A STUDY OF THE EFFECTS OF PHYSICAL EDUCATION LESSONS ON THE CARDIORESPIRATORY ENDURANCE OF SECONDARY SCHOOLBOYS

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DECLARATION

I Brian Neil Green hereby certify that this thesis has been composed by myself, that it is a record of my own work, and that it has not been accepted in partial or complete fulfilment of any other degree or professional qualification.

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ABSTRACT

The research investigated the effects of a school PE programme on a representative group of 9 boys, aged 12 years, 6 months, from a first year class in a Glasgow secondary school.

Cardiorespiratory endurance was assessed using the PWC 170 test [EUROFIT (1988)] on 7 occasions during a 12 month period, before and after blocks of teaching in Rugby, HRPF, Basketball, Volleyball and Athletics.

Physical activity levels during lessons were assessed by heart rate monitoring using the Sports Tester PE3000 telemetry system. Evaluation of the conditioning effects was carried out in relation to standard guidelines for cardiorespiratory fitness improvement.

There was no significant change in PWC 170 during the 12 month period. However there were instances in all five teaching activities where activity levels were of sufficient intensity to increase cardiorespiratory endurance.

Subjects were sub-divided into three groups of similar fitness (high, middle and low) and lesson activity levels were further examined in relation to each of these sub-groups. Results showed considerable variation in subjects response to lessons but established no relationship between fitness sub-group and lessons' conditioning effect.

Results indicated that the PE programme in general made no improvement in cardiorespiratory fitness and confirmed the individualised nature of heart rate response to PE lessons, highlighting the importance of teaching content and methodology if improved cardiorespiratory endurance is to be an objective for PE in schools.

CHAPTER 1: INTRODUCTION

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1.01: INTRODUCTION

The emphasis in Physical Education (PE) has changed over the years to reflect trends in society's participation in physical activity, in recreation and in sport, and in response to the findings of topical research.

Fundamental to the promotion of exercise for health is the concept that individuals will accrue benefits from participating in regular physical activity. This push for exercise is a product of the realisation of the positive contribution that physical activity can make to both the physical and psychological aspects of health and enhanced personal well-being.

1.02: EXERCISE AND HEALTH

An important health justification for exercise is its contribution to hypokinetic disorders;

> "those relating to, or caused by the
> lack of regular physical activity"
> (Armstrong; 1984)

In hypokinetic disorders the role of exercise centres around the prevention and amelioration of these conditions, Fentem, Bassey and Turnball, (1988) state that

> "Exercise is of general benefit at all ages because it is necessary for the preservation of optimal function and structure of muscles, bones, joints and the cardiovascular system. This ensures that the range of activities that an individual may perform with confidence and ease is maintained and the constraints of a low physical working capacity or fatigue are avoided. This contributes to an improvement in well being."
>
> Fentem, Bassey and Turnball; (1988)

Hypokinetic disease is very much a generic term covering a number of disorders influenced by inactivity. However in Western society in general and Scotland in particular the most common hypokinetic disorders are those pertaining to the cardiovascular respiratory system, with coronary heart disease (CHD) exhibiting the highest morbidity and mortality.

In Scotland disease of the cardiorespiratory system is prevalent with such disorders having a widespread epidemiology.

"Scottish mortality from coronary disease is the highest in the world, although very similar to that in Northern Ireland."

Tunstall-Pedoe et al.; (1986)

In Glasgow, the area where this research was conducted, the mortality and morbidity from such disorders is greater than for the rest of Scotland.

"Today, Scotland has the worst record in the world for premature deaths from heart disease.--- Unfortunately Glasgow is at least as bad, if not worse than any other place in Scotland. 45% of all deaths in Glasgow are attributed to coronary heart disease and strokes. This adds up to 6,000-6,500 deaths per year (of which about 1,450 are under the age of 65)!"

Greater Glasgow Health Board; (1980)

In response to this and in recognition of the need to help prevent and ameliorate cardiorespiratory disorders, Greater Glasgow Health Board has established a prevention programme called "Good Hearted Glasgow" to coordinate a range of education, screening and information services to tackle this problem.

CHD is characterised by a number of predisposing factors which significantly influence the likelihood of developing CHD. Armstrong, (1984) describes the most frequently identified coronary risk factors;

> "High serum cholesterol, hypertension, cigarette smoking and physical activity".
> Armstrong; (1984)

Although these risk factors have been listed separately it is important to regard them not only as free standing elements but also as inter-related factors, since, as Armstrong and Davies, (1980) point out.

> "a combination of risk factors increase susceptibility to coronary heart disease by a factor substantially greater than the sum of their individual contributions."

A major argument for exercise promotion is that physical activity can make a positive contribution to health through its role in preventing and combatting the effects of CHD [Fentem, Bassey and Turnball, (1988)]. Exercise promotion is of considerable importance in relation to CHD and therefore is relevant to the Scottish population. Exercise promotion should not simply be restricted to this long term, and rather medical aim, it should also be seen as an important element in general health and well-being.

Exercise and physical activity cover a great range of movement types performed to many different standards with varying levels of intensity. In recognition of this, attempts have been made to better identify and recommend the types of exercise best suited to the improvement of cardiorespiratory function. Wider discussion of the nature of such activity is provided in a later section, however, at this point these activities can be indicated as those which place the greatest demands on the cardiorespiratory system, thereby increasing the work load on the heart, lungs and blood vessels in order to sustain the oxygen demand to the working muscles.

Taking CHD prevention and amelioration as an important but not the only justification, for promoting exercise for health it is important to note that:

> "The problem of cardiovascular disease is not soley a problem of the adult population. The artherosclerotic process actually begins in childhood and progresses during adolescence and young adulthood."
>
> Moller, (1982)

Further support for this viewpoint is given by Wilmore and McNamara; (1974):

> "Coronary heart disease, once
> considered to be a geriatric problem,
> is now recognised as being largely
> of paediatric origin."
>
> Wilmore and Mcnamara; (1974)

Realisation of CHD's paediatric roots is also noted by Crittenden; (1979) reinforcing the need for physical activity to be promoted for children as well as adults.

Further support comes from Armstrong and Davies, (1980) and by Gilliam et al (1977) who examined the role of CHD risk factors, as previously identified, in children.

> "this study further substantiates
> the prevalence of coronary heart
> disease risk factors in children.
> More importantly, the data give
> evidence to the development of
> multiple risk factors at an early
> age."
>
> Gilliam et al (1977)

In view of these findings consideration must be given to the promotion of exercise and other suitable health behaviours in children, for example diet modification and smoking cessation and prevention. If attention is paid to CHD risk factor development in children then hopefully the incidence of CHD and other hypokinetic disorders will be positively influenced. It may be that promoting exercise in children

> "may influence the establishment of
> favourable habits that will extend into
> adulthood and have an effect upon
> reducing the risks of developing
> atherosclerosis."
>
> Moller; (1982)

Behavioural trends established in childhood often persist into adult life.

> "what a person does before the age of
> twelve may very well determine what he
> or she will be like after age fifty---
> The time to address risk factor prevention
> is during the early formative years
>
> Biles; (1982)

The preventative and ameliorative qualities of exercise have a more tangible meaning for adults since it is, as the previous statistics have shown, in adulthood that the disorders are likely to be manifest. This however, does not mean that the same underlying rationale for promoting physical activity in adults should be considered in relation to children.

In considering exercise promotion for children the role of the school PE department is critical as it is there that the skills and knowledge required for an active and healthy lifestyle can be developed as part of an enjoyable and balanced PE programme [Biddle; (1984) and Almond; (1983)].

Central to this approach is the integration of theoretical concepts of physical activity into the practical aspects of the PE programme. This represents a shift in the focus of fitness teaching in schools away from a prescriptive and heavily teacher directed approach to one where the learning is much more experiential, combining theoretical knowledge along with the required physical skills.

> "by working on the knowledge aspect of health related fitness, individuals will come to understand the 'why' of exercise which will make the 'what to do' and 'how to do it' aspects more meaningful"
>
> Farrally and Green; (1986)

In relation to increasing levels of physical activity and cardiorespiratory fitness in children it is evident that the focus should be on the identification and promotion of the direct benefits which are meaningful to young people. Increasing levels of activity;

> "should be promoted as a positive experience, emphasising the benefits

to health and wellbeing, rather than stressing the dangers of inactivity. Emphasis should be placed on showing how regular exercise will bring benefits to pupils now rather than building a case around the degenerative changes due to a lack of exercise which may show in later life----

Young people should be allowed to explore the benefits of exercise such as:-

-looking good
-feeling good
-relaxation
-a sense of satisfaction and accomplishment
-controlling weight, keeping figure trim
-making friends

These benefits can be linked to other areas of health promotion, such as healthy eating and non-smoking, to form the basis of a comprehensive approach to healthy lifestyles."

Scottish Health Education Group; (1988)

By considering the above a more positive approach to cardiorespiratory fitness can be promoted in children.

The specific nature of fitness and conditioning is widely recognised [Shephard; (1987) and Dick; (1989)]. Therefore if exercise is being taken with a view to improving a particular element of fitness it must have a direct influence on the component of fitness being stressed. In other words it is not simply a case of being active but rather the activity being undertaken should emphasise the specific muscles and systems which have been identified for improvement. For example, considering the role of exercise in relation to CHD, if it is to relate to the prevention of this disease then it must be exercise which will specifically involve the cardiovascular system since it is in the heart and blood vessels which suffer the consequences of CHD. This argument not only applies to CHD but also other hypokinetic disorders on which physical activity can have a positive effect.

Realisation of the benefits of exercise to health has introduced a new concept; health related physical fitness (HRPF). HRPF is concerned with fitness development aimed at the prevention and amelioration of the hypokinetic disorders and enhancing physical and psychological well being. [Falls; (1980), Pate; (1982) and Almond; (1983)]. In essence HRPF is fitness that lets you get the most out of life. Hebbelinck; (1984) introduces another important aspect of HRPF.

> "every person has a different level
> of physical fitness".
>
> Hebbelinck; (1984)

Concern for the individual is a key feature of fitness for health because everyone has a particular set of circumstances, health profile and lifestyle which will be determining factors as to the type and amount of physical activity likely to be undertaken [Armstrong and Bray; (1987)].

In determining a programme of exercise for health the individual nature of health and fitness should be considered. Since HRPF is an umbrella term covering a number of separate components the individual should identify those components of HRPF which are most relevant in terms of current health status, commitment and lifestyle.

The components which comprise HRPF are; Cardiorespiratory Endurance, Body Composition, Flexibility, Strength and Muscular Endurance. [Falls; (1980), Biddle; (1980) and Pate; (1982)].

