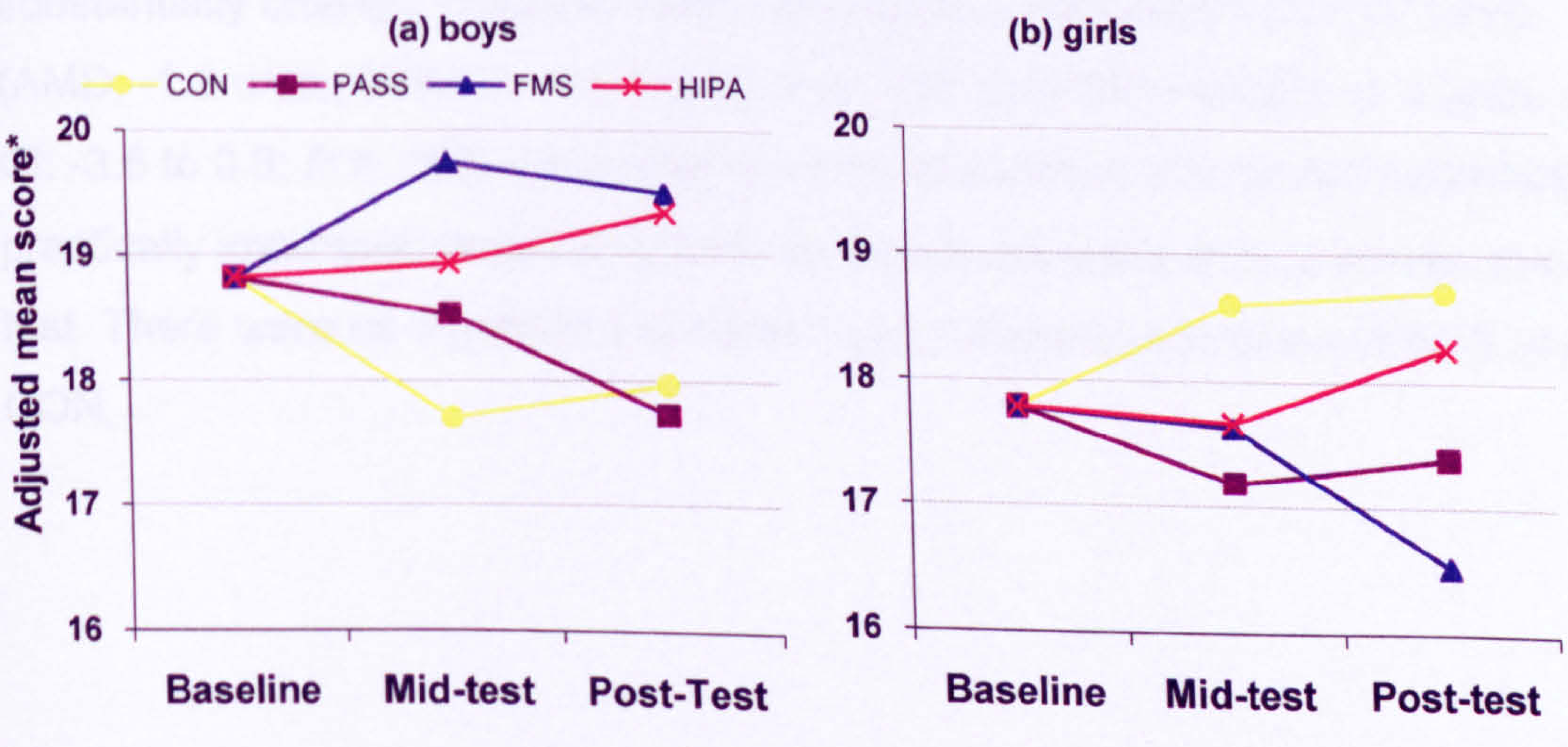
***Physical condition*: boys (MPID: 0.74)**

Intervention effects on boys' perceptions of physical condition can be seen in Figure 12a. At mid-test, FMS perceived condition had increased from baseline; CON had decreased, whilst HIPA and PASS scores remained similar. At mid-test, participation in FMS (AMD: 2.0 units, 90% CI: 0.5 to 3.6; P = .03) and HIPA (AMD: 1.2 units, 90% CI: -0.5 to 3.0; P = .024) was significantly associated with a small positive intervention effect, compared to CON. At post-test, FMS scores fell slightly, HIPA continued to increase, PASS scores continued to decline, whilst CON values remained similar to mid-test. No significant or meaningful differences between groups were observed at post-test though there was a trend for possible beneficial effects among HIPA and FMS interventions.

***Physical condition:* girls (MPID: 0.64)**

Intervention effects on girls' perceptions of physical condition can be seen in Figure 12b. At mid-test, CON perceived condition scores increased slightly from baseline, FMS and HIPA showed little change, whilst PASS scores declined. PASS was associated with a small, potentially practically important, negative effect, compared to CON (AMD: -1.4 units, 90% CI: -2.9 to 0.0; P = .108). At post-test, CON and PASS values changed little from mid-test, HIPA increased slightly, whilst FMS fell further. At post-test PASS (AMD: -1.3 units, 90% CI: -2.9 to 0.3; P = .176) and FMS (AMD: -2.2 units, 90% CI: -3.9 to -0.4; P = .040) were associated with small negative intervention effects, compared to CON.

Figure 12 Intervention effects (ANCOVA) on perceptions of physical condition, adjusting for baseline differences



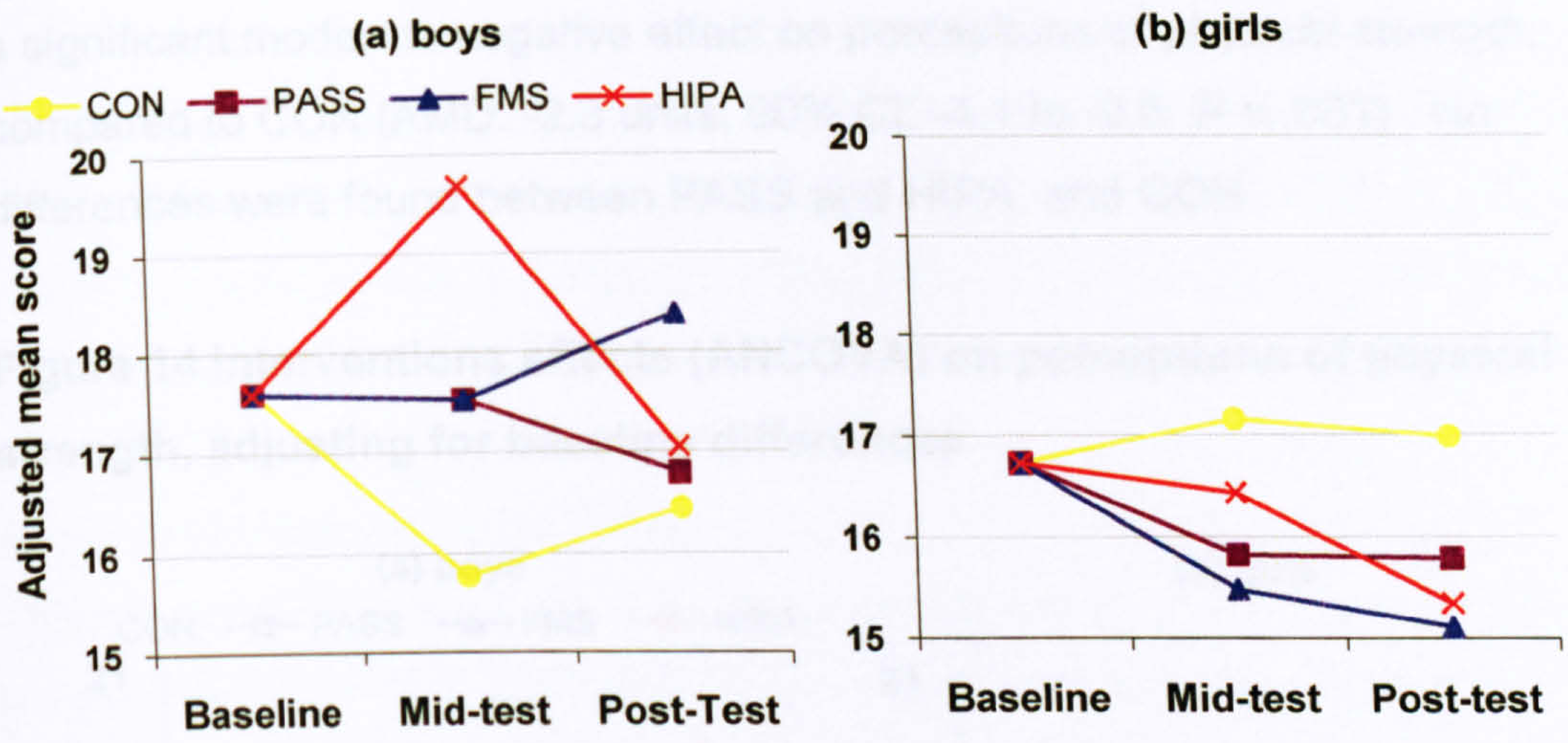
Body attractiveness: **boys (MPID: 0.91)**

The effects of the interventions on boys' perceptions of body attractiveness can be seen in Figure 13a. At mid-test CON had lower perceptions of body attractiveness than at baseline, PASS and FMS showed little change, whilst HIPA values increased. Compared to CON, HIPA was associated with a significant moderate positive intervention effect (AMD: 3.9 units, 90% CI: 1.7 to 6.2; P = .006), whilst PASS (AMD: 1.8 units, 90% CI: -0.2 to 3.8; P = .146) and FMS (AMD: 1.8 units, 90% CI: -0.2 to 3.7; P = .141) observed small, potentially practically important, positive effects. Between mid-test and post-test, HIPA perceived body attractiveness fell sharply, PASS also declined, whilst CON increased slightly. At post-test, participation in FMS was associated with a small, potentially practically important, positive effect on perceived body attractiveness compared to CON (AMD: 1.9 units, 90% CI: -0.3 to 4.2; P = .152). No other significant or meaningful group differences were found at post-test.

Body attractiveness: **girls (MPID: 0.70)**

The effects of the interventions on girls' perceptions of body attractiveness can be seen in Figure 13b. PASS and FMS scores decreased from baseline to mid-test, whilst HIPA and CON did not substantially change. Compared to CON, participation in FMS was associated with a small, potentially practically important, negative effect at mid-test (AMD: -1.7 units, 90% CI: -3.7 to 0.3; P = .163), whilst PASS and HIPA showed trends for possible negative effects. From mid-test to post-test CON, FMS and PASS perceptions of attractiveness did not substantially change, however HIPA fell sharply. Compared to CON, FMS (AMD: -1.9 units, 90% CI: -4.0 to 0.2; P = .136) and HIPA (AMD: -1.6 units, 90% CI: -3.6 to 0.3; P = .160) interventions were associated with small, potentially practically important, negative effects on perceived body attractiveness at post-test. There were no significant or meaningful differences between PASS and CON.

Figure 13 Intervention effects (ANCOVA) on perceptions of body attractiveness, adjusting for baseline differences



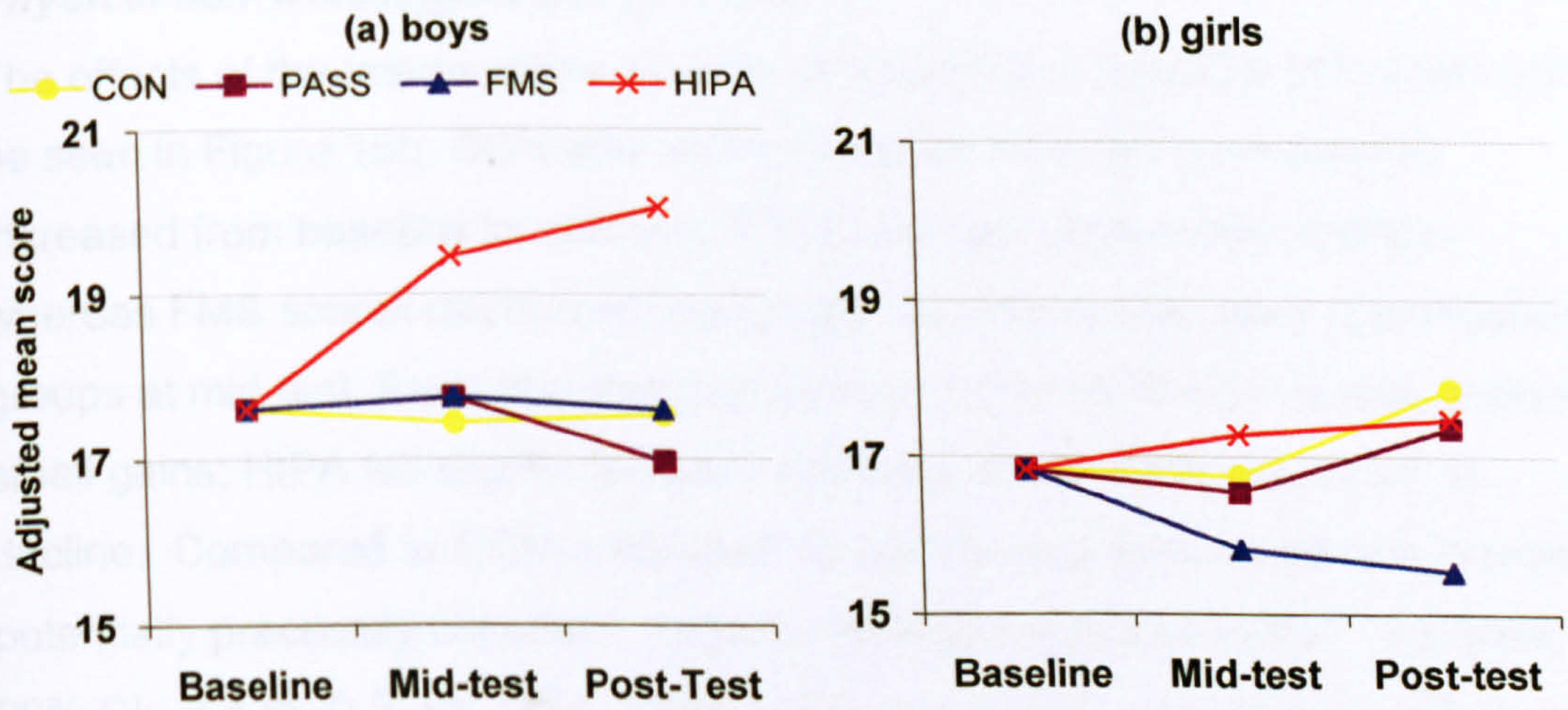
Physical strength: **boys (MPID: 0.84)**

The effects of the interventions on boys' perceptions of physical strength can be seen in Figure 14a. At mid-test CON, FMS and PASS showed little change from baseline whilst HIPA perceptions of strength increased. From mid-test to post-test, HIPA continued to increase slightly, whilst FMS, PASS and CON showed little change. Compared to CON, HIPA was associated with small (AMD: 2.0 units, 90% CI: -0.1 to 4.2; $P = .120$) and moderate (2.5 units, 90% CI: 0.1 to 5.0; $P = .092$), potentially practically important, positive intervention effects on perceived physical strength at mid-test and post-test, respectively. PASS and FMS did not enhance perceived strength, relative to CON.

Physical strength: **girls (MPID: 0.61)**

The effects of the interventions on girls' perceptions of physical strength can be seen in Figure 14b. At mid-test CON, PASS and HIPA perceived strength scores showed little change from baseline, whilst FMS had slightly lower values. No differences were found between groups at mid-test. From mid-test to post-test, FMS scores continued to fall, however CON, HIPA, PASS perceptions of strength showed minor increases with post-test values being just above baseline. At post-test, participation in the FMS intervention was associated with a significant moderate negative effect on perceptions of physical strength, compared to CON (AMD: -2.3 units, 90% CI: -4.1 to -0.6; $P = .031$). No differences were found between PASS and HIPA, and CON.

