4. Discussion

4.1 Research question one – 'In studies where physical activity was measured at baseline were children meeting the suggested physical activity levels as outlined by the HEA (1998)?'

Five studies in this systematic review examined the current levels of childhood PA. These studies used a variety of techniques to measure the levels of PA including questionnaires and accelerometry. In respect to the recommendations for PA outlined by HEA (1998) some of the studies (Abbott & Davies 2004) reported high levels of daily PA that exceeded these guidelines, whereas others (Christodoulas *et al.*, 2006) found that daily PA levels of young people failed to meet the recommended guidelines.

It is firstly important to once again consider what the recommended guidelines for PA amongst young people actually are. The Health Education Authority (HEA), while acknowledging that it is not possible to give a precise definition regarding the minimal or maximal amount of PA for young people, have provided a set of guidelines to be followed. They have recommended that all young people should participate in PA, of at least a moderate intensity, for one hour per day, and for those young people who are currently inactive a target of half an hour moderate intensity physical activity per day should be achieved in the short term. Furthermore, on at least two occasions during the week these activities should help to enhance and maintain muscular strength, flexibility, and bone strength (HEA, 1998). Sallis and Patrick (1994) suggest that there are two underlying health-related rationales for such recommendations. The first reason is for the promotion of physical and psychological health and well-being in the short term (i.e. during childhood/adolescence). And the second reason is to promote PA with the goal of enhancing long term health by increasing the probability of remaining active as an adult. This may be particularly important as it is thought that children and adolescents who develop a habit of participating in PA during childhood are more likely to remain active during adulthood (Sallis & Patrick, 1994). This process, referred to as 'tracking', appears to be a critical concept as it seems that not only do PA behaviours track into adulthood, but also some of the major modifiable risk factors for CHD including hypertension , obesity, and lipid profile (Raitakari *et al.,* 1994; Webber *et al.,* 1991). It therefore seems logical to focus on children and adolescents in any approaches targeted at reducing CHD and associated conditions in adulthood (Bouziotas et al., 2004; Bouziotas & Koutedakis, 2003).

As already mentioned the results of this systematic review have not provided an unequivocal consensus regarding the levels of actual PA participation in young people. Saakslahti *et al.,* (2004) found that the majority of children in their study (aged 4-7 years) spent more than one hour per day in high-intensity playing. It would seem therefore that the children in this particular study adequately met the PA recommended guidelines. The assessment of PA levels in this study was based on an observation diary which was filled out by the parents of each child. The observation diary involved the filling in of 5-minute time units which had to be classified as 'sleeping', 'indoor play', 'very active indoor play', 'outdoor play', 'very active outdoor play', or 'unattended play'. Because this study used an observation approach, with the parents completing the observations, it is likely to provide a fairly high degree of accuracy regarding the actual levels of PA participation. If these results are an accurate representation of actual PA levels then it could be suggested that the children in this study succeeded in meting the recommended volume of physical activity. However, this is just one study using one type of PA assessment measure and it is important to consider the findings of other studies.

Christodoulas *et al.*, (2006) used a different method of assessing the PA levels of young people in their study. They used a physical activity recall questionnaire to determine PA levels. The participants were asked to recall school curriculum physical activities, organised sport, and other leisure time activities in which they had participated in at least ten times during the preceding year. For all these different activities the subjects were required to provide information regarding the frequency and duration spent on each, and this was then confirmed by the parents and school PE teachers. The time spent in all activities was then summed to derive an overall physical activity estimate (hours/day). Results suggest that none of the participants achieved the recommended one hour PA each day. The amount of time spent in organised PA per day averaged at 42.6 minutes and the average time spent in unorganised PA was 12.6 minutes. This would combine to make a daily total PA time of 55.2 minutes which falls just below the recommended one hour per day. However, based on the particular method used in this study it is likely that the actual levels of daily PA have been somewhat underestimated.