Fentem, Bassey and Turnball; (1988), Falls; (1980) and Scottish Health Education Group; (1988) give an overview of the role of each HRPF component. In relation to the foregoing discussion in terms of CHD amelioration and prevention and the enhancement of individual well being the principal HRPF component is cardiorespiratory endurance, described by Falls; (1980) as

> "the most important concept in the health related fitness area"
>
> Falls; (1980)

If physical activity is to be tailored to the cardiorespiratory system it will focus on the response to exercise of the body's oxygen transport system. Clearly all exercise elicits some degree of cardiorespiratory response either before during or after it takes place, however exercise which has a positive effect on the cardiorespiratory system is that which places a sustained demand on the system. This concept of sustained demand is the key to identifying the most suitable forms of exercise as Beauchamp; (1982) indicates;

> "research indicates that potential health and fitness benefits result from endurance rather than power -oriented activities".
>
> Beauchamp; (1982)

Endurance in any physiological system or fitness component describes the ability to sustain performance. Therefore the term cardiorespiratory endurance refers to the ability of the heart, lungs and blood vessels to supply oxygenated blood to the working muscle and a suitable network for returning the venous blood to the heart and lungs for re-oxygenation.

> "CARDIORESPIRATORY ENDURANCE :
> The ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscles, allowing activities that involve large muscles ----- to be performed over long periods of time".
>
> Fox and Mathews; (1981)

The above quotation introduces the key to establishing the correct type of exercise to develop cardiorespiratory endurance. The important factor is oxygen transport because it is the ability to transport and transfer oxygen to the working muscle that determines the efficiency of the cardiorespiratory system. The greater the system's efficiency the fitter the individual. A more detailed review of this is contained in the methodology chapter which follows.

In terms of exercise and HRPF, increased cardiorespiratory fitness means more efficient body function at rest and during exercise with greater amounts of oxygen available at muscle level.

> "This increases the individual's ability to work and/or exercise at a greater intensity and/or a longer period of time."
> Falls, (1980)

1.03: EXERCISE AND ACTIVITY IN CHILDREN

Examination of studies into children's cardiorespiratory fitness levels and assessing their findings can help develop a picture of the extent to which physical inactivity and low cardiorespiratory fitness are likely to become established as the children grow older.

> "Lifetime habits are formed in childhood. If exercise is to be an integral part of life, it should be incorporated into the daily routine from an early age. --- children who have not established a routine of regular activity are likely to settle for inactivity in adulthood."
> Fentem, Bassey and Turnball; (1988)

Gilliam et al; (1982) identified physical activity as a common feature in children's lives. This view is supported by Bassey; (1984) who reported considerable variety in the activity levels of secondary school children, ranging from attempts to avoid PE and other activity, to participation limited to school PE, to those who enjoy frequent involvement in sport and physical activity.

Central to HRPF teaching is the concept of promotion and development of an exercise habit in childhood which can continue as lifelong physical activity. This is reinforced by Fox and Corbin; (1985), Poole; (1984), Misner; (1984), Franks; (1984) and Watkins; (1985). The concerns expressed by these and other researchers have been motivated by the findings of investigations of children's fitness levels and have in turn promoted further research to examine levels of HRPF, particularly cardiorespiratory fitness, in children.

In Scotland two investigations into school children's fitness levels took place to try to establish data for descriptive and comparative purposes.

The children's fitness surveys examined boys and girls on separate occasions. The results of the girl's survey; [Watkins, Farrally and Powely; (1983)], generally supported the findings of the earlier boy's survey; [Farrally, Watkins and Ewing; (1980)] which reported low levels of cardiorespiratory fitness in Scottish schoolboys. At this point it should be noted that emphasis will be placed on the boys' results since this research was conducted with a boy subject cohort. Further to this the poor findings of the boys' fitness survey were a factor in motivating this investigation into the effects of PE on cardiorespiratory fitness.

The results of the research were far from favourable in terms of the fitness of Scottish schoolboys, describing poor levels of performance in all fitness components including cardiorespiratory endurance. Farrally, Watkins and Ewing; (1980) reported that

> "the Scottish schoolboy has a low level of physical work capacity and therefore poor cardio-vascular respiratory functioning. Indeed the present Scottish child is not only inferior to his peers in other countries he is probably inferior to his own predecessors, and this suggest that the incidence of coronary heart disease in Scotland ---- is likely to increase as these boys reach maturity."
>
> Farrally, Watkins and Ewing; (1980)

The authors went on to conclude:

> "In order to stress the heart, blood

> vessels and lungs sufficiently to have a training effect it is necessary to undertake exercise that requires the recruitment of large muscle masses for relatively long periods of time. It is obvious that the Scottish child is not participating in these activities with sufficient regularity and frequency."
>
> Farrally, Watkins and Ewing; (1980)

These findings in relation to boys' cardiorespiratory fitness levels give one possible reason for Scotland's poor standing in the CHD league table. Perhaps more worrying however is that since cardiorespiratory fitness is largely influenced by appropriate regular physical activity it is clear that children may not be sufficiently active to enhance cardiorespiratory endurance. This combined with the fact that habits formed in childhood carry over to adult life, indicates that, as far as exercise is concerned the habit to be continued seems to be physical inactivity rather than the more productive habit of regular exercise.

In a general review of fitness levels in children Tuxworth; (1988) compares and contrasts the findings of a number of studies and raises some important points in relation to fitness and activity levels. Tuxworth supports the National Forum for Coronary Heart Disease Prevention; (1987) who report

> "Only a minority of adult men in the UK and an even smaller percentage of women, take frequent active exercise. In children the situation, both at school and in leisure time seems to be deteriorating."
> National Forum for Coronary Heart Disease; (1987)

This point is developed further to consider the role of physical activity in relation to the poor fitness levels already described.

> "Any individual's functional capacity is also a reflection of habitual demand. If the normal exertion is slight, the functional capacity will develop accordingly.
> Tuxworth; (1988)

This point reinforces the work of Farrally, Watkins and Ewing; (1980) who also suggest that a lack of physical activity is an important factor in explaining the low fitness levels of Scottish schoolboys. Tuxworth also identifies what the researcher believes to be a critical question for future research, namely the fact that although more and more data is being obtained on children's fitness there is as yet no indication as to what are acceptable levels of fitness for children in relation to positive health status.

"true longitudinal monitoring of large populations by means of comparable indices of fitness on the same individuals over a substantial period of time is virtually non-existent---
--- no one has demonstrated a level of fitness above which adults or children might be said to have healthy cardiorespiratory systems.

Tuxworth; (1988)

1.04: PE AND PHYSICAL ACTIVITY

The focus for this research examines PE in relation to cardiorespiratory fitness development. However it is essential to remember that this is only one perspective from which PE can be viewed. PE should reflect a range of objectives, a view supported by the Physical Education Association; (1987) who report nine teaching objectives for PE with skill and physical development viewed as the most important by PE staff.

This need for balance in the PE programme is considered by Farrally and Green; (1986).

"current emphasis in the school physical education programme is on skill acquisition in a broad spectrum of activities. --- staff see as their

> priority the teaching of skills to
> enable their pupils to become competent
> in a wide range of activities.
> Farrally and Green; (1986)

In recent years many significant changes have taken place in Scottish Education through a series of reports covering school curricula at all levels of education. These reports have important implications for the role of PE in relation to physical activity.

The Consultative Committee on the Curriculum (1986) in its report "Education 10-14 in Scotland" states.

> "The curriculum over the years 10-14
> should be designed to contribute to
> the pupils' capacity to ---
> Display interest and skill in bodily
> exercise and games and have appropriate
> knowledge and attitudes in matters
> relating to health, hygiene and the
> environment."
> Consultative Committee on the Curriculum; (1986)

The Consultative Committee on the Curriculum go on to identify a number of "aspects of experience" designated essential elements in a balanced 10-14 curriculum. One of these essential aspects of experience is "Physical Development and Well Being". This area is discussed in detail in the report but the points which follow are particularly relevant to HRPF.

> "The schools have much to offer in extending and deepening all children's awareness of the links between leisure, recreation and health. We have already emphasised the need for children to have experiences that are related to practical living and to the role that physical activity can have in healthy living."
> Consultative Committee on the Curriculum; (1986)

The points made in relation to appropriate curriculum content for ten to fourteen year olds give a firm statement of commitment to health and physical activity which should be included in the PE programme in years to come.

The Munn Report published in 1977 made recommendations as to "The Structure of the Curriculum in the Third and Fourth Years of the Scottish Secondary School". Here again specific "modes of activity" are described as necessary within a balanced curriculum. One of the eight specified modes of activity is physical activity.

The report states that physical activity has

> "an important contribution to make to the pupils' well-being. In a society

> in which there is a considerable
> incidence of bad posture, of obesity,
> of heart disease and other types of
> physical malfunctioning there should
> be little need to stress the importance
> of physical education and the
> maintenance of general vitality by
> engaging in regular exercise at school
> and afterwards."
> Scottish Education Department; (1977)

Looking more directly at the role of HRPF in Standard Grade PE the report also describes three essential areas of knowledge, one of which relates to knowledge of the human body.

> "including sufficient facts about
> structure and sufficient principles
> relating to function to support safe
> performance to provide a basis on which
> to make decisions affecting health and
> to promote understanding of the effects
> of physical activity."
> Scottish Examination Board; (1987)

This recognition given to the role of HRPF in standard Grade PE is an important step and one which can easily be related to the work mentioned previously in terms of the most effective ways of teaching HRPF to children. Despite the Munn Report's commitment to the value of HRPF within the PE programme for 14 to 16 year olds the researcher would question the commitment of the PE profession itself to the inclusion of HRPF in the PE curriculum. The basic format for Standard Grade PE course structure offered by the Scottish Examination Board (Short Life Working Group on PE); (1987) suggests eight possible course components;

> "Gymnastics, Dance, Water-Based Activities, Outdoor Pursuits, Individual Activities (directly competitive), Individual Activities (indirectly competitive), Games and Thematic Study. ---
> The course should include activities from a minimum of five of these categories"
>
> Scottish Examination Board; (1987)

From the above list it can be seen that although a wide range of activity categories are mentioned there is no reference to fitness related areas such as HRPF. The PE profession does not appear to perceive the fitness area as being of sufficient importance to merit inclusion as a Standard Grade component. This is not to say that there will be no attention paid to fitness development within Standard Grade PE. Rather, the assumption is that in the "Thematic Study" fitness will be the common theme to the other course components. However, the Thematic Study, with or without fitness as its content is not a compulsory element of the course. Therefore it is possible that a pupil could gain a Standard Grade certificate in PE without having any practical involvement in fitness. The researcher believes that this is not satisfactory and indeed runs contrary to the original statements in the Munn Report.

The final age range likely to participate in school PE is the sixteen to eighteen age group. The involvement of the PE profession, the Scottish Sports Council along with Scottish Vocational Educational Council (SCOTVEC) has led to the development and rapid expansion of the numbers of courses being offered under the Cognate Group heading of Physical Education and Recreation.

This increase in the numbers of modules is highlighted by the rapid increase in the presentations of students for the SCOTVEC National Certificate.