Figure 14 Interventions effects (ANCOVA) on perceptions of physical strength, adjusting for baseline differences



Physical self-worth: **boys (MPID: 0.78)**

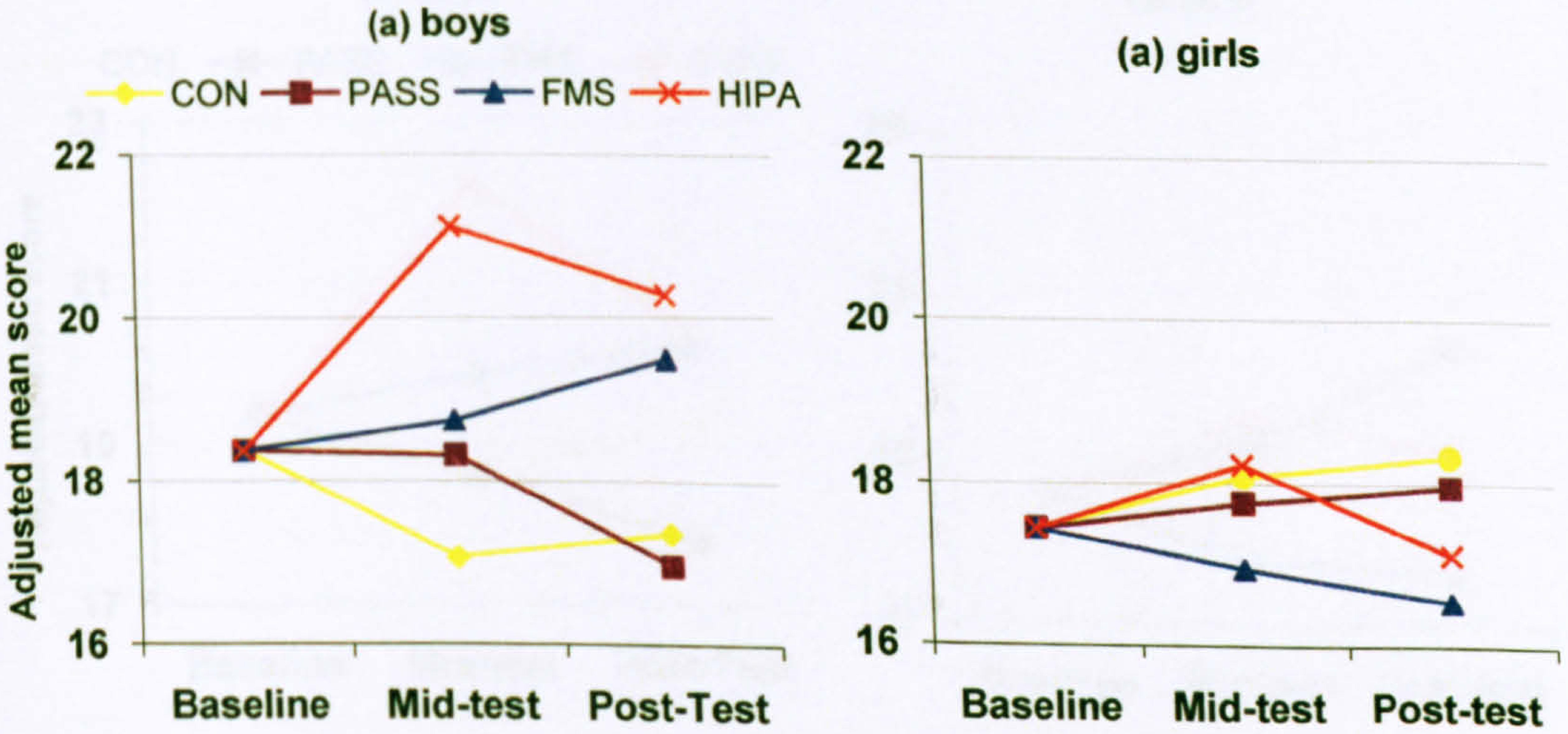
The effects of the interventions on boys' perceptions of physical self-worth can be seen in Figure 15a. CON perceived physical self-worth decreased from baseline to mid-test, FMS and PASS showed little change, whilst HIPA increased. Compared to CON, HIPA was associated with a significant moderate positive intervention effect on perceived physical self-worth at mid-test (AMD: 4.1 units, 90% CI: 1.4 to 6.7; $P = .013$), whilst participation in FMS was also associated with small, potentially practically important, benefits (AMD: 1.7 units, 90% CI: -0.6 to 4.0; $P = .216$).

At post-test, PASS self-worth declined from mid-test whilst CON remained similar. HIPA fell slightly but FMS increased. At post-test, HIPA and FMS had the highest perceptions of physical self-worth. Compared to CON, HIPA was associated with a moderate, potentially practically important, positive effect on physical self-worth at post-test (AMD: 2.9 units, 90% CI: 0.5 to 5.4; P = .052), whilst participation in FMS was associated with a small, potentially practically important, positive effect (AMD: 2.2 units, 90% CI: 0.0 to 4.3; P = .094). No differences were observed between PASS and CON groups at post-test.

Physical self-worth: **girls (MPID: 0.64)**

The effects of the interventions on girls' perceptions of physical self-worth can be seen in Figure 15b. CON and HIPA perceptions of self-worth slightly increased from baseline to mid-test; PASS did not substantially change, whereas FMS scores decreased marginally. No differences were found between groups at mid-test. From mid-test to post-test, CON and PASS scores showed small gains; HIPA fell slightly to below baseline, whilst FMS continued to decline. Compared to CON, participation in FMS was associated with a small, potentially practically important, negative effect at post-test (AMD: -1.8 units, 90% CI: -3.4 to -0.2; P= .066), whilst HIPA was possibly associated with a small negative effect. There were no differences between PASS and CON.

Figure 15 Intervention effects (ANCOVA) on perceptions of physical self-worth, adjusting for baseline differences



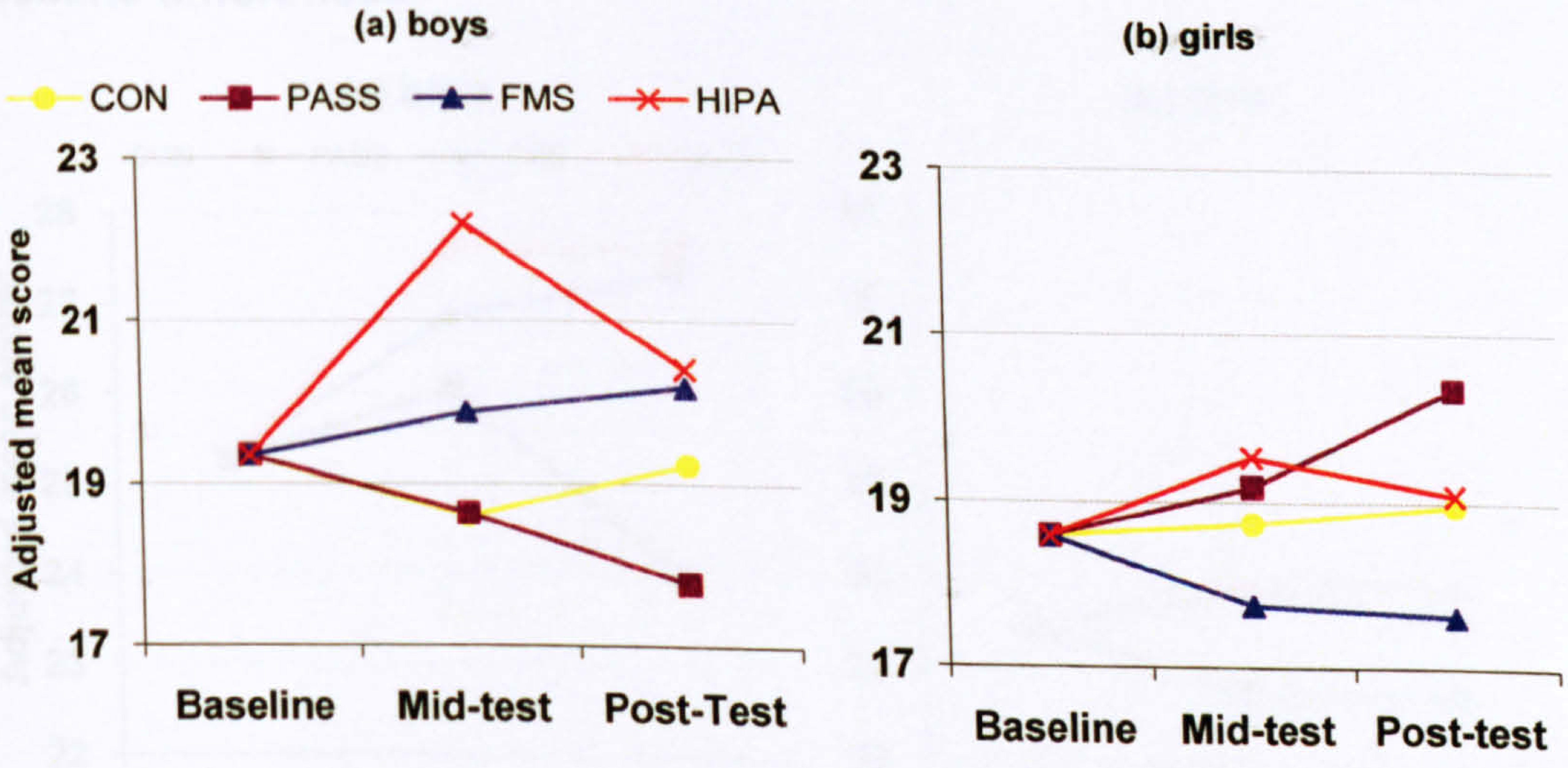
***Self-esteem:* boys (MPID: 0.82)**

The effects of the interventions on boys' perceptions of self-esteem can be seen in Figure 16a. CON and PASS self-esteem scores decreased from baseline to mid-test, whilst HIPA and FMS were associated with moderate and small improvements, respectively. At mid-test, HIPA was associated with a significant moderate positive intervention effect on self-esteem relative to CON (AMD: 4.0 units, 90% CI: 1.0 to 6.2; *P* = .023). No differences were found between PASS and FMS, and CON at mid-test. At post-test, HIPA and CON returned to near baseline scores, PASS continued to decrease, whilst FMS showed a small increase. No significant or meaningful differences were found at post-test.

***Self-esteem:* girls (MPID 0.85)**

The effects of the interventions on girls' perceptions of self-esteem can be seen in Figure 16b. In girls, CON self-esteem changed little throughout the project, PASS steadily increased across time. In contrast, FMS self-esteem scores declined over the course of the intervention, whilst HIPA showed a small benefit on self-esteem at mid-test, which fell slightly at post-test. No differences were found between groups at mid-test or post-test though there was a trend for girls' in PASS to have higher self-esteem scores than CON girls at post-test.

Figure 16 ANCOVA means for self-esteem score, adjusting for baseline differences



***Perceived skill competence: boys* (MPID: 0.88)**

The intervention effects on boys' perceived skill competence is shown in Figure 17a. At mid-test PASS, FMS and HIPA all increased perceived skill competence from baseline, whereas CON decreased. From mid-test to post-test HIPA and FMS skill scores appear to plateau, whereas PASS scores decreased sharply to below baseline with CON still subordinate. Participation in FMS and HIPA was associated with significant moderate positive effects at mid-test and post-test. Specifically, the effects of the FMS intervention (compared to CON) on perceived skill competence was a mean benefit of 3.4 units (90% CI: 1.3 to 5.5; P = .009) and 3.5 units (90% CI: 1.4 to 5.6; P = .007) at mid-test and post-test, respectively; whilst the corresponding effects of HIPA was a mean benefit of 4.1 units (90% CI: 1.8 to 6.5; P = .005) and 3.8 units (90% CI: 1.4 to 6.2; P = .012), respectively. Further, PASS had a small positive effect on perceived skill competence at mid-test (AMD: 2.6 units, 90% CI: 0.4 to 4.7; P = .049).

***Perceived skill competence: girls* (MPID: 0.83)**

The intervention effects on girls' perceived skill competence is shown in Figure 17b. PASS and HIPA scores did not substantially change over time. However, FMS and CON decreased slightly from baseline to mid-test. At post-test, FMS remained similar to mid-test scores, whilst CON recovered to near baseline levels. No differences were found between groups at mid-test or post-test.

Figure 17 ANCOVA means for perceived skill competence score, adjusting for baseline differences

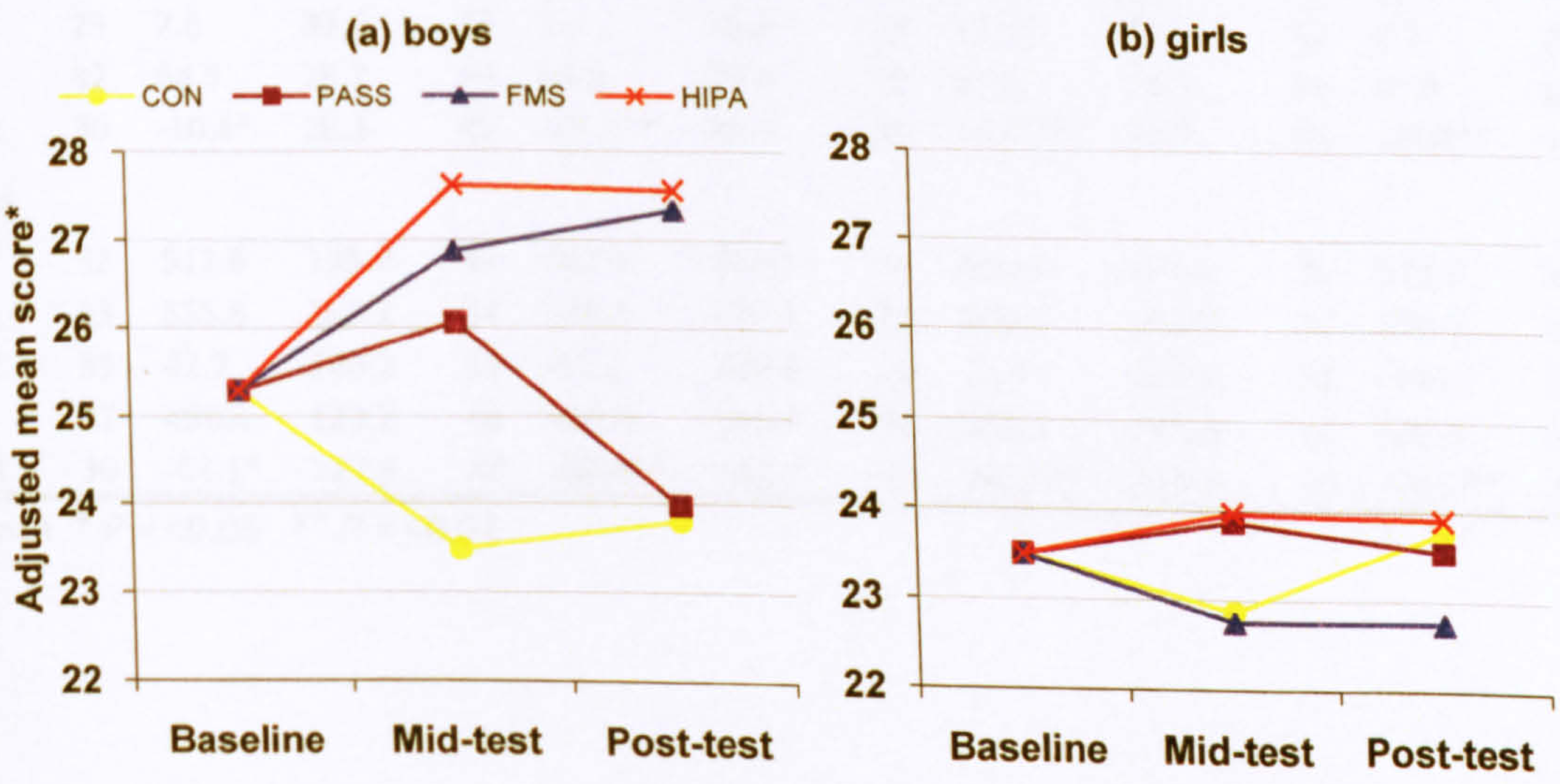


Table 23 Age, maturation, body fat, fitness and physical activity by group at baseline, mid-test and post-test.