One potentially significant problem in the measuring and assessment of daily PA is the variation in the understanding of the term 'physical activity' and the definition used to describe it. The terms 'physical activity', 'exercise', and 'physical fitness', are often used interchangeably and their meanings become mixed into one when in fact they are three distinct concepts (Sallis & Patrick, 1994). Cale and Harris (2005) have provided a definition for each physical activity, exercise, and physical fitness.

- Physical activity has been defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure, it has dimensions of duration, frequency, intensity and mode/type'.
- Exercise has been defined as 'a subcomponent of physical activity, which is volitional, planned, structured, repetitive, and is carried out to maintain any aspect of fitness or health'.
- Physical fitness has been described as 'a set of attributes that people have or achieve that relates to the ability to perform physical activity' (Cale & Harris, 2005).

The definition of physical activity as provided by Cale and Harries (2005) would be inclusive of a whole range of daily activities including walking upstairs, washing up, and playing football with friends in the park. Consequently, ascertaining the actual daily PA levels of children is problematic given its complex and diverse nature (Winsley & Armstrong, 2005). It could be suggested therefore that the study by Christodoulas *et al.*, (2006) fails to address the actual PA levels of the young people in their study as they do not consider 'activities' participated in throughout an entire day. As such their reported findings that young people accumulate 55.2 minutes of physical activity (organised and unorganised PA combined) is likely to be an under representation of their actual daily PA levels.

A more accurate assessment of PA levels may be seen in the study by Abbott and Davies (2004). They assessed habitual physical activity levels in 47 children (23 boys & 24 girls) using the ratio of total energy expenditure (TEE) to basal metabolic rate. TEE was determined using the doubly labelled water technique and the intensity of PA was recorded using minute by minute accelerometry (over two weekdays and two weekend days). The accelerometers were worn for as long as possible during the day, from when the participants first got up until they went to bed. This method of assessing PA levels would seem to be a more accurate approach than self-report questionnaires as direct measurements of actual daily PA levels are taken. Results from this study show that the number of minutes per day spent in moderate PA was 364+/-126 in boys and for girls it was 299+/-94. Additionally, the number of minutes spent in vigorous activity was 149+/-83 min/d in boys and 84+/-41 min/d in females (Abbott & Davies, 2004). The categories of activity intensity were based on the vector magnitude counts recorded on the accelerometer, with moderate intensity activity defined as counts in the range of 1000-1999 and vigorous intensity activity as 2000-3499 counts.

Two main conclusions can be drawn from these results, firstly; it is clear that the participants in this study easily meet (and have exceeded) the recommended guidelines for moderate intensity PA, and secondly; the boys in this study were substantially more active than the girls. The implications associated with the later of these conclusions will be discussed in more depth in section three.

Based on the findings of this study, which is deemed to provide a fairly accurate representation of PA levels, it could be concluded, in response to research question one, that young people are meeting the suggested PA levels as outlined by the HEA (1998). However, it is important not to view these results in isolation and assume that they are representative of young people beyond this study. For example, the study by Gutin *et al.*, (2005) which also used the method of accelerometry produced substantially different results.

Gutin *et al.*, (2005) measured PA using 5 days of accelerometry and were able to distinguish the individual amounts of light, moderate and vigorous PA for each day based on movement counts from the accelerometer. Resting or light activity was comparable to <3 metabolic equivalents (METs), while moderate intensity activity was translated as 3-6 METs, and vigorous intensity activity was classified as 6-9 METs (Gutin *et al.*, 2005). Results from their study indicate that the time spent in moderate and vigorous PA combined amounted to 44.3+/-30.4 min/d. This suggests that, within the study participants, there is a wide spread in the amount of daily PA. For example, the most active individual would be accumulating 74.7 min/d moderate and vigorous PA compared to the least active participant who would only be averaging 13.9 min/d moderate and vigorous PA. It is of course possible, and likely, that the participants accumulated larger amounts of light intensity activity but this has not been reported in the study and moreover, the HEA (1998) guidelines stipulate the activity contributing to the daily recommendations should be of 'at least' a moderate intensity.