> "In 1984 SCOTVEC introduced 16 modules for Physical Education and Recreation. They were extremely successful and by the summer of 1988 student presentations had reached 6471 from 39 colleges and 5029 from 123 secondary schools."
>
> SCOTVEC; (1988)

Early recognition of the tremendous interest shown in the SCOTVEC system led to a review of the courses on offer and there are now in excess of 215 modules available for study within the following broad categories; Sports Leadership, Practical Performance, Health Related Fitness and Movement Observation and Analysis. It is particularity important to note the inclusion of Health Related Fitness as a separate category. This category includes two 40 hour modules: Physical Well Being; Health and Fitness and Planning Personal Fitness. The importance of these modules has been recognised not only by SCOTVEC but also by the PE staff involved in teaching the courses as they are the most widely taught of the modules in the PE and recreation area.

While recognising the fact that balance within the PE curriculum is important it is clear that fitness is an important feature of the school PE programme and this raises two further issues; i) What is the role of fitness within PE ? ii) How effective is the school PE in terms of improving children's fitness?

Much of the responsibility for children's physical fitness and its development must fall upon PE as Seliger et al; (1978) point out

> "the school physical education program
> presents the most suitable area for

> influencing the motor regimes of youth"
> Seliger et al.; (1978)

In view of this the school should play an essential role in determining the development of cardiorespiratory fitness in children through its PE programme. However, as described, fitness levels may be poor in children and it therefore appears that

> "It cannot be assumed that the current physical education programme in schools will ensure that the child will reach a satisfactory level of physical fitness."
> Farrally, Watkins and Ewing; (1980)

Further explanation of existing practice in school PE is offered by Farrally and Green; (1986)

> "It is dangerous to assume, --- that the child is sufficiently active in physical education lessons to maintain adequate levels of fitness."
> Farrally and Green; (1986)

Concerns for the effectiveness of the school PE programme in developing and maintaining cardiorespiratory fitness are also expressed by Johnson; (1985) in a discussion of the role of PE in relation to HRPF.

> "As a profession we claim to be the caretakers of youth fitness. But in far too many cases we are teaching a haphazard curriculum --- it is imperative that each teacher and/or administrator evaluate the extent to which fitness basics are taught."
>
> Johnson; (1985)

This supports the view that the PE programme may have limited effects upon pupils fitness levels. Despite this pessimism regarding PE's contribution to fitness development there is evidence, for example from the 16 to 18 age range and in the other curriculum developments described earlier that attitudes towards content in PE curriculums is changing in response to a realisation of the value of physical fitness.

Much of motivation for this change and the reason behind the previously discussed criticism of existing PE practise comes not only from the poor fitness levels found in children but also from the limited attempts made to evaluate the effects of PE lessons on the pupils taking part.

1.05: PHYSICAL ACTIVITY DURING PE LESSONS

Previous sections have indicated the benefits of exercise in terms of HRPF, and also the need for PE to devote time towards fitness within the curriculum. PE presents a significant opportunity to influence children's activity levels, contrary to this positive note however is the evidence which reported poor fitness levels in school children. These poor cardiorespiratory fitness results, particularly in Scottish schoolboys raise questions as to the the extent to which PE influences pupils cardiorespiratory fitness.

This section reviews the studies conducted into children's activity levels during PE lessons. This review is primarily conducted in terms of the aim and methodology of the major studies with only a limited evaluation of their results. A more detailed review of the results obtained is conducted in the discussion chapter.

Research into the effects of PE lessons on cardiorespiratory fitness is scarce. Despite lacking in quantity the research which has been conducted is consistent in the conclusion that PE is unlikely to improve cardiorespiratory fitness. [Verabioff; (1988), Hale and Bradshaw; (1978), Knowles; (1978), Faulkner et al; (1963), Seliger et al; (1978)]. Indeed, Cumming et al; (1969) concluded that cardiorespiratory fitness

> "of fairly fit boys was unlikely to change over a school year, no matter how many hours were allocated ---- to physical education, without the institution of a training program specifically designed to improve endurance fitness."
>
> Cumming et al; (1969)

As indicated there have been very few investigations into pupils' physiological response to PE lessons, and although drawing the common conclusion that PE would have little or no effect on cardiorespiratory fitness these studies can not be seen as definitive statements which can be applied to all activities taught as part of a school PE programme, or indeed of the overall programme.

A common feature of the studies conducted was the measurement of heart rate to evaluate the level of physical activity during lessons. Monitoring heart rate to indicate levels of physical activity utilises the linear relationship between increasing heart rate and an increasing oxygen uptake which is indicative of cardiorespiratory involvement. This relationship, although not perfectly correlated [Astrand and Rodahl; (1987)] represents the most convenient and practical means or assessing pupils response to PE lessons. A more detailed review of the methodologies most frequently applied to the monitoring of physical activity in children follows in a later section. This includes a detailed analysis of the methods of heart rate monitoring used in the two major investigations conducted into activity during PE lessons [Hale and Bradshaw; (1978) and Knowles; (1978)]. The study conducted by Verabioff; (1988) was not considered in the design of the present research as Verabioff's work had not been reported when this research started. It is however, reviewed in detail in the discussion of results obtained in this study.

In light of the above point and in terms of the references to investigations of activity during PE lessons cited earlier, it is the studies conducted by Hale and Bradshaw; (1978) and Knowles; (1978) which offered a reasonable starting point for this research, but only in broad terms since both studies exhibit limitations.

The analysis which follows provides a more detailed review of these studies and examines the limitations which were important to overcome in order to conduct the present research.

Neither Hale and Bradshaw nor Knowles gave any clear statement as to the purpose of their research. Also, both studies were descriptive surveys of heart rate during PE lessons in which a limited number of pupils were monitored while participating in a range of activities. The descriptive nature of the results presented had to be considered with regard to results interpretation and comparison with the present research.

> "Descriptive statistics are used to organise, summarise and describe measures of a sample. No predictions or inferences are made regarding the population parameters"
>
> Cohen and Holliday; (1979)

Consequently, although general statements relating to the group monitored were made it was not possible to make any statement about the results in relation to the other pupils who participated in the same lessons but who were not monitored. In other words no statements can be made about any wider group, even the rest of the class or year group, or about the overall effects of the activities in respect of cardiorespiratory fitness development as sampling was conducted during very few lessons.

Looking at the research design of these two studies there are limitations which further reinforce their descriptive nature and the degree to which generalisations can be made from the data obtained.

Four areas of critical importance in relation to the present study are the subject group, the activities monitored, the monitoring method and the results obtained.

With regard to the subjects monitored, Knowles used only one class of 20 first year school boys during a single lesson. Hale and Bradshaw's sample comprised of seven girls of ages ranging from twelve to sixteen years. A further limitation was that subjects were selected because they were considered enthusiastic participants in PE lessons. The fact that the sample was in essence hand picked for being favourably predisposed towards PE raises questions as to the extent to which Hale and Bradshaw's small sample can be viewed as being representative of either class or year groupings and can certainly not be considered representative of female adolescents participating in PE lessons.

Hale and Bradshaw gave no breakdown of age in relation to activity monitored thereby affording no indication of age specific heart rate response to particular activities. Knowles measured pupils in a first year class although no direct description of age was given. This lack of information regarding ages of subjects monitored is important since, as will be discussed later, there is considerable variation in maximal heart rate in subjects of the same age.

The researcher believes that a major limitation of both these pieces of research are the activities monitored. No rationale was provided as the basis for activity selection, a point which again reinforces their limitations in relation to generalising about PE from the data obtained. Considering this in terms of the present study the researcher decided to monitor all activities, except swimming, taught as part of the PE programme as it would then be possible to draw conclusions relating to the overall PE programme for the subjects and the class from which they were a representative sample.

Knowles monitored pupils during only one activity; gymnastics. Hale and Bradshaw on the other hand monitored a wider range of activities with their group of schoolgirls; keep fit, athletics, netball and badminton. Both studies are very limited since neither can be viewed as representative of the complete PE curriculum. Also no attempts are made to build a picture of heart rate response over a number of lessons with one particular subject throughout a block of activity. Although Hale and Bradshaw assessed a number of activities these would not all be taught to boys. Full details of the activities monitored in this research are given in the next chapter.

Heart rate was monitored in both studies. Knowles used a method of monitoring called a "Transistory Electrode Device", (Brooke and Knowles; 1971). Pupils were called at random from the lesson and then monitored over a 15 beat count, a further 5 beats were added to the figure obtained to compensate for the drop in heart rate following cessation of exercise. A major limitation of this was that no continuous measures were taken of pupils throughout the lesson, thereby providing no details of how pupils responded over the whole lesson.

Hale and Bradshaw monitored heart rate using a Socially Acceptable Monitoring Method (SAMI) heart rate telemetry system. Subjects were monitored continuously during lessons with the sampling method adopted taking 15 beat averages for conversion to a beats/minute heart rate. As mentioned, however, a major limitation is that no indication of age in relation to lesson heart rate data was given in terms of the activities monitored.

Lesson monitoring methodology was a critical issue for this research and consequently a more detailed review of available methods is reported in a subsequent chapter. This includes further evaluation of the methods outlined above.

Hale and Bradshaw did not relate heart rate response to fitness status. Knowles however assessed cardiorespiratory fitness with a view to relating oxygen uptake to activity level. Despite this there were limitations as Knowles did not assess the fitness of the complete group nor did he relate fitness level to individual activity level throughout the lesson.

A further limitation of both studies is that neither attempted to evaluate the conditioning effect of a complete block of PE lessons or the overall effect of the PE programme on cardiorespiratory fitness.

Earlier in this chapter a number of developments were identified which appeared to commit PE to greater involvement in the development of cardiorespiratory fitness as an important element in a balanced PE programme, however the limited research conducted to date casts considerable doubt upon PE's effectiveness in terms of cardiorespiratory fitness improvement.

The development of physical fitness should be a serious aim of PE and research is required to quantify current activity levels during PE lessons. The data obtained should then be related to pupils' fitness and to the standardised guidelines for cardiorespiratory fitness development.

1.06: RESEARCH HYPOTHESIS

The preceding sections have described poor levels of cardiorespiratory fitness in school children and indicated that the secondary school PE programme may be of limited value in terms of cardiorespiratory fitness development.

Examination of the limited research in this area provides the researcher with the following research hypothesis:

> "The secondary school PE programme is not of sufficient intensity to improve cardiorespiratory fitness."

In order to research this hypothesis two separate but complementary approaches were adopted. Firstly the hypothesis was examined by regular assessment of subjects' cardiorespiratory fitness throughout the school year. This provided an indication of any cardiorespiratory fitness change.

Secondly, in order to see if the PE programme was likely to promote improved cardiorespiratory fitness the hypothesis was examined by monitoring subjects' heart rate responses to PE lessons throughout the year long monitoring period. This provided data on individual subjects, the research cohort, the class in general, and blocks of activity taught within the overall PE programme.

A detailed breakdown of the methodology adopted to test the research hypothesis is contained in the next chapter.