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
e (years)												
seline	34	9.8	0.4	44	9.6	0.3	35	9.6	0.3	36	9.6	0.3
id-test	32	10.3	0.4	43	10.3	0.3	35	10.3	0.3	35	10.4	0.3
Baseline - Mid-test	32	0.6**	0.4	42	0.7**	0.1	33	0.7**	0.1	35	0.7**	0.1
st-test	33	10.8	0.3	41	10.7	0.3	37	10.7	0.3	33	10.7	0.3
Baseline - Post-test	33	1.0**	0.1	40	1.1**	0.1	35	1.1**	0.2	33	1.1**	0.1
ak height velocity												
seline	34	-3.2	0.5	44	-3.3	0.5	35	-3.5	0.4	36	-3.2	0.4
id-test	32	-2.9	0.6	43	-2.7	0.5	35	-3.0	0.4	35	-2.7	0.4
Baseline - Mid-test	32	0.4**	0.2	42	0.6**	0.1	33	0.5**	0.2	35	0.5**	0.1
st-test	33	-2.6	0.6	41	-2.4	0.5	37	-2.7	0.5	33	-2.4	0.4
Baseline - Post-test	33	0.6**	0.2	40	0.9**	0.2	35	0.8**	0.2	33	0.8**	0.1
dy fat (%)												
seline	32	27.3	5.2	43	29.8	5.5	35	24.4	7.0	36	28.5	7.2
id-test	32	26.5	5.6	43	29.2	6.1	35	23.9	7.0	35	28.4	7.6
Baseline - Mid-test	30	-0.7*	1.7	41	-0.4	2.3	33	-0.4	1.7	35	-0.4	1.6
st-test	33	27.8	6.1	41	29.9	5.9	37	24.2	6.9	33	28.9	8.1
Baseline - Post-test	31	0.1	2.5	39	0.0	2.4	35	0.0	2.0	33	0.0	2.3
tness (ml·kg^{-1}·min^{-1})												
seline	30	46.5	7.1	41	45.8	6.4	33	51.5	7.4	32	44.8	7.5
id-test	31	45.2	6.5	42	43.8	5.0	33	46.4	6.8	35	43.1	5.8
Baseline - Mid-test	28	-1.2	4.2	38	-2.4**	4.8	30	-4.7**	3.8	31	-1.8*	4.2
ost-test	29	45.4	6.2	38	44.4	6.7	32	49.0	7.1	30	44.3	6.4
Baseline - Post-test	26	-0.4	5.0	35	-1.7*	3.9	29	-2.0**	2.9	28	0.8	4.7
ysical activity >4km·hr^{-1}												
seline	32	73.7	29.6	44	82.8	29.4	33	80.8	24.2	35	87.4	28.0
id-test	31	85.2	37.9	33	87.1	34.9	28	92.2	28.7	33	88.2	30.6
Baseline - Mid-test	29	7.8	30.6	33	3.2	30.8	27	11.0*	25.6	32	0.0	28.1
ost-test	32	64.5	28.2	40	69.3	28.3	35	67.6	24.7	31	67.0	20.5
Baseline - Post-test	30	-10.4*	26.3	40	-13.1**	25.3	32	-16.1**	28.3	30	-20.8**	31.4
ysical activity (cpm)												
seline	32	512.6	135.7	45	567.5	142.9	34	559.2	144.1	35	573.2	124.5
id-test	33	555.8	165.2	34	548.4	194.4	29	562.8	161.6	33	565.2	126.1
Baseline - Mid-test	31	42.7	146.2	34	-12.3	181.6	28	13.7	109.2	32	-10.6	94.0
ost-test	32	456.4	123.2	40	485.0	148.4	36	466.7	140.0	31	505.1	115.3
Baseline - Post-test	30	-62.1*	127.8	40	-80.4**	136.2	33	-96.7**	124.7	30	-71.5**	111.2

ithin-group difference * *P* = <0.05 ** *P* = <0.01

Table 24 Age, maturation, body fat, fitness and physical activity in boys at baseline, mid-test and post-test, by group

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
e (years)												
seline	15	9.6	0.3	17	9.7	0.3	16	9.7	0.4	12	9.6	0.3
d-test	14	10.3	0.3	17	10.4	0.3	17	10.4	0.4	11	10.4	0.2
Baseline - Mid-test	14	0.7**	0.1	16	0.7**	0.1	16	0.7**	0.0	11	0.7**	0.1
st-test	15	10.6	0.3	16	10.8	0.3	17	10.8	0.3	10	10.7	0.3
Baseline - Post-test	15	1.0**	0.1	15	1.1**	0.1	16	1.1**	0.2	10	1.1**	0.1
ak height velocity												
seline	15	-3.2	0.5	17	-3.1	0.5	16	-3.4	0.5	12	-3.2	0.4
d-test	14	-2.9	0.5	17	-2.6	0.4	17	-3.0	0.5	11	-2.6	0.4
Baseline - Mid-test	14	0.4**	0.1	16	0.5**	0.1	16	0.4**	0.2	11	0.5**	0.1
st-test	15	-2.5	0.5	16	-2.3	0.4	17	-2.7	0.5	10	-2.4	0.5
Baseline - Post-test	15	0.6**	0.1	15	0.8**	0.2	16	0.7**	0.1	10	0.8**	0.1
dy fat (%)												
seline	13	25.5	4.7	16	27.6	5.3	16	21.0	7.6	12	25.9	8.2
d-test	14	24.8	5.8	17	27.2	5.8	17	20.3	7.3	11	26.3	8.2
Baseline - Mid-test	12	-0.3	1.3	15	0.3	2.0	16	-0.5	1.5	11	-0.1	1.3
st-test	15	26.6	6.7	16	28.6	5.5	17	20.6	7.1	10	26.8	8.8
Baseline - Post-test	13	0.7	1.8	14	1.3*	2.2	16	-0.1	1.7	10	-0.1	1.5
ness (ml·kg^{-1}·min^{-1})												
seline	13	49.4	6.0	14	50.6	4.4	16	55.9	6.9	11	48.0	7.4
id-test	13	47.1	5.0	17	45.4	4.2	16	50.7	6.0	11	45.8	6.5
Baseline - Mid-test	12	-3.1**	3.2	13	-5.7**	3.9	15	-4.8**	4.8	10	-2.3*	2.6
st-test	13	47.2	5.0	15	47.9	5.9	15	53.7	6.3	9	47.0	7.9
Baseline - Post-test	12	-2.6	4.1	12	-2.9*	3.9	14	-1.4	2.7	8	0.7	3.5
ysical activity >4km·hr^{-1}												
seline	14	78.7	36.5	17	86.9	30.5	16	83.7	18.1	12	91.6	31.1
id-test	13	96.3	42.5	13	105.1	36.0	14	104.7	26.2	10	104.0	43.0
Baseline - Mid-test	12	6.1	27.9	13	17.7	33.3	14	22.1**	21.4	10	12.7	29.5
st-test	15	75.5	36.0	16	78.0	30.6	17	74.4	30.1	10	76.7	24.3
Baseline - Post-test	14	-4.9	26.6	16	-10.5	24.2	16	-11.9	26.4	10	-14.6	33.7
ysical activity (cpm)												
seline	14	535.6	134.1	18	641.7	127.3	16	595.0	161.7	12	653.2	141.3
id-test	14	592.6	176.3	13	671.3	178.0	14	631.0	167.8	10	672.3	133.9
Baseline - Mid-test	13	46.8	143.2	13	21.5	181.4	14	53.1	116.2	10	13.1	82.9
st-test	15	503.1	148.9	16	568.0	148.1	17	502.5	169.5	10	559.8	113.3
Baseline - Post-test	14	-35.2	133.8	16	-77.2**	128.4	16	-100**	112.5	10	-99.4*	129.1

ithin-group difference * P = <0.05 ** P = <0.01

Table 25 Age, maturation, body fat, fitness and physical activity in girls at baseline, mid-test and post-test, by group

	CONTROL			PASS			FMS			HIPA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
(years)												
line	19	9.9	0.3	27	9.6	0.3	19	9.6	0.3	24	9.7	0.3
test	18	10.4	0.4	26	10.3	0.3	18	10.3	0.3	24	10.4	0.3
seline - Mid-test	18	0.4**	0.5	26	0.7**	0.0	17	0.7**	0.0	24	0.7**	0.0
test	18	10.9	0.2	25	10.7	0.3	20	10.6	0.3	23	10.7	0.3
seline - Post-test	18	1.0**	0.1	25	1.1**	0.1	19	1.1**	0.1	23	1.1**	0.1
height velocity												
line	19	-3.2	0.5	27	-3.3	0.5	19	-3.5	0.5	24	-3.2	0.4
test	18	-2.9	0.6	26	-2.8	0.5	18	-3.0	0.5	24	-2.7	0.4
seline - Mid-test	18	0.4**	0.2	26	0.6**	0.1	17	0.6**	0.1	24	0.6**	0.1
test	18	-2.6	0.6	25	-2.4	0.5	20	-2.7	0.5	23	-2.4	0.4
seline - Post-test	18	0.6**	0.2	25	0.9**	0.2	19	0.9**	0.2	23	0.9**	0.1
fat (%)												
line	19	28.6	5.2	27	31.1	5.3	19	27.2	5.3	24	29.8	6.5
test	18	27.8	5.2	26	30.5	6.0	18	27.3	6.0	24	29.3	7.2
seline - Mid-test	18	-0.9	1.9	26	-0.7	2.4	17	-0.4	2.4	24	-0.5	1.7
test	18	28.7	5.5	25	30.8	6.1	20	27.2	6.1	23	29.9	7.8
seline - Post-test	18	-0.3	2.8	25	-0.7	2.2	19	0.0	2.2	23	0.0	2.5
ss (ml·kg^{-1}·min^{-1})												
line	17	44.3	7.2	27	43.3	5.9	17	47.4	5.9	21	43.0	7.2
test	18	43.8	7.2	25	42.8	5.2	17	42.3	5.2	24	41.9	5.2
seline - Mid-test	16	0.2	4.4	25	-0.6	4.3	15	-4.5**	4.3	21	-1.6	4.9
test	16	43.8	6.9	23	42.2	6.3	17	44.9	6.3	21	43.2	5.5
seline - Post-test	14	1.4	5.0	23	-1.1	3.8	15	-2.6**	3.8	20	0.8	5.2
ical activity >4km·hr^{-1}												
line	18	69.7	23.3	27	80.2	29.0	17	78.1	29.0	23	85.2	26.7
test	18	77.1	33.2	20	75.3	29.5	14	79.7	29.5	23	81.3	21.1
seline - Mid-test	17	9.0	33.2	20	-6.2	25.7	13	-1.0	25.7	22	-5.7	26.2
test	17	54.9	14.2	24	63.5	25.6	18	61.1	25.6	21	62.3	17.1
seline - Post-test	16	-15.1*	26.0	24	-14.7*	26.4	16	-20.3*	26.4	20	-23.9**	30.7
ical activity (cpm)												
line	18	494.7	138.0	27	518.1	132.7	18	527.4	132.7	23	531.5	93.1
test	19	528.6	155.6	21	472.4	165.7	15	499.0	165.7	23	518.6	91.1
seline - Mid-test	18	39.7	152.4	21	-33.3	182.9	14	-25.8	182.9	22	-21.4	98.5
test	17	415.2	78.6	24	429.7	122.6	19	434.6	122.6	21	479.1	109.3
seline - Post-test	16	-85.6*	121.7	24	-82.6*	143.9	17	-93.5*	143.9	20	-57.6*	101.9

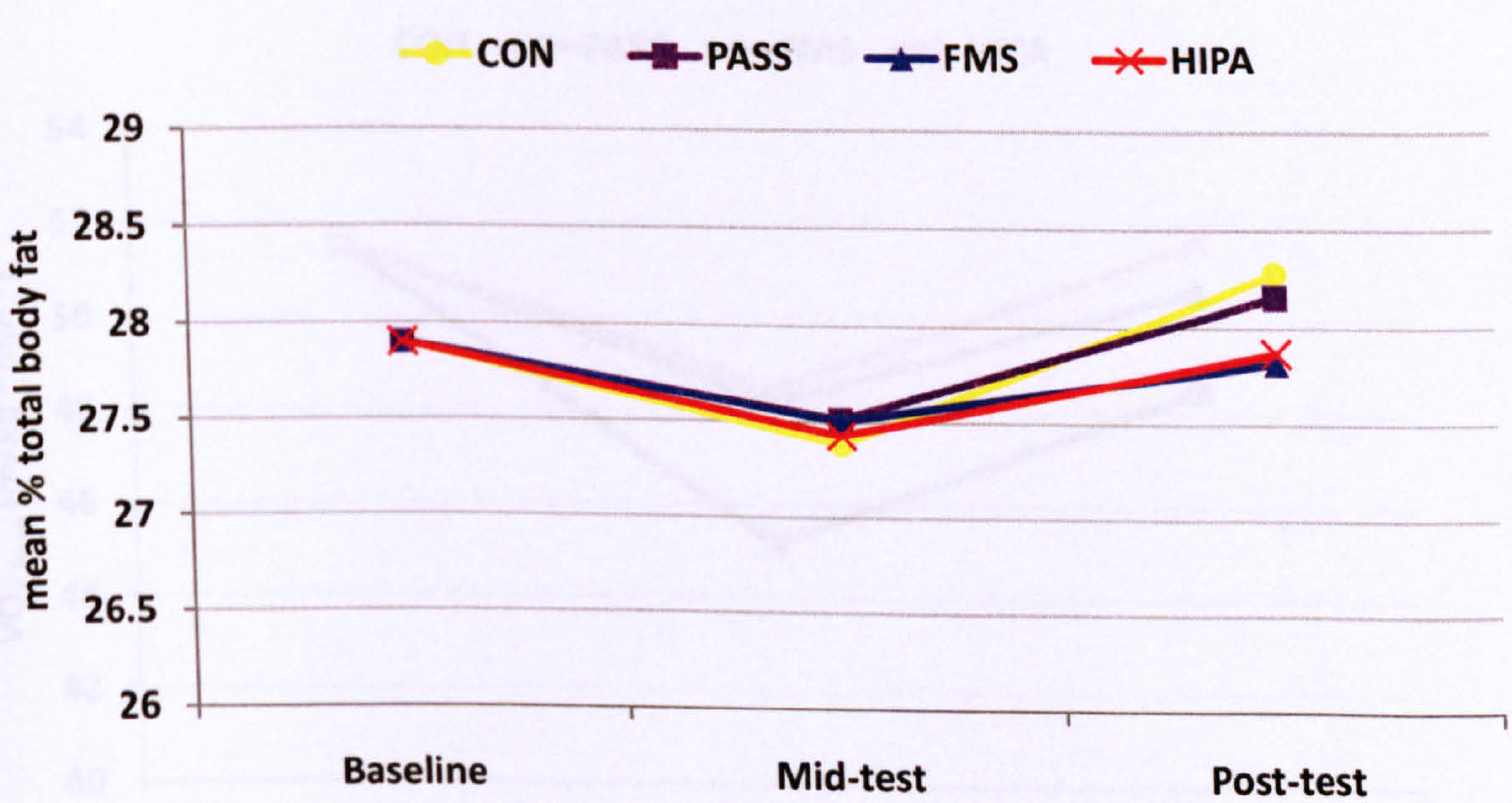
hin-group difference * P = <0.05 ** P = <0.01

Table 23 shows raw group data for age, maturation (years to peak height velocity), percent total body fat, fitness, PA>4 and total physical activity (cpm). Similar descriptive tables for boys and girls are shown in Tables 24 and 25, respectively.