A possible determining factor of the variation in reported levels of PA between the studies of Gutin *et al.*, (2005) and Abbott & Davies (2004), despite using similar assessment methods, could be the age of the participants. The age of the subjects in the Abbott and Davies (2004) study ranged from 5 years to 10 years of age, whereas the age of the subjects in the study of Gutin *et al.*, (2005) was 16 years. Therefore, not withstanding methodological and measurement errors, it could be suggested that as children move towards adolescence and then adulthood the level of habitual PA declines. It is not possible to gauge from these studies the precise reasons for this, but plausible causes for this decline may include the changing of lifestyles, such as pressure from friends and peers to engage in activities such as drinking, smoking and computer games that may potentially replace physical activity (Biddle *et al.*, 2003; Fox, 2003).

There are a number of possible problems when attempting to compare or analyse the physical activity levels of young people. One has already been mentioned, that is the variation in the understanding and definition of the term physical activity. Others include the variation in the methods used to assess activity, and also the complex nature of PA itself (Winsley & Armstrong, 2005). Consequently it is difficult to draw definitive conclusions relating to the levels of young peoples' habitual PA as reported in studies featured in this systematic review. It seems however, that only two out of the five studies included in this particular section of the review indicate that young people meet the recommended guidelines for PA as outlined by the HEA (1998). However, as already mentioned, the age of the participants in these studies vary, along with the measures of assessment and also possibly the authors understanding and definition of the term physical activity.

As such, there seems to be a requirement for future research which examines consistently the physical activity levels of children and adolescents across different ages, sex, and geographical location. It would also seem important to discover, if it is the case that PA declines with age, the reasons for this and what, if any, pursuits are replacing physical activity.

4.2 Question 2

Twenty articles included in this systematic review reported on the short-term effects of physical activity on modifiable CHD risk factors including obesity, blood pressure, and lipid profile in children. The findings from these studies will be discussed in three sections; firstly, the effects of PA on obesity/fatness, then on lipid profile, and finally on blood pressure.

4.2.1 Obesity

A report from the Department of Health (2003) suggests that the prevalence of overweight and obesity among the adult population is as high as 43% and it is thought that these figures will continue to increase. Although the exact incidence of overweight and obesity in children remains unclear it is generally considered that 2-15% of UK children are obese and 18-24% are overweight (Chief Medical Officer, 2002). One potential 'cause' of this increase in obesity and fatness among children is a decrease in energy expenditure from physical activity (Armstrong & Welsman, 2000). The HEA (1997) claim that the role of PA to help reduce/prevent levels of obesity and fatness may have particular importance as obesity has many short-term health implications for young people. However, it remains inconclusive as to whether PA can actually reduce CHD risk factors such as obesity in children. A discussion of the results from this systematic review aims to bring greater clarity to this issue.

Results from the studies included in this review typically measure and report measures of childhood obesity and fatness in terms of either body mass index (BMI) or skinfold thickness. BMI is a straightforward, non-invasive and inexpensive method as it only requires the height and weight of each subject to be measured (weight/height squared). While the measure of BMI has undoubted benefits, it also has certain drawbacks, notably that it does not distinguish between the amount of fat-mass and fat-free mass in each individual (Ruiz *et al.*, 2006). The other method commonly featured in the studies in the review is the measurement of skinfolds. This usually involves the measurements of three or four skinfolds being summed and placed into an appropriate equation to provide an estimate of percentage body fat (Tolfrey *et al.,* 1998).

The studies included in this systematic review have provided some interesting findings in relation to physical activity and obesity/fatness in children. It is immediately apparent that not all the findings of these studies are in agreement with each other. This however is not surprising given the variations between the studies in terms of population demographics, study aims, and methods. Although, a large number of these studies have reported significant associations between levels of PA, BMI, and percentage body fat among children and adolescents.