CHAPTER 2: METHODOLOGY

CHAPTER 2: METHODOLOGY

2.01 RESEARCH FRAMEWORK

The research described took place from August 1985 to August 1986. It should be noted that the work was conducted within the boundaries of a PE Department programme during a period of industrial action in schools. These restrictions had to be considered in the planning, implementation and evaluation of this study.

The features of this industrial action that were most relevant were, firstly, an embargo on curriculum development and secondly, problems with regard to teacher duties and cover for colleagues within the school. The restrictions on development work applied to courses not on the timetable at the start of the 1984-85 academic session. Fortunately this school was already committed to involvement in an HRPF research project and so, with the school's permission, it was relatively easy to extend involvement to cover a range of activities within the PE programme for S1 boys in addition to the specific HRPF course. This also allowed for comparison of the HRPF course with other activities on the timetable.

The second restriction imposed by industrial action applied to teachers' duties within the school and cover of classes. This meant that the only time for access to pupils in the research group was during periods when they were in the PE department. Therefore all testing and lesson monitoring had to be conducted during PE classes as it was not possible to work with pupils during intervals or lunch breaks, after school or to extract pupils from other classes without violating the conditions of the industrial action.

This issue had important implications with regard to the overall research design since all methods adopted would have to be such that they could be administered during class time allocated to PE. From the monitoring point of view this meant that suitable field measures were required, since pupils were not able to travel out of school to undergo laboratory tests. Field tests, however, had the further advantage that they could be administered to the complete group of subjects during one double PE period at the start and finish of a term thereby leaving the remainder of lessons to monitor activity levels.

Overall, the industrial action was not detrimental to this research as it resulted in little or no disruption to the pupils' lessons. On the contrary this was a positive point as the testing and lesson monitoring soon became readily accepted by the class in general and more specifically the pupils involved in the study. This resulted in pupils participating normally in their PE lessons, increasing confidence that the data collected truly reflected children's involvement in normal PE lessons.

The PE programme in this school was consistent with that of other secondary schools. The pupils were taught a broad curriculum of Outdoor Games, Indoor Games, Swimming, Athletics and HRPF.

In S1 pupils received a total of three 60 minute periods per week. Time was divided into one 120 minute session when Outdoor Games, Swimming or Athletics were taught. Indoor Games or HRPF were taught in the single period.

This particular school's involvement with the HRPF project meant that the researcher was already familiar with the school, its PE department and the PE staff. The interest shown and the friendly atmosphere extended towards the researcher made this school a very good choice at a time when many would have been unwilling to become involved.

Selecting this school also afforded one further benefit since the class had a block of lessons devoted to HRPF as part of their PE programme. This in turn would allow comparisons to be made between a course devoted specifically to HRPF and activities more traditionally associated with S1 PE programmes.

As the foregoing points have outlined several restrictions affected the final design. It is argued that the outcome of this had a positive effect on the study in at least two ways; the most efficient use of time and the minimum disruption to the pupils' PE classes, and, as the work was very much "self contained" in the PE department the study shows that evaluation of physical activity and its effects on cardiorespiratory fitness can be carried out in the school context.

In order to evaluate the effects of PE on cardiorespiratory fitness two considerations had to be made. Firstly, there had to be a measure of cardiorespiratory fitness which could be administered in order to assess changes in the boys' cardiorespiratory fitness levels. Secondly, in order to evaluate the effects of PE on cardiorespiratory fitness there had to be a suitable means of monitoring pupils' activity levels during PE lessons. Measurement of activity levels in PE lessons allows judgment of not only individual responses to lessons, but also the comparative effects of different activities. It also helps to indicate whether or not individuals of differing fitness levels participate with varying degrees of intensity. This information could then be compared to standard guidelines for the development of cardiorespiratory fitness development in order to assess the likely effects of the PE programme.

In summary the measures adopted to evaluate the effects of school PE lessons on cardiorespiratory fitness involved data collection on levels of cardiorespiratory fitness and levels of activity during PE lessons. Additionally, appropriate anthropometric data were collected to assist in interpreting results.

The sections which follow provide a rationale for the selection of subjects, the monitoring methods and protocols used to collect data.

2.02: SELECTION OF SCHOOL AND SUBJECTS

The catchment area of the school selected was a densely populated urban area of council housing with recognised social deprivation [Glasgow 2000; (1989)]. The first year comprised six classes with a combined total of approximately 100 boys. The school population was approximately 950 pupils.

The first year boys class which was involved in the HRPF project was selected because the class was already involved in some fitness work so to them the fitness assessment and lesson monitoring was likely to become a normal, standard aspect of their PE programme.

As the only time available to work with the group was during timetabled PE lessons the following considerations determined the sample size; first, the fitness testing programme should be capable of administration to the whole group in no more than one double PE lesson, thereby leaving the greatest possible amount of time during the year to be directed towards specific lesson analysis. Second, the practical factors of attendance and behaviour in school were important considerations. These points were difficult to establish so early in secondary school life, however their relevance to the implementation of the study soon became apparent as absenteeism and suspension due to behavioural problems influenced the monitoring programme and the sample size.

The class from which the sample was taken numbered 28 pupils. A method of random sampling, as described by

Cohen and Holliday; (1982) was adopted, thereby giving all pupils an equal chance of being involved in the research.

Following selection a letter was sent to the boys' parents giving an outline of the research and indicating the extent and type of pupil involvement. All parents to whom the letter was sent agreed to their son's involvement.

At the first monitoring session all 12 pupils were assessed. This was the one and only occasion when the complete group was present to be monitored. As the research progressed it became clear that not all of the 12 boys were sufficiently reliable school attenders. The class as a whole comprised a number of disruptive pupils (at least eight boys had been suspended by the end of term two). The combined effects of disruptive behaviour and poor attendance caused the reduction in the number of subjects from the original 12 to the final group of 9 who were monitored throughout the year. The final group of 9 proved to be reliable school attenders with good behavioural records.

As described 9 pupils were selected from a class of 28 first year boys. In order to verify that the research group was representative of the class as a whole a comparison was carried out on the basis of performance on the 6 Minute Run test of cardiorespiratory fitness (EUROFIT: (1983). The results of this comparison are described in Table 2.01 below:

	GROUP	
	Research	Class
N	9	25
$\bar{X}$	1243.3	1280.8
SD	168.1	139.1
t-test	no significant difference	

TABLE 2:01 Mean and Standard Deviation for 6 Minute Run

From Table 2.01 it can be seen that there is no significant difference in cardiorespiratory fitness as measured by the 6 Minute Run Test between the research group and the class as a whole. On this basis the researcher believes that the sample selected for the research was representative of the class as a whole.

As indicated in the previous chapter the research comprises two separate, but complementary strands within the overall investigative strategy. First is the issue of cardiorespiratory fitness. The basic considerations relating to this are; does cardiorespiratory fitness change over the period of the school year and if there is a change to what extent can this be attributed to physical activity levels promoted within the school PE programme? This latter point leads into the second major issue for the research, namely, the need to indicate the likely effects of the school PE programme in relation to physical activity levels considered necessary to develop and improve cardiorespiratory fitness.

As the topic can be viewed as having these separate components the remainder of this chapter is in two parts. The first examines the rationale and methodology for monitoring cardiorespiratory fitness. The second examines the rationale and methodology for evaluating the school PE programme in terms of cardiorespiratory fitness development.

2.03: TEST SELECTION

In terms of cardiorespiratory fitness the fitter individual will be the one with the greatest ability to utilize oxygen from inspired air. Therefore in terms of testing cardiorespiratory fitness the optimal measure is the one which best assesses the body's ability to consume oxygen. Consequently, cardiorespiratory fitness is best examined in relation to oxygen consumption, or oxygen uptake. [MacDougal et al.; (1982), Lamb; (1978) and British Association of Sports Sciences; (1988)].

> "if a physical educator, coach or physician wishes to evaluate one's circulorespiratory fitness or one's capacity for aerobic activity, he should try to estimate the maximal functional capacity of the heart, lungs and circulation of the student, athlete or patient. This maximal functional capacity of the circulorespiratory system is best evaluated with a test of the body's capacity to consume oxygen at a maximal rate, that is, with a maximal oxygen uptake test."
>
> Lamb; (1978)

A further essential factor in assessing cardiorespiratory fitness is the role played by aerobic metabolism in the performance of activity.

> "Dynamic (isotonic, aerobic) exercise involves the rapid rhythmic movement of large muscle masses against little resistance. This type of work has a high oxygen cost"
>
> Hammond & Froelicher; (1984)

This involvement of large muscle masses in aerobic work means that the body will be placing a general demand on the cardiorespiratory system since oxygen transportation will be the key factor in sustaining performance and this in turn means that aerobic metabolism dominates.

> "the amount of oxygen consumed (VO_2) depends on the amount of blood pumped (cardiac output: CO) and the amount of oxygen extracted from the blood---. Since anaerobic work can be performed for only very short periods of time, the maximal work capacity is directly related to a subject's maximal ability to consume oxygen. Thus the direct measurement of VO_2 max has become the gold standard for the quantification of aerobic capacity."
>
> Hammond and Froelicher; (1984)

The mode of exercise chosen for the assessment of cardiorespiratory fitness should reflect the need for large muscle involvement with the most frequently adopted methods of assessment being running, stepping and cycling [Cooke; (1985), Shephard; (1984) and Lamb; (1978)].

> "The determinants of endurance effort vary, depending on the extent of the muscle mass that is activated, large muscle work, such as treadmill running, is halted by impending circulatory

> failure. ---Activities that depend upon the use of a relatively small muscle group undoubtedly have some peripheral limitation, but this reflects difficulty in perfusing vigorously contracting muscles"
>
> Shephard; (1984)

Further to the role of the musculature involved in the selection of a measure of cardiorespiratory fitness is the type of test to be selected. This question is concerned with issues pertaining to the degree of complexity of equipment and protocol associated with a particular test. The standard means of assessing cardiorespiratory fitness involves the direct measurement of maximal oxygen uptake in the laboratory, by exercising the subject to exhaustion. The maximal rate of oxygen consumption can be directly established and thus provides a precise measure of cardiorespiratory fitness. (British Association of Sports Science; 1988). This measure is dependant on the availability of appropriate, expensive, laboratory equipment and, more importantly in the case of this research, it requires considerable time involvement on the part of the researcher and the group of subjects.

> "---the measurement of VO_2 max is time consuming, demanding expensive laboratory equipment and trained technicians"
>
> Miyashita et al.; (1985)

As already reported the limitations placed on this research meant that the assessment of cardiorespiratory fitness had to be conducted within the school situation and within the timetabled PE programme in the school. For this reason it was not feasible to use maximal oxygen uptake to assess the subjects and an appropriate alternative had to be selected.