5.3.5 Percent total body fat (MCID: 1.3)

Figure 18 shows the effects of the interventions on percent total body fat (n=134), adjusting for baseline scores and maturation. There were no significant or clinically meaningful differences between groups at mid-test or post-test. No significant gender by intervention interaction was found.

Figure 18 Interventions effects on percent total body fat, adjusting for baseline differences and maturation.



5.3.6 Cardiorespiratory fitness (MPID: boys, 1.4; girls, 1.3)

Preliminary analysis revealed that fitness data over the project differed considerably by gender. Therefore boys and girls fitness findings are reported separately.

The effects of the interventions on fitness in boys (n=45) is shown in Figure 19. Declines in fitness from baseline to mid-test, and increases in fitness from mid-test to post-test are visually apparent in all intervention groups. Participation in PASS was associated with a small negative effect on fitness compared to CON at mid-test (AMD: -3.2 $ml \cdot kg^{-1} \cdot min^{-1}$, 90% CI: -5.6 to -0.7; P = .037), but not post-test. At post-test, participation in HIPA was associated with small positive fitness benefits (AMD: 3.3$ml \cdot kg^{-1} \cdot min^{-1}$, 90% CI: 0.5 to 6.0; P = .051).

Figure 19 Intervention effects on fitness in boys, adjusting for baseline differences

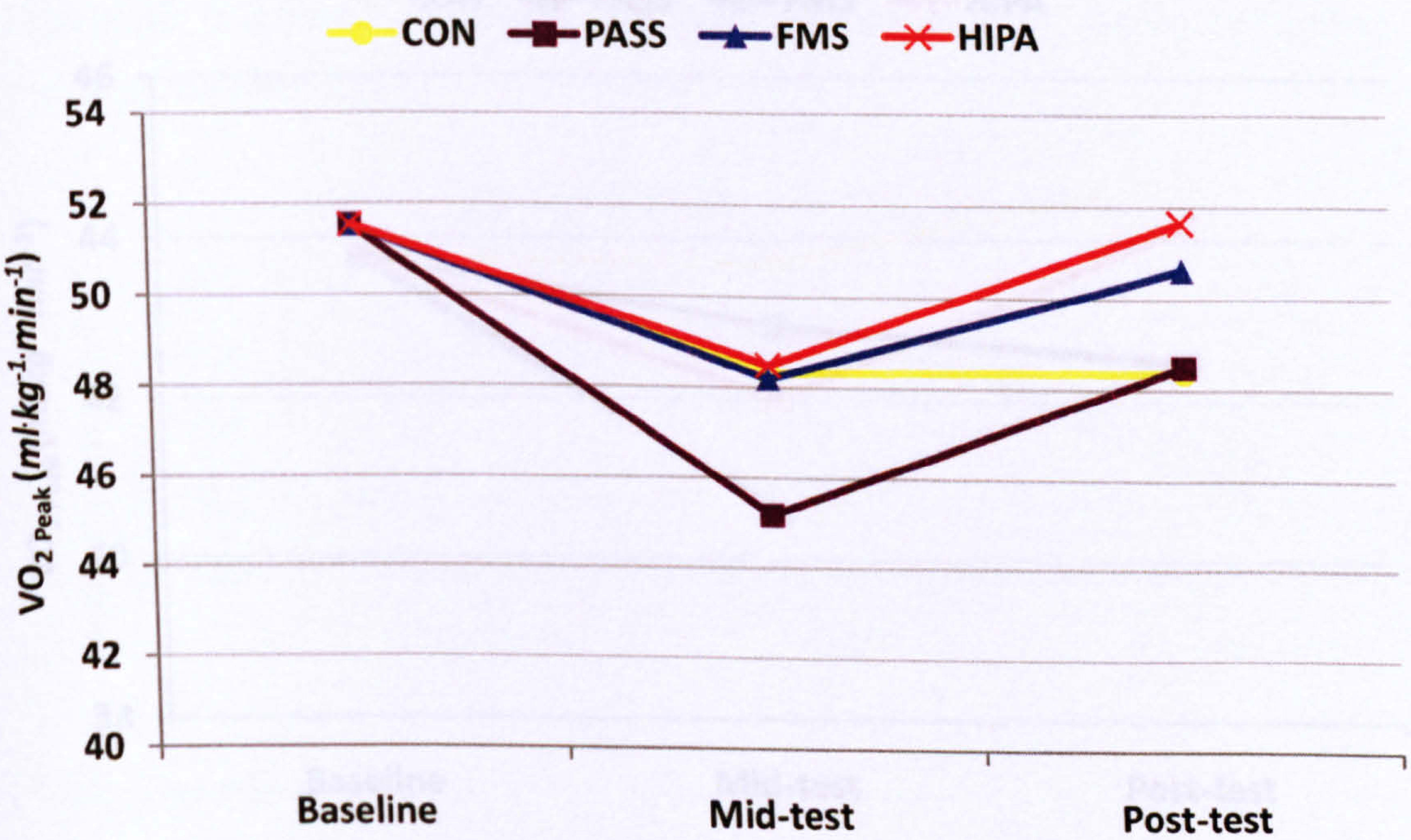
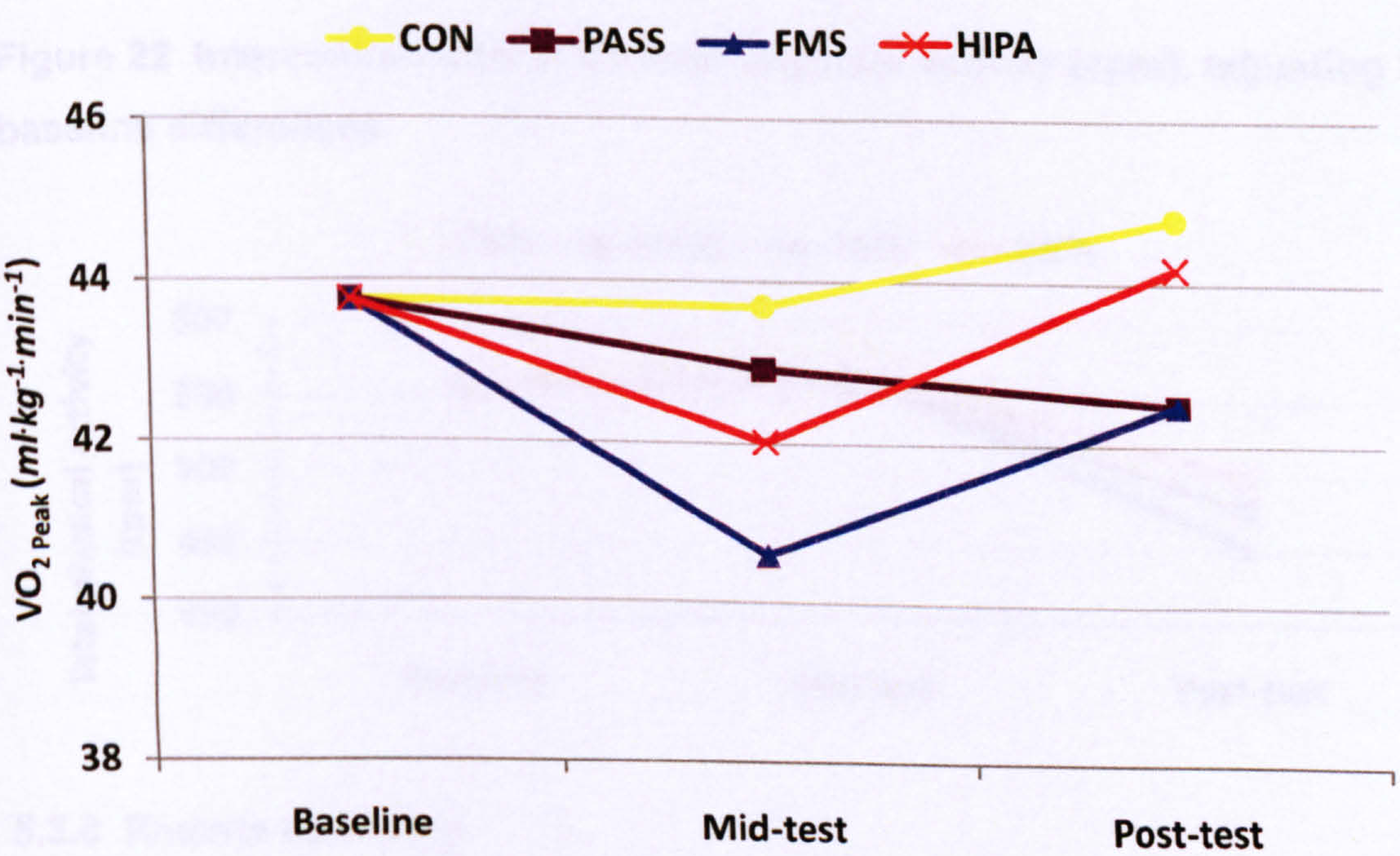


Figure 20 shows the effects of interventions on fitness in girls (n=69). Declines in fitness from baseline to mid-test, and increases from mid-test to post-test, are visually apparent in FMS and HIPA interventions, whilst PASS fitness scores show a consistent decline over time. At mid-test, participation in FMS was associated with a small negative effect on fitness compared to CON (AMD: -3.1ml·kg^{-1}·min^{-1}, 90% CI: -5.3 to -0.9; P = .023). At post-test, no differences were found between HIPA and CON girls' fitness. However, FMS and PASS had a small negative effect on fitness relative to CON. Specifically, the effect of the FMS and PASS interventions (compared to CON) on fitness was a mean decline of 2.3ml·kg^{-1}·min^{-1} (90% CI: -4.8 to 0.2; P = .135) and 2.3ml·kg^{-1}·min^{-1} (90% CI: -4.5 to -0.1; P = .089), respectively.

Figure 20 Intervention effects on fitness in girls, adjusting for baseline differences



5.3.7 Physical activity

The intervention effects on PA>4km·hr^{-1} and total physical activity (cpm) are shown in Figures 21 and 22, respectively. Adjusting for baseline, no between-group differences were found at mid-test or post-test for either physical activity outcome measure, however small increases from baseline to mid-test and sharp declines from mid-test to post-test can be observed across the project in all groups. No significant gender by intervention interactions were found.

Figure 21 Intervention effects on PA>4km·hr^{-1}, adjusting for baseline differences.

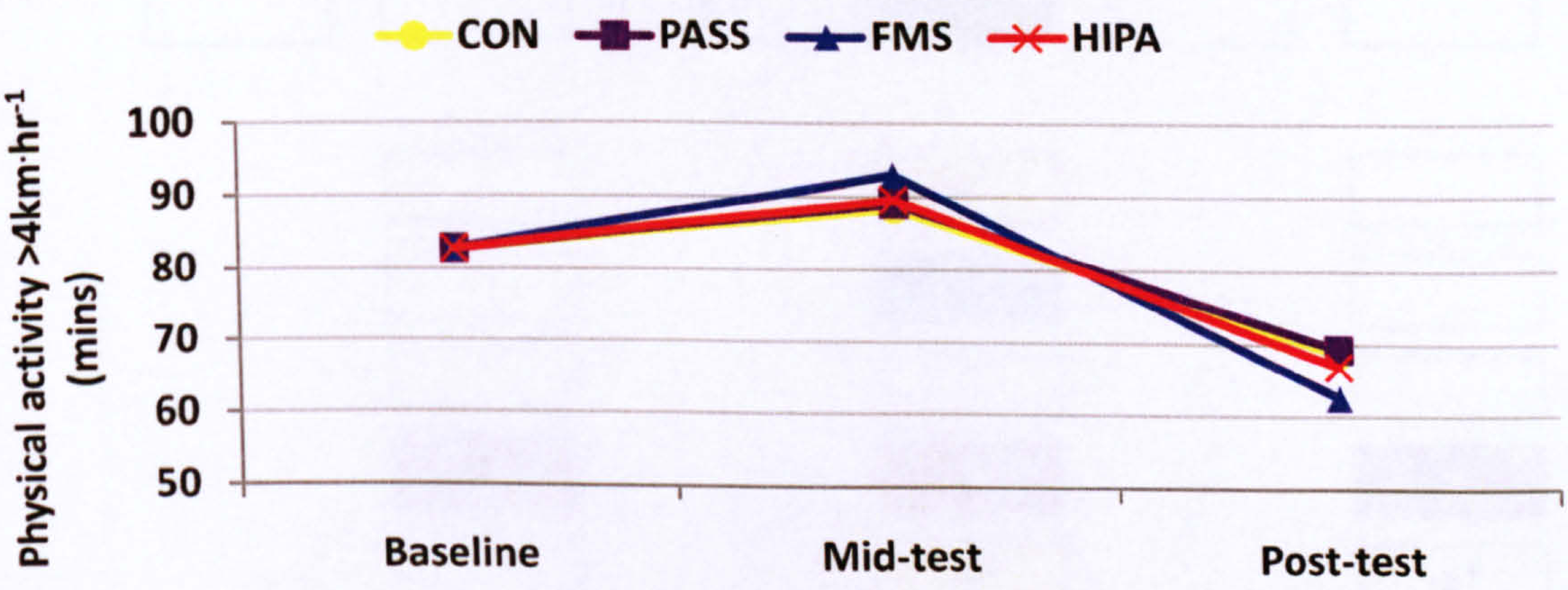
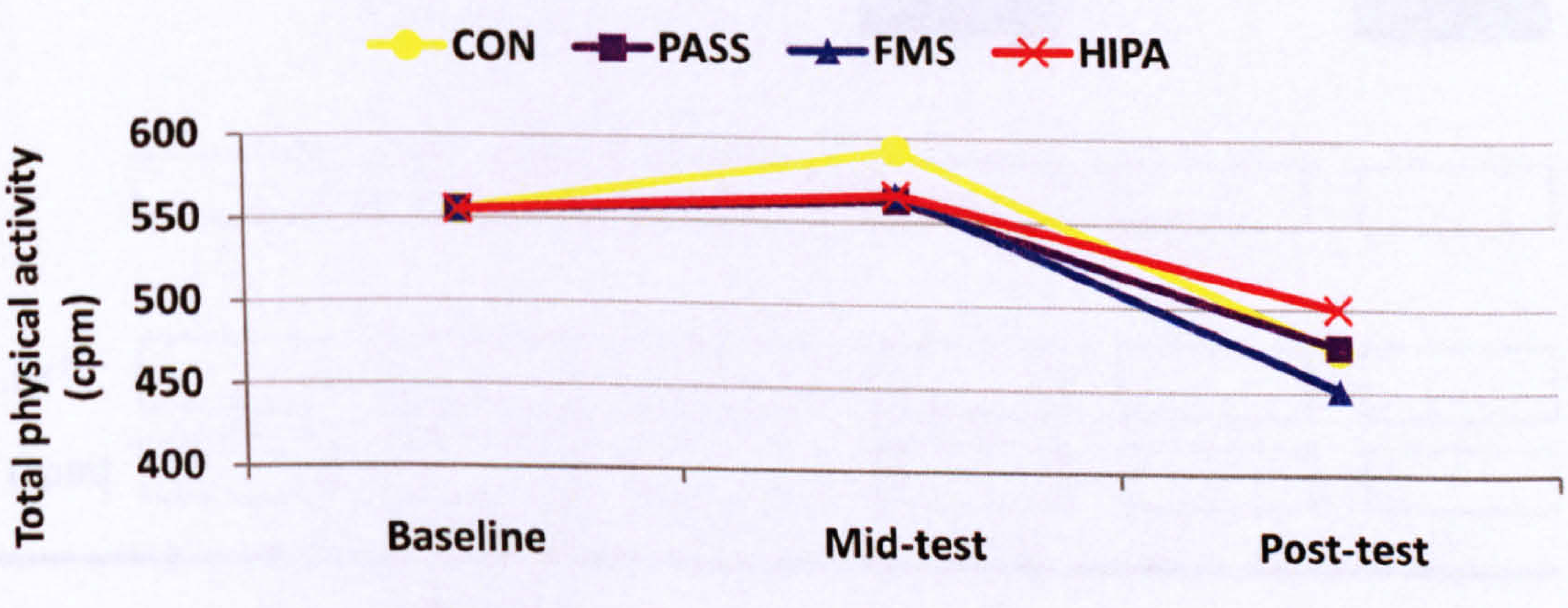


Figure 22 Intervention effects on total physical activity (cpm), adjusting for baseline differences.