Raitakari *et al.,* (1997) found that, among males, a higher level of PA was associated with a lower BMI and thinner skinfolds, and amongst females higher levels of PA were associated with thinner skinfolds. Similarly, Abbott & Davies (2004) found that PA level was significantly and negatively correlated with both percentage body fat ($r=-0.43$, $p=0.002$) and with BMI ($r=-0.45$, $p=0.001$). Additionally, Taimela *et al.,* (1996) found that in males PA was associated with BMI ($p=0.001$) and subscapular thickness ($p=0.001$).

A couple of studies examined the effect of PA interventions on measures of obesity. Owens *et al.,* (1999) aimed to test the hypothesis that controlled physical training, without dietary intervention, would reduce the percentage of body fat in already obese children. They found that, compared with the control group, the physical training group declined significantly in percentage body fat ($p<0.01$), total fat mass ($p<0.01$), and subcutaneous adipose tissue ($p<0.05$), while increasing significantly in fat-free mass ($p<0.05$). The results of this study are particularly interesting as the participants in the study were already obese, thus suggesting that appropriate physical activity/training can significantly reduce levels of obesity among young people who are currently obese. The physical training intervention involved a four-month period of controlled physical training which consisted of activity sessions that lasted for 40 minutes with a mean heart rate of 157bpm being maintained, and this took place five times each week. This suggests that the controlled training was typically aerobic in nature, which would coincide with the 'moderate intensity' activity levels recommended by the HEA (1998). It is unclear from this study however what the total daily level of PA is and whether this may have contributed to the reduction in percentage body fat.

The second intervention study by Burke *et al.*, (1998) evaluated the benefits of a school and home based physical activity 'enrichment' programme for children at a higher risk of CHD. The intervention programme involved a standard school physical education program and an additional PA 'enrichment' programme for high risk participants. Results demonstrate a significant decrease ($p=0.03$) in subscapular skinfolds for those in the enrichment group. This study provides further indication that by increasing PA levels among already 'at risk' children (already displaying CHD risk factors) can benefit the CHD risk profile (including obesity) in children and adolescents.

However, not all the studies included in this systematic review found significant alterations in measures of obesity in relation to PA. Guerra *et al.*, (2001) found no significant association between the PA index of young people and their BMI. Furthermore, an intervention study by Harrell *et al.*, (1998), which involved an 8-week physical activity intervention, reported only small decreases in body fat and with no change in BMI as a result of the intervention. Harrell *et al.*, (1998) suggest that this lack of change in body fat and BMI was possibly due to the short duration of the intervention.

It is highly plausible that certain dimensions of PA will mediate the effect that this activity will have on preventing and/or reducing the levels of obesity and fatness in young people. As described by Cale and Harris (2005) physical activity has dimensions of volume, duration, frequency, intensity, and mode/type. In the example of the study by Harrell *et al.*, (1998) it is suggested that an insufficient duration of PA was responsible for the poor response of body fatness and BMI.

Studies by Gutin *et al.*, (2005) and Ruiz *et al.*, (2006) have produced interesting findings concerning the intensity level of PA in relation to measures of obesity and fatness among young people. Gutin *et al.*, (2005) found that a lower percentage body fat was associated with higher amounts of vigorous PA but not with the amount of moderate PA. Similarly, Ruiz *et al.*, (2006) found that a lower body fat was significantly associated with higher levels of vigorous PA but not with the levels of moderate or total PA. Furthermore, children who engaged in >40 minutes vigorous PA per day had lower body fat than those who only took part in 10-18 minutes vigorous PA each day. This suggests therefore that not only is the duration of PA important but also the intensity of this PA in terms of obesity and fatness in young people.