Realisation of the limitations and problems involved in the direct assessment of maximal oxygen uptake has led to the development of numerous field tests of cardiorespiratory fitness. An appropriate consideration of this problem is offered by the Australian Council for Health, Physical Education and Recreation who, when faced with a similar problem identified three levels of test for their survey of Australian children's fitness;

> "Level 1 tests are those considered ideal for measuring the parameter of interest --- Level 2 tests --- are readily administered to a large number of subjects, in the field. From the standpoint of estimating the health and fitness of this school population, these tests will play the central role."
>
> Coonan and Dwyer; (1983)

The authors also describe a third level of assessment as being appropriate for administration by school PE staff, but with this level of assessment the data obtained may be less reliable and valid with regard to the particular fitness component.

In terms of cardiorespiratory fitness the level one measure would be direct assessment of maximal oxygen uptake. Selection of an appropriate level two test presents a wider choice of alternatives.

In considering the most appropriate test a balance had to be struck between the optimal measure and the practical constraints influencing test implementation.

The problem of direct measurement has been recognised for some time and has led to the evolution of a variety of submaximal and predictive measures of oxygen uptake and physical working capacity.

In a review of tests used for the assessment of cardiorespiratory fitness Cooke; (1985) considered the relative merits of various modes of exercise used in tests.

Tests which involve running/walking, such as the Cooper 12 Minute Run [Cooper; (1968)] or the 6 Minute Run

[EUROFIT; (1983)] require maximal effort from the subject as the test involves running/walking as far as possible in the given time.

> "The subject acceptability of maximum performance tests is also dubious--- Maximum effort in performance of run/walk timed tests is subject to the major variables of motivation and pace judgement."
>
> Cooke; (1985)

With children motivation in exercise testing is a particular problem in cases where the child is required to perform at maximal levels [Shephard; (1987)]. This issue is also raised by Zwirnen; (1989) who notes that in maximal tests:

> "A major problem with testing children is their short attention span and unwillingness to perform under the degree of physiological strain necessary to achieve a true maximal value. For children, therefore, motivation may be the limiting methodological problem."
>
> Zwirnen; (1989)

A further feature of run/walk tests is that they are primarily outdoor tests and as such are subject to effects of weather and surfaces, for example, in terms of windy or wet conditions. The variables mentioned all combine to make it difficult to administer the test under standardised conditions which in turn will affect the validity of data collected.

This conclusion is consistent with the categorisation suggested by Coonan and Dwyer; (1983) who suggest that this type of test be classed as a "Level 3" measure in recognition of the easy administration and frequent use of such tests. It is also noted by Coonan and Dwyer that the data obtained from run/walk tests should not be considered as absolutely valid in relation to the optimal standard of maximal oxygen uptake and that reliability is subject to rigour through the standardised administration of the test selected.

Cooke; (1985) also examined the use of step tests to measure cardiorespiratory fitness. Step tests differ from all other measures of cardiorespiratory fitness in that the subject's score for the test is based on heart rate recovery. The tests involve stepping on and off a calibrated bench at a predetermined rate for a set time. Cooke concludes that:

> "Control of technique and stepping
> cadence is a problem with any step
> test and liable to be most accute with
> less fit, older and very young persons.
>
> Cooke; (1985)

Returning again to the differing level of test sophistication suggested by Coonan and Dwyer; (1983) it seems that stepping tests are essentially applicable to the "Level 3" category.

Having identified types of test for levels 3 and 1 it is appropriate to consider the Level 2 category, particularly in view of the fact that the restrictions acting upon this research prevented the use of the Level 1 measure (maximal oxygen uptake) and that doubts have been expressed as to the validity and reliability of Level 3 measures.

The principal form of testing available at Level 2 involves the use of bicycle ergometry.

> "Ergometry is usually associated with measurements or prediction of the capacity and efficiency of the oxygen transport system, because it reflects the individuals ability to engage large muscle groups"
>
> Astrand; (1984)

Bicycle ergometry is frequently adopted for field testing. It provides a portable testing facility and for this reason and because cycle ergometers are relatively inexpensive, it has been used extensively in mass fitness surveys where more precise data is required but there is time to measure at the individual level. It should be noted that cycle ergometry has been criticised for the following reasons:

> "A high proportion of the power output is developed by the quadriceps muscle--- The effort required is large relative to muscle strength---(and)---Effort is peripherally limited by muscle pain and weakness".
>
> Shephard; (1984)

These negative factors have not detracted from the extensive use of cycle ergometry. While being tested on a cycle ergometer the subject is in a stationary position thereby affording greater accessibility to take physiological measurements, in particular heart rate. Calibration of the ergometer is a relatively simple process and this, combined with the fact that work intensity can be varied easily and set with accuracy, makes the cycle ergometer suitable for use in this study.

Having identified the cycle ergometer as a suitable method of testing it is now appropriate to consider the cardiorespiratory tests which use this mode of testing.

The most widely used cycle ergometer tests require submaximal effort at standardised work intensities. A further characteristic of cycle ergometer tests is that they tend to utilize heart rate measures to indicate the intensity of effort produced by the subject in response to a given work load(s).

> "heart rate during exercise is used to calculate estimated VO_2 max., or work or VO_2 at a standard level of heart rate".
>
> Cooke; (1985).

The above point introduces the major difference between the two most popular submaximal measures of cardiorespiratory fitness. One test, the Astrand-Rhyming test, used heart rate in response to a given work load to predict the subject's maximal oxygen uptake. The other test of Physical Working Capacity states a level of work which the subject can perform at a given heart rate. Commonly this is 170 beats/minute (PWC 170) but may be a percentage of the age-related maximal heart rate (e.g. PWC 85%). In deciding on the most suitable measure for this study it is appropriate to examine both tests.

2.04: ASTRAND-RHYMING TEST

The Astrand-Rhyming test is based on the Astrand-Rhyming Nomogram; (1957) and uses heart rate response to a steady state bout of exercise lasting six minutes to predict maximal oxygen uptake. It assumes linear relationships between three physiological parameters; oxygen uptake, heart rate and work intensity. It is logical to assume that there will be some degrees of variation between this prediction and directly measured oxygen uptake.

> "The standard error of prediction of VO2 max. using the Astrand-Rhyming nomogram is about 10% in relatively well trained individuals of the same age, but up to 15% in moderately trained individuals."
>
> Cooke; (1985)

The greatest source of error in the test arises from the use of heart rate as the basis for assessing maximal oxygen uptake. Many factors can influence heart rate, these include; age, fitness, status, temperature, anxiety, time of last meal, smoking, genetic endowment and environmental factors. A further detrimental influence of heart rate is the assumption in the test that the subject's

> "maximal oxygen uptake and the maximum heart rate are reached at approximately the same time"
>
> Sinning; (1975)

This problem is noted by Davies; (1968) who indicates that the relationship between heart rate and oxygen uptake is asymtotic. Nagel; (1973) supports this stating;

> "the H.R. - VO_2 curve is not strictly linear, so extrapolation to a maximal H.R. would not be appropriate."
>
> Nagel; (1973)

Another limiting factor on the use of heart rate to estimate maximal oxygen uptake is the relationship between heart rate and age. This is a particularly important consideration for this study where the subjects were children.

In the original Astrand-Rhyming nomogram the maximal heart rate for the group in their mid twenties was assumed to be 195 beats per minute; [Astrand and Rhyming (1954)]. This assumed maximum does not account for variation in age and its resultant effects on maximal heart rate. The effect of age on maximal heart rate is considered by Davies; (1968) who reports that maximal heart rate drops by approximately 10 beats/decade. In addition Davies reports variations in maximal heart rate in individuals of a similar age.

The fact that an assumed maximal heart rate was a source of error led to the introduction of age correction factors in later versions of the nomogram. (Astrand; (1960). By using these factors the prediction of maximal oxygen uptake is related to a more appropriate age related maximal heart rate for the individual but this does not measure error due to variability in maximal heart rates for people of the same age.

On examination of the age correction factors supplied as part of the test documentation one discovers that the lowest age catered for is 15 years, therefore any attempt to use the test with the group in this study (aged 11 and 12) would invalidate the test.

> "It should be emphasised that the nomogram is based on results from experiments with healthy subjects 18 - 30 years of age. We do not know its validity when testing younger or older people or patients with diseases in the oxygen transporting system".
>
> Astrand and Rhyming;(1954)

Clearly, the Astrand Rhyming test is unsuitable for use with subjects under 15 years of age and therefore unsuitable for use in this study.

> "the Astrand-Rhyming nomogram does

> not seem applicable to children aged
> 11 to 13 years for the obvious reason
> that it was not adequately evaluated
> from data on children".
>
> Tokmakidis et al; (1982)

In view of the possible problems involved in the prediction of this capacity is was necessary to select an alternative means of evaluating cardiorespiratory fitness.

One drawback with the use of maximal oxygen uptake in the assessment of cardiorespiratory fitness is that it provides little information about performance capability below maximum levels.

In health related fitness activities individuals are asked to exercise at a comfortable, sustained and submaximal rate. It may be that testing in relation to a maximal exercise capacity is incompatible with health related fitness development.

In other words it may be more appropriate to evaluate cardiorespiratory fitness in terms of a sustainable, functional working level rather than a maximal capacity. There is physiological information which supports the concept that there may be a distinction between maximal oxygen uptake capacity and endurance performance.

Shephard; (1987) considers this issue stating that

> "with moderate intensity endurance training, the gain of fitness is larger in a submaximal than in a maximal test - an example of an intensity-specific pattern of response".
>
> Shephard; (1987)

Therefore it may be that by using maximal oxygen uptake as the criteria against which individuals are judged much information about their functional endurance capacity is being missed.

> "The measurement of VO_2 max is not an assessment of the subjects athletic performance per se; it reflects rather, the subjects maximal ability to use oxygen on a treadmill or stationary bicycle--- although VO_2 max. is the best available measurement of aerobic capacity it does not ideally reflect athletic performance".
>
> Hammond & Froelicher; (1984).

This distinction between aerobic capacity as measured by maximal oxygen uptake and endurance performance has been investigated by researchers from Loughborough University. The Loughborough research attempted to evaluate changes in endurance capacity relative to maximal oxygen uptake in a mixed group of 16 club runners.

> "The main finding of this study was the relatively small improvement in VO_2 max of 4.6% in contrast to the much larger improvement in endurance capacity of 168%. --- The results of this study suggest that training induced changes in endurance capacity are not adequately reflected by the modest increases in VO_2 max values."
>
> Williams and Nute;(1986).

In relation to the above findings it could be that if cardiorespiratory endurance is the focus of an investigation, as in this research, then a measure of cardiorespiratory endurance rather than maximal aerobic capacity would be the most appropriate.

One characteristic of any type of physical conditioning is adaptation. Indeed adaptation to the conditioning programme and its increasing workloads is what is meant by improving fitness.

> "Adaptation is the raising of the athlete's functioning capacity due to external loading."
>
> Dick; (1989)

If adaptation is considered in relation to cardiorespiratory fitness in terms of both endurance capacity and maximal oxygen uptake then several possible adaptations exist. Two of these training effects have already been discussed in that maximal oxygen uptake and endurance capacity can increase. One further adaptation has also been shown to be important, particularly with regard to selecting an appropriate test for this study.