5.3.8 Results summary

Table 26 and Table 27 provide a summary of the intervention effects.

Table 26 Summary results table for effectiveness of interventions on fundamental movement skills, body fatness and physical activity (compared to control-comparison group).

	PASS		FMS		HIPA	
	Mid-test	Post-test	Mid-test	Post-test	Mid-test	Post-test
FMS composite scores						
Total skill score			↑*	↑*		↑*
Locomotor skills	↑*		↑*	↑*		↑*
Object-control skills			↑^{Tr}	↑*		
FMS proficiency						
Hop				↑*		
Vertical jump				↑**		
Sprint run						
Dodge		↑*		↑*		↑**
Catch				↑^{P}		↑^{P}
Throw		↑^{P}		↑^{P}		↑^{P}
Kick		↑^{P}		↑^{P}		↑^{P}
Strike				↑**		↑^{P}
Body fatness						
Total body fat (%)						
Physical activity						
Physical activity >4km.hr^{-1}						
Total Physical Activity (cpm)						

Key

↑ Positive intervention effect

↓ Negative intervention effect

* $P < 0.05$, ** $P < 0.01$

^{P} Practical importance

^{Tr} Trend

Effect size

No effect

Small

Moderate

Large

Very large

Table 27 Summary results table for effectiveness of interventions on cardiorespiratory fitness and physical self-perceptions in boys and girls (compared to control-comparison boys and girls).

	BOYS						GIRLS					
	PASS		FMS		HIPA		PASS		FMS		HIPA	
	M-t	P-t	M-t	P-t	M-t	P-t	M-t	P-t	M-t	P-t	M-t	P-t
Cardiorespiratory Fitness												
VO2 Peak ($ml.O_2.kg.min^{-1}$)	$\downarrow^{*}$					$\uparrow^{P}$		$\downarrow^{P}$	$\downarrow^{*}$	$\downarrow^{P}$		
Physical self-perceptions												
Sports competence	$\uparrow^{P}$			$\uparrow^{P}$	$\uparrow^{P}$	$\uparrow^{P}$	$\downarrow^{P}$		$\downarrow^{P}$			
Physical condition			$\uparrow^{*}$	$\uparrow^{Tr}$	$\uparrow^{*}$	$\uparrow^{Tr}$	$\downarrow^{P}$	$\downarrow^{P}$		$\downarrow^{*}$		
Body attractiveness	$\uparrow^{P}$		$\uparrow^{P}$	$\uparrow^{P}$	$\uparrow^{**}$		$\downarrow^{Tr}$		$\downarrow^{P}$	$\downarrow^{P}$	$\downarrow^{Tr}$	$\downarrow^{P}$
Physical strength					$\uparrow^{P}$	$\uparrow^{P}$				$\downarrow^{*}$		
Physical self-worth			$\uparrow^{P}$	$\uparrow^{P}$	$\uparrow^{*}$	$\uparrow^{P}$				$\downarrow^{P}$		$\downarrow^{Tr}$
Self-esteem						$\uparrow^{*}$		$\uparrow^{Tr}$				
Perceived skill competence	$\uparrow^{*}$		$\uparrow^{**}$	$\uparrow^{**}$	$\uparrow^{**}$	$\uparrow^{*}$						

Key

↑ Positive intervention effect

↓ Negative intervention effect

* $P < 0.05$, ** $P < 0.01$ — M-t, Mid-test

P Practical importance — P-t, Post-test

Tr Trend

Effect size

- No effect
- Small
- Moderate
- Large
- Very large

5.4 Discussion

The purpose of this study was to examine the effects of a one year bi-weekly fundamental movement skill (FMS) or high intensity physical activity (HIPA) after-school club, and a lifestyle intervention (PASS), on fundamental movement skill competence and physical self-perceptions in UK primary school children, whilst concurrently assessing children's physical activity, fitness, maturation and percent body fat.

5.4.1 Influence of interventions on skill competence

There is growing evidence that FMS interventions can increase motor skill competence in preschoolers (Kelly et al., 1989; Reilly et al., 2006) and amongst young children at risk of developmental delay (Goodway et al., 2003a, 2003b). However, there is limited research in school aged-children without developmental delay (McKenzie et al., 1998; van Beurden et al., 2003; Graf et al., 2005, 2008; Salmon et al., 2008). This study adds much needed experimental data to the research evidence base.

The primary goal of the FMS afterschool intervention was to increase skill competence. This aim was achieved successfully – on average, children in the FMS group possessed significantly more skill components than children in the comparison group over the project. The FMS intervention effects were comprehensive - with moderate positive effects found for both locomotor and object-control skills at post-test. This suggests that a structured afterschool FMS intervention can facilitate children to make significant gains in skill competence.

Children in the FMS group were exposed to a number of intervention components which likely contributed to the FMS intervention effectiveness: (1) coaches used direct instruction in recognition of the specific goals of the intervention (i.e. to increase skill competence). Pedagogical research within PE supports the use of direct instruction for motor skill development (Silverman, 1991; Sweeting & Rink, 1999), whilst the command style of teaching has also been associated with skill acquisition (Boyce, 1992); (2) developmentally appropriate practices were provided for children with tasks based on sequential skill learning. In addition, coaches gave accurate demonstrations of each skill, an important factor in motor skill learning (Rink, 1996); (3) though time on task and the number of practice trials was not assessed in this study, it seems logical that children in the FMS group would have had more opportunities to practice each movement skill compared to other experimental groups. This is important as the quantity of correct practice trials is a key determinant of skill improvement (Silverman, 1991); (4) coaches were equipped with a wide variety of developmentally appropriate equipment e.g. bigger balls for those less skilled at catching; (5) coaches used cue words to emphasise qualitative elements of each skill and assist children's learning (Rink, 1996). Two previous interventions that used cues to encourage skill learning reported that intervention children could be heard repeating key words to remind them and others about the correct movement technique (Goodway et al., 2003a, 2003b); (6) coaches were trained to provide children with positive-corrective feedback, as opposed to in-contingent praise (Horn, 1985); and (7) coaches offered encouragement for persistence on task and praise for success in learning. These factors along with a twice-weekly structured FMS intervention which was guided by a resource pack, developed by specialist PE consultants with extensive teaching experience, resulted in a curriculum that corresponded to children's developmental needs as reflected by substantial improvements in skill competence.

There was no significant gender interactions for the intervention effects, indicating that the FMS intervention strategies were broadly effective for boys and girls. This important finding compares favourably with the FMS group within the Switch-Play intervention involving similar aged Australian children (Salmon et al., 2008), which observed significant intervention effects on FMS z-scores in girls but not boys. Salmon and colleagues (2008) speculated that this may be due to girls being more receptive to the FMS intervention than boys as they had poorer skill competence at baseline. Likewise, gender differences in skill competence were found in the cross-sectional study (Study 1), and are well documented amongst the literature (see section 2.4.6). It is possible that differences in the dose of intervention may explain the divergence in findings. The Switch-Play intervention lasted for one year, comprised 19 lessons (40-50 minutes each) and aimed to improve six skills (run, vertical jump, dodge, throw, kick, strike). In contrast, 70 one hour coaching sessions were offered to enhance competence in 8 skills over a one-year period and found skill gains across both genders. It is possible that boys, who had higher levels of skill acquisition at baseline, may need a greater frequency of opportunities for practice and instruction to develop and fine-tune more advanced aspects of each skill - and so the intervention dose was too short in Switch-Play - whereas girls, who had lower competence at baseline, may be learning the initial phases of movement which may be consolidated over a shorter period of training. Further research is needed to examine this hypothesis.

The substantial FMS intervention effects also match up positively with a much longer school curricular programme in German children - the 4-year Children's Health Interventional Trial (CHILT: Graf et al., 2008). The CHILT intervention was designed to promote a healthy lifestyle by increasing physical activity through the introduction of an extra health education lesson and activity breaks during lessons, as well as teacher training to optimise PE lessons. Significant gains in motor abilities were found following the intervention in children's balancing backwards and lateral jumping. However, no differences were found between intervention and control children in tests of sideways movement or one-legged obstacle jumping (Graf et al., 2008). Within CHILT PE teachers were trained to deliver activities to improve motor abilities, physical activity and fitness (Graf et al., 2008), and these components, alongside cognitive and emotional development, reflect common objectives of physical education programmes

(McKenzie et al., 1998). In CHILT, the motor-related activities may have been 'watered down' amongst the delivery of activity and fitness objectives (i.e. less actual skill trials) resulting in divergent intervention effects. This could also explain why the 6-month SPARK curricular intervention influenced catching and throwing but not kicking (McKenzie et al., 1998). Alternatively, the differences between the findings of this study and others could be explained by the tests of motor abilities used, and it is possible that the CHILT and SPARK findings may have been more comprehensive had they used a process-orientated instrument or tested a greater number of motor abilities/skills.

Large numbers of primary classroom teachers have difficulty and lack confidence when delivering physical education and suffer from a shortage of time, support and resources for effective teaching in PE (DeCorby et al., 2005; Hardman & Marshall, 2001; Morgan & Bourke, 2005). To combat this, the CHILT, Move it Groove it, and SPARK interventions trained classroom teachers to deliver the intervention curriculum and had some success (Graf et al., 2008; McKenzie et al., 1998; van Beurden et al., 2003). The effectiveness of the FMS intervention suggests that afterschool programmes delivered by specialist coaches could help relieve the strain on classroom teachers, without increasing the pressure on an already crowded curriculum; supporting the contention that outside school physical activities provide a perfect opportunity for skill development (Raudsepp & Päll, 2006).

Although its' primary aim was to increase physical activity and fitness, the HIPA intervention resulted in a small positive intervention effect on total skill score at post-test. However, when the different types of skills were examined for group differences, locomotor skill components were significantly increased but object-control skills were not. This likely reflects the nature of the HIPA intervention with a focus on jumping activities and movement games like tag or relays that were well-matched to the locomotor skills assessed in this study. The results of the HIPA intervention indicate that locomotor skills can be augmented by practice alone, but it is important to note that practice and skill-related instruction, as received by children in the FMS group, generated greater skill competence gains. One study of the kicking abilities of 716 children aged 4 to 14 years that played youth football found that participation in football does not guarantee improvements in skill performance of the kick (Butterfield & Loovis, 1994), highlighting the importance of instruction. Whilst the HIPA intervention improved locomotor skills, it did not positively influence object-control skills. This is perhaps not surprising as the HIPA coaching sessions rarely gave access to equipment (balls, bats, etc) and did not include ball games or activities to develop such skills. Further, object-control skills are generally mastered later in childhood than locomotor skills due to the many complex visual-motor adjustments required to perform each skill (Gallahue & Donnelly, 2003; Payne & Isaacs, 2008).

Cross-sectional research has found that skill competence is positively associated with fitness (Reeves et al., 1999; Okely et al., 2001). It is interesting to note that despite their lower levels of fitness at mid-test and post-test, girls in the FMS group had increased their skill competence compared to girls in the control-comparison group. It has been proposed that decreases in fitness could reduce the physical capacity to participate in games and activities for long periods, thus limiting opportunities to practice and nurture movement skills and constraining skill development (Stodden et al., 2008). However, it appears that lower levels of fitness did not impact on FMS girls' skill development, which suggests that the intervention programme was sufficient to improve such skills but not to promote fitness. On the contrary, girls in PASS did not improve skill competence but had lower levels of fitness at post-test. Interestingly, boys who participated in HIPA had higher fitness scores than comparison boys at post-test. It is possible that positive gains in locomotor skills may improve movement efficiency which could have facilitated HIPA boys' improvements in fitness scores by increasing the time spent in games and activities (Wrotniak et al., 2006), although this was not reflected in the physical activity data. The divergent results suggest that the nature of the relationship between fitness and skill competence is unclear and requires further examination.

On average, participation in the PASS group showed no effect on total skill score, or object control skill score compared to the comparison group at mid- or post-test. PASS participants did possess significantly more locomotor skills than comparison children at mid-test but performance declined slightly at post-test and group differences were removed. In contrast, girls who participated in the behaviour-modification condition of the Switch-Play intervention had higher FMS z-scores compared to children in the control group immediately post-intervention and at one year follow-up (Salmon et al., 2008). The authors speculated that this could be explained by their higher overall movement counts and moderate-intensity physical activity (Salmon et al., 2008). In this sample, no differences were found between PASS and the control-comparison group for physical activity outcomes though a significant within-group decrease was found in PASS from mid-test to post-test. This decline in physical activity behaviour could explain why gains over control at mid-intervention were not sustained at post-test. However, FMS and HIPA groups physical activity data showed similar trends without decrement to skill competence scores, indicating that the afterschool programmes may have facilitated the maintenance of skill competence.

As a lifestyle programme, PASS was not designed to increase skill competence and offered no structured exercise sessions. The findings suggest that to improve skill competence in children of this age organised programmes are required, as in FMS and HIPA, with opportunities for developmentally-appropriate practices and instruction to facilitate learning. This is similar to findings from studies of young children, which have shown that children who receive a motor skill intervention demonstrate significant increases in skill competence compared to children who have access to free-play with appropriate equipment but no structured programme (Miller, 1978; Goodway & Branta, 2003).

5.4.2 Influence of interventions on skill proficiency

In his model of motor development, Seefeldt (1980) argued that it was not enough for children to simply be able to perform motor skills - children need to pass through a 'proficiency barrier' of fundamental movement skill competence in order to successfully apply these skills to sports and games. In this way, physical skills enable children to be physically active through increased perceptions of competence and self-efficacy (Welk,1999). This study is unique in that it reported the intervention effects on both skill competence and the prevalence of skill 'proficiency' (i.e. a mature movement pattern), as this level of performance is thought necessary to achieve health benefits (Seefeldt, 1980).

Compared to children in the control-comparison group, children in the FMS group were more likely to attain proficiency at post-test in seven out of the eight skills assessed - representing the strongest intervention group effects on proficiency. The findings that the FMS intervention positively impacted on both sub-groups of skills compares favourably to a 9-week pilot study (Foweather et al., 2008), in which object-control skills were improved but locomotor skills were not. The results support the findings of the one-year 'Move it Groove it' intervention, which improved all 8 skills assessed (van Beurden et al., 2003), and extend the evidence into older children. This supports the earlier contention that a longer intervention is necessary to increase the likelihood of attaining proficiency at locomotor skills in this age group. Short interventions may prove effective in young children, as they are at a developmental stage appropriate for the learning of such skills (Gallahue & Donnelly, 2003).

It is unclear why some skills were more open to changes in proficiency following the FMS programme than others. Three of the four skills with the lowest prevalence of proficiency across groups at baseline (dodge, strike and vertical jump) had the largest intervention effects, yet the smallest intervention effects were found in the catch and hop which initially had low and moderate prevalence of proficiency, respectively. van Beurden et al. (2003) also found no clear pattern for the magnitude of intervention effects on rates of skill mastery and near-mastery.