When the recommended guidelines for PA in young people, as outlined by the HEA (1998), are considered it is interesting to note that they recommend activity of a moderate intensity. However, the results reported by Gutin *et al.*, (2005) and Ruiz *et al.*, (2006) suggest that it is only physical activity of a vigorous intensity that produces significant alterations in measures of obesity and fatness in children. This would therefore raise questions regarding the suitability of the guidelines produced by the HEA (1998) for eliciting short-term benefits from PA in children. As such, it could be suggested that these guidelines may not be appropriate to reduce modifiable CHD risk factors, such as obesity, during childhood and adolescence. That said, it does not necessarily mean that these guidelines should simply be discarded, firstly because more research is needed to confirm the relationship between the intensity of PA and obesity, and secondly, these guidelines may be effective at promoting lifelong health.

These guidelines not only aim to improve health during the years of childhood and adolescence but they also seek to promote PA with the goal of enhancing future health by increasing the probability of remaining active as an adult (Sallis & Patrick, 1994). The development of lifelong physical activity behaviours, established in childhood and adolescence, is arguably more important (in terms of health) than imposing large quantities of vigorous PA on children and adolescents (Webber *et al.*, 1996). The reason for this, as Pate *et al.*, (1995) suggest, is that the consequences of physical inactivity and the health benefits of PA are more pronounced in adults than in children. Therefore, although the HEA (1998) guidelines might be questioned concerning the CHD risk factor of obesity during childhood, they may be highly relevant and appropriate in the development of long-term health and well being. It seems clear that this is an area that requires more research, especially in determining the type, amount, and intensity of PA in childhood that brings about lifelong participation.

4.2.2 Blood pressure

The articles included in this systematic review have provided a limited section of results concerning the role of PA in improving the modifiable risk factor of blood pressure in children. One possible reason for this lack of information regarding the relationship between blood pressure and PA, as compared to other modifiable CHD risk factors such as obesity and lipid profile, might be due to the effect that body composition and maturation have on blood pressure in children. Durant *et al.,* (1993) found that blood pressure in children is related to body size. Additionally, Alpert and Wilmore (1994) report that blood pressure in children is also related to the maturational process, and as such any studies examining blood pressure in children must be interpreted with a degree of caution. However, the results that did feature in this review will now be examined.

In an intervention study by Hansen *et al.,* (1991) a period of eight months training produced a mean fall in SBP of 6.5mmHg in the normotensive subgroup and 4.9mmHg in the hypertensive subgroup. Additionally, DBP at the end of the intervention was significantly lower in both training subgroups (normotensive & hypertensive) compared to the control subgroups. These results are interesting as they suggest that not only does an eight month physical training programme produce significant decrease in both SBP and DBP, but this occurs in both normotensive and hypertensive individuals. This is in contrast to previous suggestions which propose that exercise training programs only produce reductions in SBP and DBP in already 'at risk' individuals but not in normotensive people (Riddoch & Boreham, 2000). Although the reason for these contrasting results is unclear, a possible mediating factor may be the type of exercise training programme utilised (i.e. differences in type, duration, and intensity). Although this is an area which would benefit from more research, it has been suggested that aerobic endurance type exercise is the most effective form of activity for reducing blood pressure, while both endurance and resistance type exercise are suitable to maintain these reductions (Armstrong & Welsman, 1997).

The physical training intervention of Hansen *et al.*, (1991) involved extra lessons of an ordinary school physical education programme with the sessions lasting for 50 minutes, and taking place three times a week for 8 months. As such, it seems that this coincides with the recommendations made by Armstrong and Welsman (1997) and thus may explain the significant results from their study. Other studies concerning the relationship between PA and blood pressure featured in this review include Bouziotas *et al.*, (2004) and Raitakari *et al.*, (1997). Bouziotas *et al.*, (2004) found that PA was associated negatively with SBP ($p<0.01$), however, Raitakari *et al.*, (1997) found no relation between PA and SBP and DBP in either sex. These differing results indicate that the relationship between PA and blood pressure in children is by no means definite and as such, it could be beneficial to conduct further research directed at clarifying the potentially beneficial effect of PA on blood pressure in young people.