> "It has been suggested that endurance training enables an individual to adjust to the energy requirement of constant load submaximal work more rapidly. --- Individuals with high VO2 max did not necessarily have a more rapid increase in aerobic metabolism at the onset of exercise. In summary the results of this study suggest that the magnitude of VO2 max does not appear to dictate the rate at which a steady-state in VO2 is attained."
>
> Lake et al; (1986)

The above points illustrate that when attempting to evaluate cardiorespiratory endurance the use of maximal oxygen uptake, although the best measure of aerobic capacity, may not be the most appropriate test of cardiorespiratory endurance. From the health related fitness perspective it may be better to provide a statement of what the subject can do in functional terms, for example - working capacity, rather than to extrapolate to a maximal potential representing an intensity of effort not expected of or necessary for the improvement of cardiorespiratory endurance.

This leads to consideration of the second type of test used previously, namely, a test of physical working capacity.

2.05: PHYSICAL WORKING CAPACITY (PWC) TESTS

PWC tests assess cardiorespiratory endurance by measuring the amount of work done by a subject at a pre-determined heart rate level. The heart rate criterion is set at a level at which the subject will be working aerobically and the greater the subjects working capacity at that heart rate, the greater the cardiorespiratory fitness level.

Unlike the Astrand Rhyming test where only one workload of six minutes is used PWC tests usually involve three or four workloads each lasting between two and six minutes. It has not been until recently that standardised protocol guidelines have been available.

The concept of PWC tests was developed by Walund in 1948. In recent years much research has been carried out in Europe to help establish a standard protocol for testing cardiorespiratory fitness in school children as part of the EUROFIT initiative.

The EUROFIT project started in 1977 with the following aims:

> "i. to establish a commonly agreed test Battery in Europe;
> ii. to help teachers in assessing the physical fitness of their pupils in schools;
> iii. to help in measuring the health related fitness of populations."
>
> EUROFIT, Council of Europe; (1988)

Several meetings were held over a ten year period but at a very early stage the PWC test was established as the recommended measure of cardiorespiratory fitness as it was decided by the EUROFIT project contributors that

> "The PWC 170 is the best available field test for the evaluation of cardiorespiratory fitness, being already widely used and comprehensively validated against standard laboratory measures".
>
> Klissouras and Tokmakidis; (1982)

In order to obtain a PWC 170 value the subject pedals a cycle ergometer. During the test the subject undergoes three or four incremental workloads designed to bring the heart rate steadily up to 170 beats per minute. The subject's PWC 170 value is then obtained either by direct observation if the value of 170 beats per minute was reached, or by extrapolation or interpolation to 170 beats per minute depending on the heart rate responses to the last two workloads. Interpretation of the subjects score is carried out on the basis that individuals with the highest PWC 170 values are able to work harder at the given heart rate. The higher the PWC 170 value, the greater the cardiorespiratory fitness level.

Klissouras and Tokmakidis; (1982) reviewed seven different studies correlating PWC 170 results with data from maximal oxygen uptake tests. The reported correlations for the seven studies range from 0.78 to 0.95 with a mean value of 0.87. These data support the validity of the PWC 170 test as a measure of cardiorespiratory fitness. Further support for the PWC 170 test comes from the conclusion that

> "laboratory work also revealed that
> the PWC 170 is clearly performed with
> aerobic energy sources"
>
> Tokmakidis et al; (1982)

However, perhaps the most significant reason to choose the PWC 170 test lies in the fact that it was selected by EUROFIT as the most appropriate measure of cardiorespiratory fitness for school children. In the light of this selection and the supporting research, it was decided to adopt the PWC 170 test for use in this study.

Having identified the PWC 170 as the best available measure of cardiorespiratory fitness it is now appropriate to decide on the protocol to be used.

> "many different protocols have been used for the measurement of PWC 170. Variations in work time range from 1 minute to 10 minutes. The number of workloads used seems more standardised with numerous studies using three or four workloads"
>
> Cooke; (1985)

The need to find the optimal protocol for the use of the PWC 170 test for children was recognised by the EUROFIT development committee and in 1982 a special seminar was organised to review the PWC 170 test and to decide on the protocol to be adopted as part of the final EUROFIT battery.

The EUROFIT seminar identified and discussed a number of issues which had to be considered with a view to finalising the protocol; intensity of work load and related increments, continuous or discontinuous protocol, pedalling speed, number of workloads and workload duration.

Increasing work intensity as required by the PWC 170 test could be achieved in three ways using a cycle ergometer; by increasing the cadence, by increasing the resistance or by a combination of these.

Pedalling speed is an important factor. Klausen et.al.; (1985) reported that when children were asked to pedal at 50 rpm the actual speed was almost 55 rpm. In the same study when subjects were allowed to pedal at a rate of their own choice the cadence observed was in the region of 65 rpm.

These rates are faster than the 50 rpm used in the prediction of maximal oxygen uptake, Astrand and Rhyming; (1954). In the PWC test a series of standard work intensities are administered. When establishing the intensity, cadence is an important factor. A reduced cadence means that a higher resistance would be needed in order to produce the required intensity. Therefore if 50 rpm was used it could be that the resistance to be added would be such that it would produce local muscular fatigue in the legs. Also since children find it difficult to pedal at 50 rpm the extra resistance would produce an even greater fatiguing effect.

The cadence or pedalling speed adopted by EUROFIT is 60 rpm [Tuxworth; (1982), Klissouras and Tokmakidis; (1982). Tokmakidis et.al. (1982)]. 60 rpm is maintained as a constant speed throughout the test. Increases in work intensity are therefore achieved by increasing resistance against which the subject has to pedal at this constant speed.

Two general approaches to increasing the resistance against which the subject has to pedal at this constant 60 rpm have been adopted. One approach involves administering three or four predetermined work intensities and observing the heart rate response to each work load. This rather arbitrary approach was adopted in the early stages of the test's development and was superseded by protocols more directly related to the subject's reported fitness and physical activity level and, more importantly, the subject's response to the work intensities administered in the course of the test.

The EUROFIT Seminar in Athens, (1982) discussed the most appropriate methods of regulating work increments for the PWC 170 test.

Tuxworth; (1982) suggested that the work intensities should be such that the following rates are reached in each work intensity.

WORK INTENSITY	HEART RATE RANGE
1	100-120 bts/min
2	135-155 bts/min
3	160/165 bts/min

TABLE 2.02 Target heart rates for the PWC 170 Test

The above target heart rates are suggested so that the test progresses from low intensity warm up, through a comfortable level "in the mid range of aerobic capacity" ending with a third level which should

> "bring the heart rate near to but below 170 beats / min, so that extrapolation may be made from an adjacent value but there is little chance of exceeding maximum steady state capacity".
>
> Tuxworth; (1982)

In the final EUROFIT Handbook (1988) the PWC 170 test protocol involves an initial subjective judgement by the tester of the subject's fitness level. A starting work intensity is calculated from the Table 2.03 below.

	obese or unfit	normal	fit
Boys	¾	1	1¼
Girls	½	¾	1

EUROFIT; (1988)

TABLE 2.03 PWC 170 Starting Workloads
(UNITS: Watts/Kg of body weight)

The initial work intensity is administered and the heart rate response is judged in relation to the target heart rate range for the first work intensity. The measured heart rate response in relation to the work intensity is used to establish the second work load. The same procedure determines the third work intensity for the test on the basis of heart rate response to the second work intensity.

The tables which follow indicate the appropriate work load increases.

ESTABLISHING 2nd WORK INTENSITY (W.I.)	
Heart rate at end of W.I. 1	% INCREASE
<100	70%
100 - 110	60%
111 - 120	50%
121 - 130	40%
131 - 140	30%
141 - 150	20%
151 - 160	10%
>155	STOP TEST

TABLE 2.04 Values for establishing WI2

ESTABLISHING 3rd WORK INTENSITY	
Heart rate at end of W.I. 2	% INCREASE
<130	70%
130 - 140	50%
141 - 150	30%
151 - 160	10%
>165	STOP TEST

TABLE 2.05 Values for establishing WI3
[Tables adapted from EUROFIT Handbook; (1988)]

The percentage increases obtained from the above tables are calculated in relation to the workload on the ergometer in order to establish the new work intensity, to illicit the target heart rate values indicated in Table 2.02. In addition to these percentage increase values in the tables above, the EUROFIT handbook; (1988) provides an indication of the amount of weight to be added to the bicycle ergometer in relation to the the percentage increases required. Combined use of both sets of tables allows for quick administration of the new work intensity.

Having established the factors involved in determining the work intensity, namely cadence and resistance, the final factor to be determined in the overall test protocol is the duration of the work intensities.

As with other details of the PWC 170 test protocol duration of work load has not been standardised. Klissouras and Tokmakidis; (1982) report considerable variation in work intensity duration:

> "Although the genesis of the PWC 170 called for a 10 minute duration, later versions introduced various durations ranging from 2 to 6 minutes. Most of these studies, however, were done in adults and some were not even validated."
>
> Klissouras & Tokmakidis; (1982)

Fundamental to deciding on the optimal duration is the fact that at each work intensity the subject should attain a steady state heart rate, thereby indicating that the body has adapted. Steady state adaptation to work relates to

> "work that can be maintained for a long period with aerobic energy production".
> Lamb; (1978)

In view of this, and the fact that the PWC 170 test is a measure of cardiorespiratory fitness then steady state response should be achieved for each work rate as an indication that the oxygen transport system is sustaining performance. If the work intensity is too short it would not be possible to establish whether or not a steady state heart rate would be reached and therefore not possible to determine whether or not the subject was performing aerobically or anaerobically.

One initial reason for selecting cycle ergometry as the method of monitoring cardiorespiratory fitness was its practicality. In order to maintain this practicality it was important to select a realistic test duration in order to satisfy both scientific rigour and time available for testing. This problem was also investigated by EUROFIT in an attempt to find

> "minimum time for such (steady state) adaptation to occur in an acceptable percentage of the population to be

> studied. This latter will vary in accordance with the degree of importance of individual data; relatively low for surveys, relatively high for individual diagnosis and monitoring".
>
> Tuxworth; (1982)

The same author also concludes from his research that:

> "Adaptation can reasonably be expected to occur in less than three minutes".
>
> Tuxworth; (1982)

Support for the attainment of steady state adaptation in less than three minutes also came from Tokmakidis et al;(1982).

> "it appears that 2 minutes of exercise are sufficient to stimulate the aerobic mechanism in the muscle cells---2 minutes of exercise is enough time for any individual to reach a steady state and satisfy his metabolic demands aerobically."
>
> Tokmakidis et al;(1982)

As a consequence of the available evidence EUROFIT in its provisional handbook suggested the following protocol for the PWC 170 test

> "the load periods should be 3 in number continuous and each of 2 or 3 minutes duration".
>
> EUROFIT; (1983)

In considering the most appropriate duration for the PWC 170 test in this study the three minute protocol was selected in order to allow more time to monitor heart rate, establish the new work load and to increase the resistance by the appropriate amount. Indeed in the finalised EUROFIT Handbook (1988) it is the three minute protocol which is recommended.