Participants in HIPA were, on average, approximately 16 times more likely to attain proficiency in the dodge than children in the comparison group - the strongest intervention effect of all intervention groups. As with locomotor skill competence gains, this may reflect the nature of the activities within HIPA coaching sessions. For example, the game of 'Tag' requires children to be skilled at dodging in order to escape getting 'tagged'. Given the type of games used in HIPA it was surprising that the prevalence of proficiency at object-control skills was increased - HIPA participants were, on average, over twice as likely to attain proficiency at the overarm throw, kick and strike, whilst a small positive intervention effect was also found for catching. This finding is somewhat conflicting with the intervention findings for skill competence, which found no differences between children in the comparison group and children in HIPA for the total number of object-control skill components checked as present. This confusing message can be partially explained by an examination of the raw data (Table 19), which reveals that HIPA did not increase the prevalence of proficiency at the Strike, whilst effects on the Kick were modest. This suggests that, for these skills at least, the positive intervention effects on proficiency can be explained by the prevalence of proficiency slightly falling within the comparison group. Intervention effects on throwing and catching proficiency are more difficult to explain as the intervention did not include activities to develop such skills and no increases in physical activity behaviour was observed. It is possible that a few children may have attained proficiency by improving throwing and catching following physical education lessons or through participating in a sports team outside of school (Raudsepp et al., 2005).

Children in the PASS intervention were, on average, over 8 times more likely to attain proficiency at the dodge than children in the comparison group, and over twice as likely to attain proficiency at the throw and strike. The relative improvements in these 3 individual skills was not expected and were not reflected in the skill competence outcome measures. A closer inspection of the raw data (Table 19) shows that the within-group PASS intervention effects on the strike were modest, and the relative intervention effect was likely due to the prevalence of proficiency in the comparison group slightly falling. PASS children did not receive structured exercise sessions but it is possible that the activities and games included in healthy missions, or activities children participated in external to the intervention, helped some children to attain proficiency at the dodging and throwing. No previous studies have explored the effects of a high-intensity physical activity intervention or a behaviour-modification programme on motor skill *proficiency* and more research is needed to confirm these findings. In addition, information from children on the types of activities that they engaged in outside of the intervention would also assist future researchers.

Running is one of the earliest maturing skills (Payne & Isaacs, 2008). It is therefore unclear why none of the intervention groups, but in particular the FMS programme which focused on skill development, did not increase the likelihood of attaining proficiency in the sprint run. In contrast, higher prevalence of mastery at the sprint run was found following the 12 month "Move it Groove it" intervention (van Beurden et al., 2003), whilst Goodway et al. (2003a) assessed 12 skills in young children at risk of developmental delay and found that running improved the most following a 9-week intervention. These studies involved slightly younger children than those in this study and young children may respond better to movement skill development programmes. Surprisingly, the results in this study showed that sprint performance deteriorated over the project in all groups. This may indicate issues with the sprint assessment procedures which may have confounded the results. However it should be noted that the sprint protocol was identical to that used in the "Move it Groove it" intervention (van Beurden et al, 2003). An alternate assessment of the product of the sprint trial (i.e. time) may have yielded different findings, as there is a reasonably consistent year-on-year improvement in running speed in boys and girls (Payne & Isaacs, 2008). It is also possible that children's motivation and effort may have waned for this particular assessment over time, which was reflected in poorer performance.

5.4.3 Influence of interventions on physical self-perceptions

This is the first UK study to assess the effects of various interventions on physical self-perceptions in 9-10 year old UK children. The intervention effects on physical self-perceptions were complex and inconsistent across genders. In boys, participation in the structured afterschool interventions (HIPA and FMS) appeared to have a positive effect on perceptions of physical and skill competence, whilst the PASS intervention was associated with some beneficial effects at mid-test which diminished at post-test. In girls, participation in the intervention groups, in particular the FMS condition, appeared to negatively impact on select physical self-perceptions, whilst no intervention effects were found on perceived skill competence.

The effect of the interventions on physical self-perceptions in boys

The HIPA intervention focused on promoting moderate-to-vigorous physical activity and increasing fitness; therefore it was perhaps not surprising that participation in HIPA was associated with positive effects on perceived of physical condition. This likely reflected a perceived increase in fitness as a result of coaching activities at mid-test, and increases in cardiorespiratory fitness *per se* at post-test. The results support cross-sectional research that showed predicted VO_2 max score was positively associated with perceived condition in boys (Welk & Eklund, 2005). In addition to fitness-based games, sessions included circuit training activities such as push-ups and sit-ups, which may have contributed to more positive perceptions of physical strength.

The HIPA intervention did not aim to improve children's sports skills, so it is interesting that boys' perceptions of sports competence increased. The findings may reflect the observed HIPA group increases in locomotor skill competence or the increased likelihood of attaining proficiency in the dodge, catch, throw, kick and strike. Cross-sectional evidence has documented associations between perceived sports competence and fitness in boys (Welk et al., 1997; Welk & Eklund, 2005). Children have a less differentiated concept of fitness (Welk & Eklund, 2005), so it is possible that fitness gains may have increased boys' perceptions of sports competence. However, it is more difficult to explain why participation in HIPA was associated with a moderate intervention effect on perceived body attractiveness at mid-test which was not sustained at post-test. Skinfold thickness and BMI have been found to be negatively related to perceived attractiveness (Raustorp et al., 2005; Welk & Eklund, 2005), and it is possible that changes in body composition may have influenced feelings of attractiveness. However, no differences were found between groups for percent body fat over the project, which suggests that psychological rather than physiological factors may explain the boys' results. Nevertheless, the changes in the perceptions of sports competence, condition, and strength sub-domains likely led to a more positive view of physical-self worth, which in turn elevated self-esteem (Harter, 2003; Weiss & Ebbeck, 1996).

The FMS intervention aimed to develop fundamental movement skills and did so successfully, which likely enhanced perceptions of sports competence at post-test. This is in contrast to the findings from the FMS group in Study 2, where increased proficiency in 4 skills was not associated with higher perceived sports competence. The results from this study suggest that boys recognised that their ability was improving and thus provides support for the skill enhancement hypothesis by demonstrating that increasing actual competence can influence perceptions of competence (Harter, 1978; 1985a; Fox & Wilson, 2008). However, it was surprising that the FMS intervention impacted on boys' perceived physical condition. It could be that boys perceived their fitness to increase via participation in the after-school club, although no physiological change in fitness was observed. A small positive effect on body attractiveness was also unexpected, particularly as perceptions of body attractiveness have previously been thought of as the CY-PSPP sub-domain least amenable to change through exercise (Fox, 1997, 1998), and no differences were found between FMS boys and comparison boys in percent body fatness. Participation in the FMS group seemed to improve how boys felt about their physical appearance, although the mechanisms for this change are unclear and require further research. The combined effects of enhanced perceptions of sports competence, physical condition and body attractiveness likely contributed to a feeling of increased physical self-worth.

At mid-test, participating in PASS was associated with a small positive effect on boys' perceptions of sports competence and body attractiveness. However, these differences may be related to comparison boys self-perceptions decreasing rather than PASS enhancing self-perceptions. Nevertheless, it is possible that increased competence in locomotor skills at mid-test may have fostered perceptions of sports competence though influences on feelings of attractiveness are less clear as no differences were found between groups for body fatness.

Participation in PASS was not associated with any benefits on CY-PSPP constructs at post-test. It is unclear why the benefits of PASS on body attractiveness observed at mid-test were not maintained following completion of the intervention at post-test. The explanation may be psychological as the body fatness data could not account for these findings. Perceived sports competence gains were also removed at post-test, which may be explained by the locomotor skill differences between the PASS and comparison group subsiding. Feelings of competence stem from actual competence and social support (Harter, 1978; Weiss, 1993). PASS components included social support from parents in completing tasks, and positive reinforcement and feedback from intervention delivery staff, which could have enhanced self-perceptions during the intervention. It may be that once the intervention finished these social support mechanisms were removed and consequently physical self-perceptions dropped.

The effect of the interventions on physical self-perceptions in girls

In contrast to boys, participation in PASS, FMS and HIPA was not associated with beneficial effects on any of the CY-PSPP constructs relative to comparison girls, though there was a trend for girls who participated in PASS to have elevated self-esteem at post-test. This finding is unfortunate and questions whether the intervention components were appropriate for enhancing physical self-perceptions in girls. According to Fox (2000a; 2000b), the beneficial effects of exercise on self-perceptions are most likely in children with low self-esteem or self-perceptions at programme onset. Therefore the presence of a ceiling effect (i.e. high scores in each sub-domain at baseline) may offer one explanation for the lack of improvements in girls' physical self-perceptions. However, above average self-perceptions did not prevent positive intervention effects for boys who participated in the FMS and HIPA afterschool clubs.

Body attractiveness is dissimilar to the other CY-PSPP sub-domains as it does not assess competence in a particular skill or attribute, rather it assesses how children feel about their looks (Gilson et al., 2005). Participation in FMS and HIPA was associated with small negative effects on girls' perceptions of body attractiveness, whilst there was also a trend for a negative effect in PASS at mid-test. There are several reasons why girls' perceived body attractiveness may have declined. One reason is that girls may opt to avoid situations where others can pass judgments on their figures (Hagger et al., 1998), such as exercise settings. It could be that participating in the intervention led to girls encountering more situations where others could view their appearance, including boys. This possibly raised self-presentation awareness which, coupled with societal pressures on girls to conform to an unrealistic ideal of a slim and slender body (McCabe et al., 2002), lowered perceptions of attractiveness. Alternatively, girls' perceptions of body attractiveness may have become more negative as the intervention coincided with a period of physical maturity, which is associated with increases in body fat, moving them away from the cultural ideal body image (Niven, Fawkner, Knowles, & Stephenson, 2007). However, no differences were found between groups for changes in maturation or body fatness over the project - suggesting that psychosocial mechanisms may explain the findings.

Perceived physical condition has been found to be positively associated with girls' endurance performance (Welk et al., 1997; Welk & Eklund, 2005). Cardiorespiratory fitness decreased at post-test (relative to comparison girls) in girls' within FMS and PASS groups. This physiological change may have caused girls to fatigue quicker during exercise and corresponding feelings of tiredness may have contributed to lower perceptions of physical condition. It is interesting that FMS and PASS intervention girls' perceptions of sports competence went down at mid-test. Positive associations between physical activity participation and perceived sports ability have been documented in girls (Hagger et al., 1998; Crocker et al., 2000; Welk & Eklund, 2005). However, no differences were found between groups for physical activity outcome variables which might account for these results. Additionally, the findings do not reflect changes in fundamental movement skill competence, which increased. It is possible that declines in fitness may have contributed to lower perceptions of sports competence and strength in FMS intervention girls as these sub-domains have been shown to be related to mile run time (Welk et al., 1997), and children have less refined concepts of fitness (Welk & Eklund, 2005). In addition, perceived sports competence reflects athletic ability, ability to learn sport, and confidence in sport (Fox, 1990). Whilst one might expect that increases in fundamental movement skill competence would augment feelings of sports competence; skill gains may not have been sufficient to influence each of the global indicators of sports competence, thus positive feelings at the lower order competence levels did not generate upwards.

Gender differences in intervention effects on physical self-perceptions

Neither HIPA nor FMS interventions were associated with positive adjustments to physical self-perceptions in girls, suggesting that the psychological benefits associated with the structured exercise sessions may have been limited to boys. The strongest evidence for gender differences is illustrated in the perceived skill competence results for FMS and HIPA participants. Both boys and girls improved actual skill competence (relative to comparison boys and girls) as a result of the afterschool interventions. However, whilst boys' perceptions of skill competence increased, girls' feelings of skill competence showed no change.

According to Harter (1978), four psychological constructs influence the development of perceived competence: (1) past experiences, (2) difficulty or challenge associated with the outcome, (3) reinforcement and personal interactions with significant others, and (4) intrinsic motivation. It is thought that children do not have the levels of cognitive functioning necessary to synthesise this information into an accurate depiction of competence until approximately 12 years of age (Piaget, 1955). Indeed, several studies have shown that children do not become more accurate at perceiving their physical competence as they advance from 9 to 11 years of age (Harter, 1982; Rudisill et al., 1993; Ulrich, 1987). Thus it seems unlikely that the findings are explained by developmental differences between genders in their cognitive capacity to make accurate evaluations of competence. Moreover, rather than girls making less precise judgements of competence than boys, it is possible that girls may not have been aware of changes in ability as they have lower expectations for success in physical activity behaviours than boys and they place less value on physical competence (Eccles et al., 1993).

The accuracy of self-perceptions are directly influenced by the sources of information used to judge competence (Horn & Hasbrook, 1987; Weiss et al., 1997). Peer comparison is one source of competence information that is increasingly used by children as they grow and mature (Horn & Hasbrook, 1987; Weiss & Ebbeck, 1996). The structured exercise sessions included boys and girls, and boys generally had higher levels of fitness and proficiency in fundamental movement skills than girls. If girls were assessing competence by means of social comparison and evaluation by peers then participating in sessions with boys may have affected girls' competence beliefs as they were less able than boys. Indeed, girls may be happier in single-sex sessions, with many reporting displeasure at mixed gender sessions in the coaching evaluation forms (unpublished observation).

In addition to children attending coaching sessions, children's classmates and friends outside of the intervention may have had some influence of competence judgements. In boys, participation in the afterschool clubs may have been supported by friends and classmates and viewed as a positive, given the socio-cultural values and expectations on boys to participate in sport and physical activity (Eccles et al., 1993; Lee, Fredenburg, Belcher & Cleveland, 1999). This could have contributed to more positive self-perceptions. Conversely, in girls, participation in the afterschool clubs may have been seen by girlfriends and classmates as contrary to the ideology of femininity, and a lack of support and encouragement from peers could have contributed to more negative self-perceptions. This contention requires further research.

Other social sources of competence information used by children include interaction and positive reinforcement from significant adults such as parents, coaches and teachers (Weiss & Amorose, 2008). Parents exhibit behaviours that can enhance their child's physical competence beliefs and expectations. For example, Brustad (1993) found that increased parental encouragement was associated with higher levels of perceived physical competence and physical activity participation. Further, girls received less parental encouragement to be physically active than boys and had lower levels of perceived competence. In addition, Bois et al. (2005) found that mothers' perceptions of their child's physical competence was related to children's competence judgements. This suggests that parental interactions can affect children's motivation and competency beliefs, and these socialisation influences could partially explain the gender differences found in this study.

Though not assessed in this study, coach behaviour and pedagogic style can also significantly impact on perceived competence (Horn, 1985). One could speculate that children in PASS, FMS and HIPA were encouraged to participate in more physical activity, and informed about the importance of developing sports skills or increasing fitness by intervention coaches. Participation in the intervention may have increased the importance that girls attached to being competent at different sub-domains, which may previously have been discounted. This in turn may have increased focus on physical abilities, and drew attention to lack of competencies, causing lower self-perceptions.

Coaches also shape the motivational climate and it has been suggested that a mastery-orientated environment is thought to best impact on child learning and perceptions of competence (Ames, 1992; Epstein, 1988). Epstein (1988) introduced the acronym TARGET (Task, Authority, Recognition, Grouping, Evaluation, and Time) to propose six structures which could be manipulated within the classroom to encourage a mastery climate. Epstein suggested that children should have a variety of *tasks* or activities which challenge their abilities. Further, children should have some *authority* over these tasks by having the opportunity to make decisions in choosing activities, equipment, or class rules. The *recognition* dimension of TARGET relates to children being given rewards and being acknowledged for progress, while the *grouping* structure within class should be flexible and encourage participation with a variety of children. In addition, children should be encouraged to make self-referenced *evaluation*'s of performance and identify participation and effort as key components of learning, while the *time* on activities and tasks should be flexible and self-paced. There is some evidence from education that teachers implementing a mastery-orientated approach promotes equality and accommodates boys *and* girls (Duda et al., 1991; Papaioannou, 1998) . The extent to which TARGET structures were adhered to in the FMS and HIPA coaching sessions could explain gender differences in perceived physical competence, particularly if the environment was constructed in a way that was more favourable to boys. For example, girls may favour more choice in deciding games or intensity of activities than boys. Similarly, experiences children had within PE classes and the teaching styles of the PE teacher could have influenced our results. Future intervention studies should seek to explore how coaching behaviour influences changes in physical self-perceptions.