4.2.3 Lipid profile

Raised cholesterol levels have been identified as one of the most important modifiable risk factors for CHD (Newby *et al.*, 2005). Cholesterol and triglycerides are the two major lipids contained in plasma (Betteridge & Morrell, 2003). While the strongest influence of LDL cholesterol levels may be the diet of the individual, low levels of HDL cholesterol ('good' cholesterol) may be manifested by low levels of physical activity (Young & Libby, 2007). As such, it would seem that increasing levels of PA, or maintaining current levels if already high, would result in a more favourable lipid profile.

On examination of the studies included in this systematic review many of them report significant alterations and associations between blood lipid profile and PA. Suter and Hawes (1993) found that in boys a higher level of PA was related to higher concentrations of HDL cholesterol ($r=0.32$, $p<0.03$), and in girls they also found a positive relation between PA and HDL ($r=0.29$, $p<0.05$). Taimela *et al.*, (1996) also found that in males PA was positively associated with HDL ($p=0.0043$). It is always of interest to examine the results from intervention studies in which levels of PA have deliberately been increased in a controlled and measurable manner. This type of study allows the specific effects of PA to be seen on a number of physiological variables such as blood lipid profile.

Harrell *et al.*, (1998) conducted an intervention study with children already demonstrating multiple cardiovascular risk factors. The intervention was eight weeks long and contained a classroom based intervention group, a risk based intervention group, and a control group. Both interventions produced large reductions in total cholesterol (-10.1mg/dL and -11.7mg/dL respectively) compared to a small drop in the control group (-2.3mg/dL). This indicates that, in children already exhibiting abnormal lipid profiles, increasing levels of PA produces a significant decrease in total cholesterol. Unfortunately, the results did not provide the component breakdown of this cholesterol decrease, as such the direct effects of PA on the individual fractions of HDL, LDL, and TG could not be analysed in 'at risk' patients.

Another intervention study included in this review examined the impact of a physical training programme on lipid profile in apparently healthy children (Tolfrey *et al.*, 1998). The exercise intervention involved stationary cycling for 30 minutes, three times a week for 12 weeks, while the control group maintained their usual lifestyle pattern. Tolfrey *et al.*, (1998) found that LDL decreased in the exercise group (-10%) but remained unchanged in the control group (0.3%). Furthermore, HDL increased in the exercise training group (9.3%) but decreased in the controls (-8.9%, $p<0.01$). This suggests that not only can PA improve lipid profile in individuals already displaying an 'at risk' profile for CHD, but also in those children who are apparently healthy. It is not surprising that

Tolfrey *et al.*, (1998) reported an increase in HDL as a result of increased PA given the relationship between HDL and physical activity, as mentioned previously (Young & Libby, 2007). However, the finding that LDL levels decreased is somewhat surprising but encouraging if these results are indeed accurate.

It is generally thought that the primary cause of high levels of LDL is a poor diet (Young & Libby, 2007) and not low levels of PA. Thus if the beneficial effects of PA on LDL levels could be confirmed in young people, independent of diet, increasing PA could be a possible mechanism of reducing CHD risk, especially considering that raised cholesterol levels have been cited as a vital modifiable CHD risk factor (Newby *et al.*, 2005).

Despite Tolfrey *et al.*, (2004) finding that the group mean lipid-lipoprotein concentration did not change as a result of training energy expenditure ($p>0.05$), the majority of the studies included in this review appear to indicate that physical activity can have a positive effect on lipid lipoprotein profiles, especially the HDL component, in children and adolescents.

4.3 Question 3

Ten of the studies analysed in this systematic review reported on the differences that PA produces on modifiable CHD risk factors between younger and older children, and between males and females. The findings related to age differences will be discussed first, followed by an examination of sex related differences.

The articles included in this review contain a very limited assessment of the differing impact of PA on modifiable CHD risk factors, depending upon age, within young people. Although the reason for this is unclear, it is possible that differences in age within the specific population of young people are not considered as an important influence on CHD risk. However, this is merely speculation and it is more likely that the main focus' of the articles in this review lies in other areas. Although, there have been some interesting and potentially important findings reported within these studies.