Based on the available evidence the PWC 170 test was adopted as the measure of cardiorespiratory fitness in this study.

As the preceding discussion has shown the PWC 170 test is a valid and reliable measure of cardiorespiratory fitness. Further to these important qualities it has the additional benefits of requiring limited equipment, relatively short duration and an easily administered, standardised protocol. The adoption of the test by EUROFIT as the optimal measure of children's cardiorespiratory fitness for use with European children serves as testament to the test's value and appropriateness.

An added benefit from selecting the PWC 170 test is that this measure was used in previous research into the fitness levels of Scottish Schoolboys [Farrally, Watkins and Ewing; (1980)]. The protocol used in this study differs from that used in the national survey which used two work loads of four minutes at a cadence of 50 rpm. The different protocol, and the age of the subjects in the national survey (13 was the youngest group) makes a direct comparison impossible. However the national data will provide a helpful indication, and a basic reference in order to make general judgements about this particular group's fitness level relative to that measured in slightly older boys.

A more direct comparison of the data obtained in this research can be made with the results of the survey into the fitness levels of schoolchildren in Belfast conducted by Queens University; (1988) since these researchers also used the standard protocol recommended by EUROFIT.

The following is a summary of the protocol adopted for the PWC 170 Test for cardiorespiratory endurance.

Number of Work Intensities		=	3
Duration of Work Intensity		=	3 minutes
Pedalling Speed		=	60 R.P.M.
Work Intensity	1	=	based on body weight
		=	target heart rate 100-120 Bts/Min
Work Intensity	2	=	based on heart rate response to Work Intensity 1.
		=	target heart rate 135-155 Bts/Min
Work Intensity	3	=	based on heart rate response to Work Intensity 2.
		=	target heart rate 160-165 Bts/Min

2.06: FITNESS TEST BATTERY - ADMINISTRATION

The preceding section identified the PWC 170 test as the most appropriate measure of cardiorespiratory endurance for this study.

> "Once test items are selected they must be administered consistently at all times."
> MacDougall, Wenger and Green;(1982)

The above point reinforces the need for consistency and standardisation in fitness testing. Many different factors influence the degree to which standardisation can be attained. This section outlines the standardised administrative procedures adopted.

SUBJECTS: Nine subjects were monitored on seven occasions during the school year. As already discussed 12 subjects were tested on the first occasion but for subsequent tests only nine subjects were monitored.

All monitoring had to be done within the class' timetabled PE allocation. As the timetable remained the same throughout the year this meant that all tests were conducted at the same time; between 09.10 and 11.10 on Tuesdays. Similarly the majority of lesson monitoring was done at the same time of day as the subjects cardiorespiratory fitness was monitored. All tests were conducted in the school's Fitness Room. All subjects received the same instructions for all test items. These instructions were as described by EUROFIT; (1983 and 1988).

EQUIPMENT: All testing was carried out using the same equipment on all occasions. The equipment used is summarised in Table 2.06 and complies with the standards set by EUROFIT; (1988).

FITNESS MONITORING EQUIPMENT		
MEASURE	EQUIPMENT	MANUFACTURER
PWC 170 TEST	Monark Ergometer	Monark Crescent Sweden
	Lab Clock	Cranlea
	Metronome (Tunturi Pulsemeter)	Tunturi
	Heart Rate Monitor- SPORTS TESTER PE 3000	Polar Electro Finland
WEIGHT	Scales	SECA Germany
HEIGHT	Harpenden Anthropometer	Holtain Wales
SKINFOLD THICKNESS	Harpenden Skinfold Callipers	British Indicators

TABLE 2.06 Testing Equipment

All equipment was checked and calibrated prior to subjects arriving to be tested. In terms of calibration the item of equipment which required most attention was the cycle ergometer.

The Monark 864 Ergometer is a weight suspension braked ergometer. Weights added to the scale pan on the ergometer produce increased tension on the belt surrounding the fly wheel thereby causing the subject to increase work rate to maintain the given cadence.

Calibration of the ergometer was carried out in accordance with the instructions issued by the British Association of Sports Sciences:

> "To ensure the free running of the belt before use place a 5 kg weight onto the weight basket and turn the pedals. If the belt is correctly adjusted then the basket should lift between 1-2 cm from its lower stop position".
> British Association of Sport Sciences (1988)

The above calibration procedure took place prior to all test sessions on the two Monark 864 Ergometers used for testing. In cases where calibration indicated variation from the required level of operation the friction belt was adjusted and if necessary cleaned and re-calibrated to ensure correct operation and consistency in the two ergometers used.

FAMILIARISATION: All subjects had parental consent to participate however none had undergone any type of fitness monitoring prior to this study. In the light of this the group were taken through all the measures in the week prior to the start of the research.

This familiarisation exercise took place in the room used for testing and all pupils underwent the battery of tests following demonstration and explanation of the procedures involved.

Allowing this practice run proved to be worthwhile as subjects were noticeably more familiar and confident on subsequent tests. A further benefit was that by allowing subjects to perform the PWC 170 test on the cycle ergometer the problems relating to establishing the correct cadence as outlined by Klausen et al; (1985) were largely overcome in subsequent tests. In the subsequent tests all subjects quickly established the correct pedalling speed and showed no apprehension with regard to any element of the test battery.

ORDER OF TESTING: The test battery was administered in the order below:

TEST		ORDER
HEIGHT		1
WEIGHT		2
SKINFOLD	BICEPS	3i
	TRICEP	3ii
	SUBSCAPULAR	3iii
	SUPRAILIAC	3iv
PWC 170		4

TABLE 2.07 Testing Order

In the administration of the tests all subjects were tested in alphabetical order relating to their surname. For the PWC 170 test subjects were tested in pairs with a one minute period separating the start of the two tests in operation.

For the measures of height, weight and skinfolds subjects were tested wearing only shorts. For the PWC 170 test, socks and shoes were also worn.

HEIGHT: Height was measured using the Harpenden Anthropometer. Subjects stood straight, looking directly ahead with arms relaxed at their side. The anthropometer's horizontal caliper was lowered until it made contact with the highest point of the head.

WEIGHT: Weight was measured using Seca Scales. Subjects stood on the scales looking straight ahead with arms relaxed at their side.

SKINFOLDS: Skinfolds were measured using Harpenden Skinfold Callipers at the four sites described. Subjects stood still with arms relaxed at their side. The following points were considered in the measurement of the skinfold measures

> "When measuring skinfolds it is important to: a) Make sure the subject is standing straight and relaxed.
> b) Roll the skinfold between the finger and the thumb to remove any under-lying muscle tissue.
> c) Take the reading when the pointer or sliding gauge changes from moving quickly to slowly.
> d) Take many measures until constant readings are obtained".
> Scottish Health Education Group; (1988)

The above points were incorporated in the measurement of skinfolds at the four sites described below, measures were taken on the right side of the body.

> "Biceps: over the mid-point of the muscle belly with the arm resting supinated on the subject's thigh.---
> Triceps: over the mid-point of the muscle belly, midway between the olecranon and

the tip of the acromion, with the upper arm hanging vertically.---
Subscapular: just below the tip of the inferior angle of the scapula, at an angle of about 45 to the vertical.---
Suprailiac: just above the iliac crest in the mid-axillary line.

At these four sites, the skinfold was pinched up firmly between the thumb and forefinger and pulled away slightly from the underlying tissues before applying the callipers for the measurement".

Durnin and Rahaman; (1967).

PWC 170 TEST: The test was administered using the already described equipment and protocol (EUROFIT; 1988) following calibration as previously discussed.

The PWC 170 test was administered as follows:

1. A general review of the test was described to the subject along with a brief explanation of the equipment involved.

2. The saddle height was adjusted to allow only slight leg flexion when the pedals were at the bottom of a revolution.

3. The Sports Tester PE3000 heart rate monitor was attached and checked.

4. The starting load was established on the basis of body weight.

5. The subject began pedalling to establish the rate of 60 rpm. When the rate was established, the load was added for work intensity (WI) 1 and the test started.

6. At the end of WI1 heart rate was recorded and the new load for WI2 established from from the EUROFIT tables.

7. A new load for WI2 was added and its value recorded.

8. At the end of WI2: steps 6 and 7 were repeated.

9. At the end of WI3: final heart value was recorded.

10. Subject warmed down with light load for approximately 2 minutes.

In addition to these steps subjects were watched during the tests for any signs of undue stress. No such signs were observed and all tests went smoothly.

2.07: LESSON MONITORING

As indicated at the start of this chapter this research has two separate, but complimentary strands. The first strand, cardiorespiratory fitness has been reviewed and an appropriate monitoring method identified and described. The second research feature was that of lesson monitoring. In order to to establish the effects of the PE programme on the pupils' cardiorespiratory fitness an indication of activity levels during lessons was necessary. This information could then be evaluated in relation to cardiorespiratory fitness development, and conclusions drawn with regard to the effects of PE lessons on cardiorespiratory fitness.

The focus of this component of the research is to investigate the levels of physical activity of the pupils during PE lessons with a view to considering these activity levels in terms of those associated with improving cardiorespiratory fitness. One further point is of importance, namely, the need for a method of monitoring which was as unobtrusive as possible and therefore allowed pupils to participate freely in PE lessons.

This problem is noted by Saris; (1985) who states

> "A problem encountered in measuring physical activity is the presence of contradictory aims. On one hand, it is desirable to record the normal daily movements of the child, which usually means the person in question must be burdened with equipment for measuring a number of body functions. On the other hand, there is a need not to interfere with the normal activities of the child."
>
> Saris; (1985)

The potential dichotomy of interests between a desire to obtain precise measures and the need to collect data which accurately reflects activity levels relative to cardiorespiratory fitness has led to the utilisation of a variety of measures.

This is considered further by Saris (1985) who supports Edholm (1966) through the identification of two general categories for the monitoring of activity.

> "First there are methods by which the physiological responses to the activity e.g. oxygen uptake, heart rate etc., are obtained. The second category includes observational methods by which the physiological response is

> estimated ... questionnaires and the
> diary method."
>
> Saris; (1985)

In selecting the method which is most appropriate for this research it is important to consider the two general categories identified above. The second category is a broad one which does not involve any direct physiological monitoring. Several alternatives exist within this category; observational methods, questionnaires and pedometers. Activity diaries can also be used but their application tends to be in studies requiring longer duration monitoring and not short sessions of work.

Observational methods have been used by researchers to obtain an estimate of subjects activity levels. These studies have utilizised a variety of recording techniques ranging from observation and note taking [Wallace et al.; (1985)] to highly-structured systems where observers code activities which are then fed to computer for detailed analysis. [Klesges and Klesges; (1985)].