The type of physical activity interventions offered may also have influenced the physical self-perception findings. The FMS intervention focused on skill development, while children in the HIPA group participated in fitness and active games to keep them moving. It is possible that these activities may have been more appealing to boys than girls. Indeed, aerobic dance, which is a popular activity for girls, was included as the physical activity component within a recent interventions which successfully impacted adolescent girls' physical self-perceptions and body image (Burgess et al., 2006). Whilst dance activities may not have been appropriate for skill development; the inclusion of dance within HIPA sessions may have been viewed positively by girls and, in turn, may have enhanced self-perceptions. This relates to the authority aspect of TARGET (Epstein, 1988), and suggests that children, particularly girls, may need to be included in decisions regarding the activities to be included within the intervention programme. Children did have a voice in the nature of the PASS intervention as healthy missions were designed using action-research methods following focus groups with children, parents and teachers. Whilst this process may have helped intervention compliance and ensure the components of the intervention were required, it is possible that the nature of PASS activities were not appropriate or relevant (e.g. targeting sedentary behaviour) for enhancing physical self-perceptions. Behaviour-modification programmes may need to be combined with structured exercise programmes to impact self-perceptions.

5.4.4 Study strengths and limitations

A major strength of this study is the rigorous measurement of fundamental movement skills, which were assessed by a trained researcher using video analysis (which affords a greater level of objectivity than 'live' observations) and a qualitative assessment tool. Further, the assessment of 4 locomotor skills and 4 object-control skills provided a comprehensive overview of skill competence. Furthermore, the standardisation of test conditions over the 3 measurement periods bestows confidence in the intervention effects. Another strength of this study is the valid assessment of physical self-perceptions and reporting results separately by gender. Further, the addition of specific items to address perceptions of competence in movement skills allowed the sensitivity to detect any intervention effect on perceived skill competence. Another strength was the inclusion of objective measures of fitness, physical activity, and body fatness, which facilitated the understanding of the causal mechanisms of intervention effects, while assessing years from peak height velocity allowed consideration of the influences of maturation. A further strength is that the intervention was delivered to children living in deprived areas. The high proportion of children classified as overfat or obese at baseline (37% boys, 66% girls: see Study 1) indicates this is an important section of the population to reach. The implementation and delivery of this school-based intervention was completed successfully. The intervention programmes were simple, relatively inexpensive, and used the school infrastructure without intruding into an already crowded primary school curriculum. The afterschool clubs were enjoyed by children and had high rates of participation, despite being out of school hours, while the

PASS intervention adherence rates were considered acceptable in relation to the 50% natural drop out expected from exercise programmes (Dishman, 1988). The reward scheme was well received by children and enhanced compliance.

This study had several limitations. Fundamental movement skills were not assessed during games or activities and so no conclusions can be drawn on whether skill competence gains, as assessed in a closed environment, were transferred and applied in real play situations (Rink et al., 1996). Coaching drills were not observed. Therefore, the amount of time spent on task and on each motor skill was not objectively quantified. This information could have helped to explain why some children improved skill competence but others did not, as well as providing important information on the number of practices and time on task necessary to enhance each movement skill. Additionally, coach behaviour and teaching style was not assessed. This process data could have assisted in identifying the causal mechanisms for intervention effects in fundamental movement skills and physical self-perceptions, and aided the understanding of gender differences in the latter. Though physical activity was measured, the types of physical activities that children engaged in outside of the intervention were not recorded (e.g. sports participation) but may have affected outcome variables. The one-year intervention ran over the school summer holidays. This vacation period, which did not include intervention delivery, may have reduced the potency of the intervention. No long term follow-up of participants was completed and so it is not possible to know whether the intervention effects were sustained, and if they were then to what extent. Moreover, the inter-relationships between skill, perceived competence, fitness, maturation, and body fatness may become clearer over a longer time lag. Finally, the study is limited by the small sample size, which limits the generalisability of the findings, and the inclusion of only 2 schools per condition, which restricts the statistical power of the study.

5.4.5 Conclusions and implications for future research

The 12-month afterschool multi-skill club intervention had the greatest effect on children's skill competence and increased proficiency in 7 out of 8 skills. These comprehensive intervention effects confirm the need for longer interventions to augment movement skills in older children and support the notion that the strongest skill gains are through instruction and practice. To a lesser extent, participation in a high-intensity physical activity afterschool club also benefited locomotor skills and increased proficiency in five skills, suggesting that providing children with activities that give them the opportunity to practice such skills can also impact skill acquisition. Participation in the behaviour-modification programme (PASS) increased proficiency in 3 skills but did not influence skill competence composite scores. This suggests that children need opportunities for structured exercise to best impact fundamental movement skills.

In boys, after-school clubs may provide a means to augment physical self-perceptions, irrespective of activity mode. After-school clubs did not enhance physical self-perceptions in girls, with participation in the multi-skill afterschool club having the strongest negative effect. The mechanisms behind these negative changes are unclear, but may be related to declines in fitness and/or factors associated with the intervention programme. Participation in a behaviour-modification programme does not appear to positively impact physical self-perceptions in boys or girls. Experimental trials are needed to determine appropriate physical self-perception interventions for girls. In addition, future researchers should include qualitative methods to explore the mechanisms of change in physical self-perceptions during interventions. Finally, a subsequent follow-up study is warranted to assess the longer term impact of the intervention.

Chapter 6

Synthesis of Findings

6.1 Introduction

The purpose of this chapter is to discuss the overall results of the studies within the thesis. The chapter starts with a recap of the aims of the thesis. Next, a summary of the main findings for each study and the overarching themes of the thesis are presented. The final segment of this chapter offers recommendations arising from the thesis, including the practical implications of the results and potential future directions.

6.2 Thesis recap

The purpose of this thesis was to investigate the importance of fundamental movement skill competence and physical self-perceptions to children's physical activity, fitness, and body fat and identify strategies to increase these variables. Specifically, the aims of the thesis were to: a) investigate the prevalence of skill proficiency and levels of perceived physical competence in UK primary school children; b) examine the associations of skill competence and physical self-perceptions with physical activity, fitness, and body fatness; and c) determine the effectiveness of non-curricular interventions to increase movement skill competence and enhance perceptions of competence.

6.3 Main findings

The cross-sectional (baseline) study found that the prevalence of proficiency in fundamental movement skills among 9-10 year old UK children was low-to-moderate in boys and low in girls, while boys performed better than girls at object control-skills. In addition, skill competence was positively related to physical activity and fitness and negatively related to body fat. In particular, locomotor skill score was a significant predictor of physical activity, fitness and body fatness. These findings are broadly consistent with previous research which suggests that the prevalence of proficiency at fundamental movement skills among older children is low to moderate (Booth et al., 2006;

Hume et al., 2008; van Beurden et al., 2002), boys are more skilled than girls in manipulative skills (Booth et al., 1999; Okely & Booth, 2004; van Beurden et al., 2002), and motor skill proficiency is positively related to physical activity (Hume et al., 2008; Wrotniak et al., 2006) and fitness (Okely et al., 2001; Reeves et al., 1999), and inversely related to overweight and obesity (McKenzie et al., 2002; Okely et al., 2004; Wrotniak et al., 2006).

Study 1 was unique in that it was the first study to have investigated the skill levels of UK primary school aged children in recent times. That a large proportion of children had not attained proficiency in fundamental movement skills is of concern, particularly as children have the potential to reach proficiency by 8 years of age (Gallahue & Ozmun, 1998; Payne & Isaacs, 2008). A pertinent point is that locomotor skill competence may be a more important influence on children's health (physical activity, fitness, and body fat) than object-control skill competence. The finding for a stronger influence of locomotor skills is particularly interesting as recent longitudinal work in Australian children suggests that children with good object-control skills are more likely to become fit and active adolescents, yet being proficient in locomotor skills in childhood did not predict adolescent physical activity behaviour or fitness (Barnett et al., 2008a; 2008b). This indicates that there are developmental stages surrounding the importance of different categories of movement skills to health behaviours/outcomes. This suggests that it is important for children to learn and master a broad range of movement skills.

The exploratory trial (Study 2) confirmed that a school based intervention was feasible and provided an important springboard for the 12 month intervention (Study 3). The 9-week afterschool multi-skill club was associated with practically important effects in four of the eight fundamental movement skills assessed (Balance, Catch, Throw, Kick), supporting the notion that an afterschool multi-skill club may offer a viable opportunity for movement skill acquisition, but suggesting that a longer programme should be undertaken to identify if this type of activity could benefit all categories of skills. However, participation in the multi-skill club intervention was associated with small potentially negative effects, including higher BMI and possibly lower perceptions of body attractiveness and physical condition, which warranted further investigation. Additional measures (physical activity, cardiorespiratory fitness) were added in Study 3 to provide a more detailed analysis and better understand the key causal mechanisms of such changes.

The recommendations from Study 2 informed the design of Study 3, which included a larger sample size, more interventions (inclusion of a high-intensity physical activity afterschool club: HIPA; and a behaviour-modification programme: PASS), and a longer intervention programme (12 months). Of the three interventions, unsurprisingly, the afterschool multi-skill club 'FMS' intervention had the greatest effect on children's skill competence and increased proficiency in 7 out of 8 skills, supporting and extending the findings from a previous FMS intervention in primary school children (van Beurden et al., 2003). These comprehensive intervention effects confirmed the need for longer interventions to augment movement skills in older children and support the notion that the strongest skill gains are through instruction and practice (Payne & Isaacs, 2008). It should be noted that to a lesser extent, participation in a high-intensity physical activity afterschool club also benefited locomotor skills and increased proficiency in five skills, suggesting that providing children with activities that give them the opportunity to practice such skills can also impact skill acquisition. Participation in the behaviour-modification programme (PASS) increased proficiency in 3 skills but did not influence skill competence composite scores. This suggests that children need opportunities for structured exercise to best impact fundamental movement skills.

The 12 month intervention (Study 3) provided a unique insight into the effects of different interventions on physical self-perceptions in children and revealed some interesting gender differences in responses to the intervention. In boys, participation in afterschool club interventions appeared to provide a means to augment physical self-perceptions, irrespective of activity mode. Yet afterschool clubs did not enhance physical self-perceptions in girls, with participation in the multi-skill afterschool club having the strongest negative effect. The mechanisms behind these negative changes are unclear, but may be related to declines in fitness and/or factors associated with the intervention programme. The results suggest that participation in a behaviour-modification programme does not appear to positively impact physical self-perceptions in boys or girls. Despite the intervention having conflicting effects across genders, the results provide a strong evidence base which can guide future interventions seeking to enhance perceived physical competence.

6.4 Generic themes

6.4.1 Cohort

It should be noted that in all studies within the thesis, attempts were made to recruit a 'normal' sample of children. In Liverpool, around one-third of children are rated as overweight or obese by BMI classifications (Stratton et al., 2007). In Study 1 the prevalence of overweight and obesity within our sample was 38% in girls and 38% in boys (Cole et al., 2000). The sample therefore included a slightly higher proportion of overweight children than the local and national average, and this may be because children were recruited from areas of high deprivation (Kinra et al., 2000). The number of overweight children within the sample should not be discounted, particularly as percent body fat was negatively associated with perceptions of physical competence and fundamental movement skill competence.

Given the number of children classified as overweight it is pertinent to note that a significant proportion of children (71% boys, 69% girls) met the recommended guidelines for physical activity. In addition, as a representative sample, each study included children who were rated as proficient at fundamental movement skills and children who were rated as non-proficient; and children with high perceived competence and children with low perceived competence. The interventions were therefore not tailored to specific populations and have high external validity. However, it is possible that the intervention effects may have been more substantial had each study focused exclusively on children with poor motor skills and/or those low in perceived physical competence. Similarly, beneficial impacts on physical activity and body fat may have been found had inactive or overweight children been exclusively targeted. Future research should consider targeting specific populations.

Future studies may also wish to consider the age of participants to recruit into an intervention programme. The intervention studies recruited primary school children aged 8-9 years old for Study 2 and 9-10 years old for Study 3. Given that a window of opportunity for development of fundamental movement skills exists in early childhood (3-8 years of age), the intervention effects may have been more substantial had the programme been implemented in younger children. Conversely, interventions to impact physical self-perceptions in girls may wish to target slightly older girls (>10-11 years) and focus on sustaining positive self-perception profiles as they pass through puberty.

The relatively small sample size for each study, but in particularly within the experimental trial (Study 3), limits our ability to generalise the intervention findings to the wider population. Unfortunately the infrastructure for programme delivery (e.g. coaching staff) and scientific investigation did not permit more than a two schools-per-condition design and consequently the project did not have the capacity to recruit a larger sample size. On a positive note, a smaller sample enabled a rigorous scientific evaluation through a number of objective measures. However, the small sample size meant that both the intervention studies were statistically underpowered, which may have limited the number of significant effects. To counter this, the recommendations of Hopkins et al. were followed (2009) and each study focused on practical significance rather than statistical significance and employed an estimation approach for the analysis (Curran-Everett et al., 1998).

6.4.2 Minimum Practically Important Difference

As proposed by Batterham and Hopkins (2006), adjusted mean intervention effects were evaluated for their practical significance by pre-specifying the minimum clinically (termed 'practically' for the purpose of this thesis) important difference. The use of MPID to define intervention effects in Study 2 and 3 as either positive or negative is a relatively novel approach within the discipline of Sports Science. In the absence of a robust practical anchor from the scientific literature to define what is practically important, van Beurden et al. (2003) were followed and a Cohen's *d* of 0.2 between-subject standard deviations was used to define practical significance. Indeed, future studies may disagree with this anchor and choose to define practical significance differently, perhaps in light of new evidence from the scientific literature or in relation to the population of interest. Although a traditional analysis framework is included in the thesis, we contend that by reporting the adjusted mean intervention effects together with 90% confidence intervals the reader can make an interpretation of the magnitude of the effect and the likelihood that the true effect is at least as large as the MPID, thus providing a strong indication of the real world importance of the finding.

6.4.3 Fundamental Movement Skill Analysis

Seefeldt (1980) proposed that children need to be proficient at fundamental movement skills in order to be able to apply them to sport and physical activities. For the purpose of this thesis, 'proficiency' (sometimes termed mastery/near-mastery) was defined as possessing all, or all but one required components of a skill - an approach consisted with previous studies using the skill assessment tool (Booth et al., 2006; Hume et al., 2008; van Beurden et al., 2002). Prevalence of proficiency and intervention effects on proficiency was reported to enable comparisons with past research. However it should be noted that there is little consensus among academics on what actually constitutes skill 'proficiency' and some have questioned the value of reporting the proportion of children who are 'proficient' and 'non-proficient' as this does not account for the developmental stages in children's performance of motor skills (Stodden et al., 2008). To avoid possible 'floor' effects that would have occurred as a result of using skill proficiency data (because many children in our sample were rated as 'non-proficient'), skill composite scores were used to enable discrimination between children of high and low motor skill competence for the purpose of evidencing relationships with other variables (Study 1). Skill composite scores were included in the analysis for Study 3 as these variables were considered more sensitive to intervention effects than skill proficiency outcomes. For example, using a skill proficiency approach would not indicate the presence of a positive intervention effect should a child progress from two components of a skill at baseline to 4 required components of a skill at post-test as they will still be rated as non-proficient. It is therefore recommend that in the absence of a developmentally valid measure of motor skills, and until academics reach consensus surrounding what constitutes skill proficiency, future researchers should examine the intervention effect on the number of skill components checked as present.