Firstly, Boreham *et al.,* (1997) found that PA was beneficially associated with coronary risk status in adolescents, and this was particularly evident at the age of 15 rather than at the age of 12. Within these 15 year old males PA was beneficially associated with SBP ($p<0.05$), lipid profile and cardiovascular fitness (both $p<0.01$). These findings were confirmed by Rizzo *et al.,* (2007) who reported that the association of vigorous and total PA with the metabolic risk scores were generally stronger in the 15 year old than the 9 year old participants. Findings from these studies seem to indicate that PA is a stronger influence on CHD risk factors in older children rather than in younger children. Although the reason for this has yet to be categorically confirmed, a number of possible causes have been suggested. Sallis *et al.*, (1993) suggest that such age differences could be influenced by the poorer reliability and validity of questionnaire responses from the younger children. Alternatively, Telama *et al.*, (1993) propose that qualitative changes in the intensity of physical activity as children grow older may influence the physiological response to exercise. It could also be suggested that the CHD risk factors may not be as pronounced in younger children as compared to older children and thus the potential role of PA in reducing these risk factors may be less important.

If the age different response to PA, in relation to CHD risk in children, is confirmed it could be a potentially important area requiring future research. For example, it may be necessary to consider producing age specific PA guidelines even within the already distinct child and adolescent population. An intervention study would be required to investigate the response of CHD risk factors to different types, durations, and intensities of PA in younger and older children in order to produce the optimum PA recommendations for each age group. The goal of such research would be to further our knowledge and understanding of the physiological responses in children to PA with the aim of improving and promoting long term health.

Compared to the research relating to age difference responses, there is a wider range of studies included in this review that report on the different impact of physical activity on CHD risk factors, between young males and young females. The majority of studies that are relevant to this section of the review suggest that PA is more strongly associated to modifiable CHD risk factors in males than in females. For example, Guerra *et al.*, (2001) found a significant association between SBP ($p<0.05$) and DBP ($p<0.05$) and physical activity index in boys but not in girls. Furthermore, Boreham *et al.*, (1997) have reported that in boys a 20% difference in PA was associated with a 1.54 fold increase in the probability of belonging to a high risk group for SBP and TC/HDL ratio ($p<0.05$), but in girls PA was unrelated to any of the CHD risk factors. Taimela *et al.*, (1996) also reported a similar pattern of results with the males displaying lower levels of TC, LDL, and HDL than the females. Furthermore, no significant associations were found between PA and TC or LDL levels in females. Additionally Raitakari *et al.*, (1997) found that among young males there were many beneficial relationships between PA and CHD risk factors, which included obesity, HDL, and TG, compared to females in whom the benefits of PA were only seen in obesity and TG levels. All these results indicate a distinct difference in young males' and females' CHD risk factors in response to exercise. As such it is important to consider why such differences exist and the potential short and long-term health implications of these differences in terms of CHD risk.

A number of the studies have suggested that this pattern of results may be attributed to a gender difference in the lipid response to exercise (Raitakari *et al.*, 1997; Taimela *et al.*, 1996). That is to say, it appears that PA in young males has a beneficial effect on levels of HDL, LDL, and TG to a greater extent than in the females from the same studies. Taimela *et al.*, (1996) suggest two possible reasons for this apparent sex difference in the lipid response (and other modifiable CHD risk factors). Firstly they propose that endogenous hormones influence the lipid profile and thus may partially explain these sex agreement with previous studies (not included in this review) that indicate that boys in the U.K. and elsewhere in Europe are significantly more active than girls (Armstrong & Van Mechelen, 1998). Winsley & Armstrong (2005) acknowledge that although the explanation of this may be based on socio-cultural factors or physiological reasons, the long-term health implications of low levels of PA in both sexes remains a concern.