6.4.4 The importance of actual and perceived competence

It is of significance that perceived physical competence did not explain variance in physical activity behaviour in the cross-sectional study whereas fundamental movement skill competence was a significant predictor. Welk (1999) proposed that such skills can *enable* children to be active but likely exert an indirect influence on physical activity through increasing perceptions of physical competence, which *predispose* children to be an active lifestyle. However, Stodden and colleagues (2008) contend that motor competence precedes perceived competence and is the key determinant of an active lifestyle. This research lends support to the model of motor development proposed by Stodden et al. It appears that at this age, children's skill level appears to be a "...primary underlying mechanism that promotes engagement in physical activity" (Stodden et al., 2008). *With advancing age* children will be better able to make accurate judgements of their physical competence and so it is likely that the relationship between physical activity and perceived competence will strengthen (Stodden et al., 2008).

6.4.5 The impact of interventions on health outcomes

Though not the primary outcome variables in this thesis, it is important to consider that the intervention in Study 2 failed to demonstrate a beneficial influence on BMI, while the interventions in Study 3 failed to demonstrate a beneficial effect on physical activity, cardiorespiratory fitness or body fatness. This is despite our findings that fundamental movement skills were significant predictors of these health behaviours/outcomes in the cross-sectional study, and such skills were significantly increased following the interventions.

The interventions were not effective in reducing percent body fat. This finding is despite the fact that the FMS and HIPA afterschool clubs both increased competence in locomotor skills (which significantly predicted body fatness in Study 1), and provided children with an opportunity to access 120 minutes of structured physical activity per week. It may be that locomotor skills were not increased substantially enough to directly influence body fat or that this exercise dose is not strong enough for beneficial effects on adiposity and that. Children may need 3-5 sessions per week to impact body composition (Vizcaino et al., 2008; Yin et al., 2005) but in practical terms the feasibility of such programmes is dependent on the availability of school facilities.

The PASS intervention included healthy missions to reduce sedentary behaviours and increase physical activity, but no intervention effect was found for body fatness. In support of these findings, classroom based health education lessons that were implemented in the "Switch-Play" and "Switch-off-Get Active" interventions which included physical activity and sedentary behaviour topics did not impact on BMI (Salmon et al., 2008; Harrison et al., 2006). In contrast, two studies which targeted sedentary behaviours were found to positively impact BMI (Robinson et al., 1999; Gortmaker et al., 1999). In the Switch-Play study, when health-education lessons were combined with physical education lessons designed to increase fundamental movement skills the intervention did reduce BMI, relative to controls (Salmon et al., 2008). This positive finding for a combined approach is supported by an eight week school-based study which only observed favourable outcomes on body fat when exercise classes' were supported by healthy lifestyle education (McMurray et al., 2002). In future trials, it would be pertinent to explore whether a combined PASS and HIPA/FMS intervention have a stronger effect on body fatness. Such approaches may provide children with the skills and opportunities to replace sedentary pursuits with more active pastimes (Salmon et al., 2008).

The lack of an intervention effect on body fatness may be explained by the failure of the interventions to increase physical activity – no intervention effect was found for total physical activity (cpm) or PA>4, which provides an indication of time spent in MVPA. Again, this was interesting as motor competence predicting physical activity participation in Study 1, and the FMS and HIPA interventions significantly increased skill competence. This finding is symptomatic of the literature at present. A recent review found that the evidence for the effectiveness of school-based interventions to increase physical activity was inconclusive, with only 4 out of 19 studies in children reporting a statistically significant intervention effect (van Sluijs et al., 2007). Two other randomised-controlled trials in primary schools within the UK also reported no intervention effect on physical activity (Sahota et al., 2001; Warren et al., 2003). The results of these studies and this thesis suggest that more research is needed to design effective physical activity interventions in UK children, while important lessons can be learned from this research.

The HIPA and FMS sessions provided children with an environmental stimulus to access facilities and activities bi-weekly for two hours, which is significant as after-school sessions are important contributors to the physical activity of attending children (Trost et al., 2008). However, the after-school sessions did not enable participants to increase overall physical activity. It may be that children may have compensated for the increases in physical activity during these sessions by reducing physical activity at other times.

PASS included school and family components (parents were asked to assist with healthy missions) but no effect was found for physical activity. This finding disagrees with the results from other studies that increased physical activity following interventions which included healthy-education topics and family components such as asking parents to offer encouragement and provide verification of behaviour (Salmon et al., 2008; Harrison et al., 2006). These classroom-based interventions taught healthy education topics via school lessons. PASS healthy missions were given to small groups of children at school, but outside of lesson time. This suggests that behaviour-modification programmes such as PASS may need to be employed within school lesson time to be effective. Children may then benefit from increased social support as all classmates would be involved. The lack of an effect for the interventions suggests that multi-component interventions, which include environmental, educational and family components, may be necessary to increase physical activity in children. This is in keeping with social-ecological approaches to physical activity which have been advocated in recent years (Sallis & Owen, 1999; Welk, 1999).

A clear decrease was found in physical activity (total and PA>4) from baseline to post-test in all conditions. This may be explained by several reasons. First, this decrease may be symptomatic of an age-related decline in physical activity (Riddoch et al., 2004; Trost et al., 2002). Second, physical activity levels were sustained at mid-test, which was mid-intervention, but fell at post-test, when the intervention had ceased. This suggests that the intervention components did not induce long term behaviour change, which may be explained by no programmes being offered as exit strategies to replace the interventions. Finally, no intervention was offered during the summer holidays and this period of 'detraining' may have reduced the potency of the intervention, leading to declines in physical activity behaviour which were demonstrated at post-test. Taken together, this suggests that the transition from Year 5 to 6 may be an important period and could be targeted in future interventions to prevent this age-related decline. Qualitative research could provide salient information to explain these changes.

Another explanation for the failure of the interventions to reduce body fatness was that generally the interventions did not enhance cardiorespiratory fitness, which has been shown to be negatively related to markers of overweight and obesity (Ortega et al., 2008). While boys in HIPA did show some small positive benefits on fitness, these gains may not have been sufficient to reduce body fat. It is likely that the intervention dose would have to be stronger to promote fitness (Baquet et al., 2006), particularly in light of decreases in habitual physical activity. Promoting fitness while encompassing activities for skill learning, which are generally conducted at a much lower intensity, remains a challenge for physical educators and coaches.

6.4.6 Feasibility

The school based interventions were implemented successfully with the support of school teachers and without placing additional pressure on an already crowded school curriculum. Afterschool interventions appear to be a promising strategy for targeting health behaviours/outcomes and the interventions in this thesis could easily be adopted by schools relatively inexpensively. The intervention programmes were well received by children, with the majority reporting that they enjoyed coaching sessions and this was reflected with strong attendance rates. The return rate for the PASS intervention was also reasonable and it is likely that the reward scheme had a positive effect on compliance in all interventions. Parents were also supportive of the intervention programme and encouraged children to maintain compliance with the intervention.

6.5 Implications of findings

The findings indicate that whilst the majority of children within this sample meet the recommended guidelines for physical activity (Biddle et al.,1998; Chief Medical Officer, 2005) and have high levels of perceived physical competence, a large proportion are not proficient in fundamental movement skills. For skill development, the nature of the physical activity is important - in order to improve skill competence, children need to be provided with opportunities for practice and instruction.

Afterschool multi-skill clubs appear to provide a means for children to develop competence in movement skills and children should be encouraged to attend multi-skill club programmes at schools. However, as many children do not enrol in afterschool programmes, to influence motor skill development in all children it may be necessary to target primary school Physical Education programmes (van Beurden et al., 2003). The primary PE curriculum (see www.curriculum.qdca.gov.uk) states that children should explore and develop new skills in Key Stage 1 (5-7 years) and learn, practice and apply these skills to different sports and activities in Key Stage 2 (8-11 years). Classroom teachers who are not physical education specialists lack confidence, time and resources for delivery of effective PE programmes (DeCorby et al., 2005; Hardman & Marshall, 2001; Morgan & Bourke, 2005). As many children are not reaching skill proficiency then professional development courses could be offered to primary school teachers to improve their confidence and competence at delivering activities to promote such skills. As well as children learning skills, the primary PE curriculum has a number of other objectives, including the promotion of physical activity. It is important that teachers who target physical activity do not do so at the cost of motor skill development

It is vital that children develop competence in locomotor skills as they appear to be a key determinant of children's physical activity, fitness and body fatness. Interventions to combat obesity could target improvements in locomotor skills to reduce body fatness. It is pertinent to note that childhood object-control skill competence predicts physical activity and fitness in adolescence (Barnett et al., 2008a, 2008b), so children need to learn all forms of movement skills. Girls performed less well than boys at object-control skills. Therefore, it is important to ensure that girls are provided with sufficient opportunities for skill development and access to equipment necessary to develop such skills. Remedial programmes could be offered if girls fail to reach skill proficiency.

The findings that participation in the 12 month afterschool club interventions positively impacted perceptions of competence in boys suggests that boys low in perceived physical competence could be encouraged to attend afterschool clubs or other forms of structured exercise to enhance perceptions of competence. However, the type of physical activity programmes necessary to increase perceptions of physical competence and self-esteem in girls, particularly as they start to enter the pubertal years, warrants further study. Girls may respond better to single sex structured exercise classes and dance activities (Burgess et al., 2006). Practitioners should seek to create a mastery climate to enhance perceptions of competence (Ames, 1992; Epstein, 1988).

6.6 Limitations

The inclusion of only one school per condition in Study 2, and two schools per condition in Study 3, restricts the statistical power of each study. It is a limitation that it was not possible to account properly for the design effect of clustering by school, as there were only 1 or 2 schools in each cluster. Hence, the cluster component of variance was ignored and data analysis was conducted at the level of the individual. This results in the precision of the estimate of the mean intervention effect being somewhat overestimated (narrower confidence limits). However, this design is considered useful for preliminary trials (Varnell et al., 2001), and estimations of the effect of the intervention and its uncertainty can inform a subsequent definitive trial. A related issue with the design employed is that in randomising one or two schools to each condition the equivalence of groups at baseline is not secure. To address this threat to validity, the schools selected were as closely as possible for a range of characteristics, including socioeconomic status, school size, and current afterschool physical activity provision.

Again, it is important to note that the small sample size within each study limits the generalisability of the findings. Further, all three studies were unblinded for practical reasons as it was not possible to mask the interventions from the participants as they were active participants and the Research Coaches were responsible for co-ordinating and delivering the intervention programme. A further limitation is that the intervention studies (Study 2 and Study 3) lacked follow-up assessments and so it is not possible to know whether the intervention effects were maintained, and if they were then to what extent. Further, fundamental movement skills were assessed within a standardised, closed environment. Therefore it was not possible to ascertain whether children demonstrated the same level of competence in an open environment during 'real' play, nor whether skill competence gains following the intervention were transferred and applied during games and sports (Rink et al., 1996). Furthermore, the pedagogic practices utilised by the afterschool club coaches in Study 2 and Study 3 were not observed and we did not assess coach behaviour. This could have provided information on the dose response of the intervention necessary to increase fundamental movement skills competence and helped elucidate the mechanisms for the intervention effects on physical self-perceptions and skill competence.

Though physical activity was measured in Study 1 and Study 3, the nature of children's physical activity was not recorded. The type of sports and physical activities that children engaged in outside of the intervention may have influenced the outcome variables. In addition, several children had missing data for physical activity and so were not included in the respective analysis; a number of children did not meet the inclusion criteria for accelerometer wear time (>9 hours per day, any 3 days per week). Despite the inclusion of a reward scheme, many children stated that they had 'forgot' to wear the monitors or had taken them off during water-based activities and not put them back on. Similarly, a number of children did not meet the criteria for Peak VO_2 despite strong verbal encouragement during the test and all participants going through a familiarisation protocol. Reasons given by children for not achieving peak criteria included a lack of motivation, injury or discomfort with the face mask. In addition, on a few occasions the test equipment failed and the VO_2 data was lost.

6.7 Future research directions

To more precisely determine the nature of the relationships of fundamental movement skills and physical self-perceptions with physical activity, body fatness and fitness, more studies are needed that use objective measures of physical activity, fitness and body fatness. It is important to establish how this relationship changes with age. Further, the potential for distinct influences of locomotor skills or object-control skills through childhood and adolescence warrants further study. In addition, motor development specialists should seek to develop an appropriate assessment tool which is capable of assessing the developmental stages of motor skill competence (Stodden et al., 2008). Only two longitudinal studies have examined the relationships between motor skills and physical activity (Barnett et al., 2008a; McKenzie et al., 2002). More longitudinal evidence is needed which follows children from their preschool years to adult life, while such studies should also include assessments of body fat to aid understanding of how these variables interact with one another.

Future researchers investigating the effects of physical activity interventions on fundamental movement skill competence should seek to include a larger sample size to permit greater generalisability of findings. From a practical perspective, prioritising and selecting a few important outcome measures (e.g. physical activity, fitness, body fatness, and fundamental movement skills) may shorten assessment procedures and facilitate the inclusion of a greater number of children. Researchers employing a group randomised design should seek to increase the number of schools *within* each condition to avoid the issues associated with cluster randomisation. Study designs should include follow-up assessments at least 12 months post-intervention to determine the long term effects of the programmes. Interventions should also consider assessing the pedagogic practices associated with the intervention programme to determine their influence on children's skill development and perceived competence, while an account of the sources of competence information used by children would also be useful in explaining changes in the latter.

Further, information on the types of activities, sports and pursuits that children engaged in external to the intervention should be recorded. To maximise the potential benefits to children's skill levels, future fundamental movement skill interventions should target younger children. It is possible that combining skill-based interventions with behaviour modification programmes may best impact health outcomes (e.g. McMurray et al., 2002; Salmon et al., 2008) and such interventions should be explored further. For example, a combined FMS and PASS intervention could be undertaken. Experimental trials are needed to determine appropriate physical self-perception interventions for girls. In addition, future researchers should include qualitative methods to explore the mechanisms of change in physical self-perceptions during interventions.

6.8 Conclusion

This thesis has provided a unique look at the fundamental movement skill competence and physical self-perception profiles among a 'normal' sample of 9-10 year old UK children, and explored the subsequent impact of various interventions on important health behaviours/outcomes. Children of this age appear to have relatively positive physical self-perceptions but the findings highlighted that many children are yet to reach proficiency at fundamental movement skills. This is important, as children's skill competence (particularly in locomotor skills) was found to be a key determinant of their physical activity, fitness and body composition. The afterschool intervention programmes were effective in helping children to learn and improve fundamental movement skills, with the magnitude of effects largest following participation in the 12 month FMS intervention. The afterschool FMS and HIPA interventions appeared to have positive effects on physical self-perceptions in boys, but a negative effect in girls. The mechanisms behind these effects are unclear and require further research. The behaviour-modification programmes had little benefit on skill development or perceived physical competence and may need to be combined with structured exercise to impact health behaviours/outcomes. Future research should seek to examine the long term effects of these interventions.

At the beginning of the thesis the specific aims were to:

a) *Investigate the prevalence of skill proficiency and levels of perceived physical competence in UK primary school children.*

   Prevalence of proficiency was low-to-moderate in boys and low in girls, while boys had better object-control skills than girls. Children had relatively positive physical self-perceptions but were not capable of making accurate judgements of their actual competence.

b) *Examine the relationships between fundamental movement skill competence and physical self-perceptions with children's physical activity, fitness, and body fatness (overweight/obesity).*

   Children's competence at locomotor skills was found to have a unique and important influence on levels of physical activity, fitness and body fat. Perceptions of competence were not associated with physical activity and only weakly predicted body fat and fitness levels.

c) *Determine the effectiveness of non-curricular interventions to increase fundamental movement skill competence and enhance perceptions of competence.*

   The afterschool interventions enhanced skill competence, with participation in the FMS intervention having the largest benefit. The afterschool clubs had positive effects on physical self-perceptions in boys but not girls, while the behaviour-modification programme did not positively impact skill competence or perceived physical competence.

Chapter 7

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