With observational methods, although the recording method may differ the basic principle is consistent in that:

> "an observer watches an individual and rates that observed activity at specific time intervals. The ratings are used as an estimate of the physical activity level"
>
> Laporte et al.; (1985)

A further feature of observational methods is that they tend to be used in studies where extended activity monitoring is required, for example, on a daily basis.

It is appropriate to recognise that direct observation can be a useful method for estimating physical activity levels as noted by Klesges and Klesges (1985).

> "Direct observation methodology is prohibitive for population studies. However, when problems associated with it are controlled (e.g., observer reliability, observer drift, and reactivity), it can be highly accurate."
>
> Klesges and Klesges; (1985)

The use of direct observation is limited, in that it would be very difficult to observe more than one pupil at a time. Also if the subject is aware of being observed this may induce the type of actions which the subject perceives as important to the observer.

> "the observations themselves may influence typical behaviour"
>
> Laporte et al.; (1985)

Another pencil and paper method for assessing physical activity is the use of questionnaires where children are asked to recall activity over a given time period. As with direct observation, questionnaires tend to be associated with surveys of activity over an extended time-scale.

Fundamental to the quality of this method is the ability of the subjects to accurately recollect their activity and record it. These basic components of the use of questionnaires are indeed the greatest sources of error in this method of recording activity in children. [Klesges and Klesges; (1985) and Wallace et al.; (1985)].

Cunningham et al.; (1984) raise a further issue in that

> "Questionnaires of daily physical activity do not appear to be sensitive to the small differences in activity levels in normal children".
>
> Cunningham et al; (1984)

Questionnaires are recognised as a source of activity data in large scale epidemiological studies. However as Saris; (1985) points out;

> "data which are drawn from questionnaires and/or diaries about physical activities, is of questionable value in children."
>
> Saris; (1985)

The above indicates that where children are asked to complete their own activity records it may be that errors are likely in that the child may not be able to recall activity accurately or perhaps simply give the response which is perceived as being desirable.

> "the ability to correctly recall activities and/or classify one's level of activity is certainly a subjective evaluation, and individual differences in the perception of one's activity may affect the outcome measure."
>
> Freedson; (1989)

One further reason that questionnaire data is not appropriate for lesson monitoring in this research is that:

> "children remembered that they engaged in activity, but had trouble reporting the specifics.."
>
> Wallace et al.; (1985)

This would suggest that better motivated children would provide more accurate information within the limitations of the recording device adopted but it could also be the case the responses given would, as already suggested, be those which were perceived to be desirable.

Clearly as the intensity of the effort in lessons was likely to be a major factor as to whether or not PE lessons would influence cardiorespiratory fitness levels, questionnaires were considered inappropriate for this research.

Data which would not require observation or memory recall and recording could be obtained through the use of pedometers of other forms of movement counters. Saris; (1985) differentiates between two general types of movement counters.

> "The first is the so-called stepcounter principle: only one unit is counted when the intensity of the movement (a step for instance) reaches a certain level. The second principle is based on the measurement of the acceleration of the movement. In this case, the intensity of the movement is also measured."
>
> Saris; (1985)

The stepcounter principle is the foundation for the use of pedometers as indicators of activity levels. The use of pedometers provides information about the frequency of limb movements for example legs in walking and running, but does not differentiate between movements of varying intensity. Saris; (1985) expresses concern over the use of commercially available pedometers in physical activity research, a view supported by Cunningham et al; (1984) who indicate that pedometers are of limited value in studies involving children.

Pedometers were used by Kemper et al.; (1975) to measure the amount of physical activity in terms of a number of lower limb movements during the monitoring period. Kemper found that there were significant correlations between boys with high pedometer scores and those with high levels of cardiorespiratory endurance. However, due to the limitations of data obtained from pedometers, no information relating to the intensity of effort was obtained. In other words pedometers can only indicate an amount of activity, they cannot provide any indication of the quality of the activity in terms of levels of exertion.

Realisation of the limitations of a simple count of stepping frequency as a measure of activity levels led to attempts to develop methods able to differentiate between movements of varying intensity through monitoring the degree of acceleration produced in the movement.

Use of accelerometers receives a mixed review from researchers, with Freedson; (1989), Saris; (1985) and Klesges and Klesges; (1985) reporting conflicting evidence as to their accuracy.

> "the proposed advantage of the accelerometer being able to evaluate intensity was not supported in this study of young children."
>
> Freedson; (1989)

The variety of methods described above for use in the study of children's physical activity, although different in process, are essentially the same in their outcome in that all attempt in some way to quantify the amounts of activity in which children engage. In other words, all are fundamentally descriptive measures which in addition tend to be used over long periods of time, for example, days, rather than one or two hour sessions as monitored in this study.

Another feature of the methods identified so far is that they provide a written description or an indication of lower limb displacement as in walking or running. Considered in relation to the aim of this research these restrictions in type of movement that can be recorded fail to provide an adequate picture of the subject's response to PE lessons where a wide range of different movement types (for example; jumping, running, lateral and backward movement, and throwing) would be demonstrated.

As the purpose of this research is to investigate the efforts of PE on cardiorespiratory fitness then the method adopted for monitoring PE lessons has to be such that data obtained can in turn be considered in relation to cardiorespiratory fitness development. Considering this in relation to the initial differentiation [Saris; (1985)] between physiological and observational methods of monitoring children's activity it is clear that a physiological approach has to be adopted.

In terms of judging the most appropriate means of monitoring activity in PE lessons it is important to identify the physiological parameters which could be measured, consider which is the most relevant, and finally identify the best method to use.

An earlier section of this chapter reviewed the considerations, both physiological and practical, important in deciding how to best to assess cardiorespiratory fitness. As the aim of this section is to establish the most appropriate means of evaluating the aerobic component of PE lessons then many of the features and considerations will be the same since cardiorespiratory functioning is the common element.

As already noted, individuals with high levels of cardiorespiratory fitness are those with the greatest ability to process oxygen. Consequently, monitoring oxygen consumption during physical activity would provide an indication of the oxygen cost of PE lessons. However, as with testing maximal oxygen uptake, monitoring oxygen consumption during lessons presents problems which made it unsuitable for this research. The necessary equipment was not available in the school situation. Even if the equipment had been accessible it is far from unobtrusive and would not allow for the pupils to participate normally in their lessons as noted by Shephard; (1987).

> "All respirometers have a fair bulk and mass(2 to 3kg), so that both the pattern of activity and oxygen cost may be distorted by the measuring devise. The problem of distorting normal activity patterns is exacerbated by the need to wear a facemask or mouthpiece."
>
> Shephard; (1987)

2.08: HEART RATE

Recognition of the above problems has led to the widespread use of heart rate as an indicator of activity levels. The basis for the use of heart rate as an indicator of the body's response to physical activity is based on the already identified relationship between oxygen uptake, heart rate and work intensity. Reservations have been expressed as to the precision of this relationship, but nonetheless heart rate is widely accepted in terms of both its physiological foundation and its practicality.

> "Of all physiological parameters heart
> rate is the most easily registered,
> with the least encumbrance to the
> subject"
>
> Saris; (1985)

Further support for the use of heart rate as a measure of physical activity comes from Astrand and Rodahl; (1987) and Shephard; (1987). Laporte et al.; (1985) also uphold the use of heart rate monitoring as a means of obtaining an indication of the cardiorespiratory system's response to exercise.

> "Heart rate monitoring is attractive
> because it directly measures a
> physiological parameter known to be
> related to physical activity and

> because it provides a continuous record
> that may reflect both intensity and
> duration of daily activity."
>
> Laporte et al.; (1985)

The last point raised above is an important one, and one which makes heart rate the most practical and relevant measure for this study. The description of the other possible methods of monitoring physical activity indicated that one feature common to all methods reviewed was the ability to describe the amount of activity taken. Heart rate provides a further measure, namely one of the intensity of effort, because of the relationship whereby an increased work load produces an increase in heart rate.

By adopting heart rate as the measure of physical activity in PE lessons for use in this study the researcher was able to assess both the duration of the lesson and the intensity of effort required of the subject to perform the various tasks required during lessons. A detailed review of the heart rate criteria in relation to cardiorespiratory fitness development is given later in this section.

Another important reason for selecting heart rate as the best method for PE lesson analysis was that previous studies in this area utilized heart rate as the indicator of pupils activity levels. [Hale and Bradshaw; (1978), Knowles; (1978), Faulkner et al.; (1963), Seliger et al.; (1978) and Verabioff; (1988)]. By using heart rate, comparison could be made between pupils in this research and data obtained from other studies.

As with cardiorespiratory fitness the monitoring of heart rate can be carried out using a variety of procedures and equipment. Available methods range from complex laboratory based electrocardiograph systems to manual pulse counting. Central in considering the most appropriate method for this research was the fact that there had to be minimal interference with the pupils actions and movements during lessons, consequently an unobtrusive non-invasive method was required.

The need for a means of heart rate monitoring which afforded minimal restriction to movement during PE lessons excludes a number of widely used laboratory measures which are either electrical mains dictated and/or directly linked to the heart rate monitor. In response to the restrictions of such equipment several field based heart rate monitoring systems have been developed. In broad terms these can be divided into three categories; tape recording, manual palpation and telemetry, which in turn can be differentiated on the basis of being either continuous or intermittent measures.

If a true measure of heart rate was to be obtained during PE lessons then continuous rather than intermittent monitoring had to operate.

> "The continuous monitoring of the heart rate permits an uninterrupted collection of data which reflect the workload."
> Astrand and Rodahl; (1987)

Consequently the method used had to be one which allowed continuous data heart rate recording but which still allowed the necessary freedom of movement. These considerations meant that manual pulse palpation was not considered as subjects had to be stationary to record pulse rate. Further problems with manual counting have been recognised:

> "Development of aerobic training intensity was held up by pupils unable to locate and count pulse rate and the inability of some to correctly judge a ten second time period."
> Farrally and Green; (1986)

Gilliam et al; (1981) used a tape recorder system for recording heart rate in studies of children's physical activity. This involved the attachment of electrodes to the child's chest, which were wired to a recording devise held stationary by shoulder and waist straps. Data obtained was then interpreted and recorded by computer for subsequent analysis. Both Gilliam et al; (1981) and Cunningham et al;(1981) report successful use of the system but reservations are noted by other researchers. Saris; (1985) believes that the size and weight of the tape recorder system make it unsuitable for use in children's studies.

Shephard; (1987) has noted that problems can arise

> "the vigorous activities of many
> sports can cause a variation in speed
> of the tape recorder."
>
> Shephard; (1987)

The tape recorder has tended to be used over extended time periods where heart rate has been monitored with a view to generalising the data obtained. Although it is a valuable method of recording heart rate, the limitations described above make it inappropriate for this study.

The final commonly used method for obtaining heart rate data is telemetry. Telemetry involves the transmission of the subject's heart rate or electrocardiograph to a receiver unit which then displays and/or records the data received as either an electrocardiogram or heart rate. This data can then be reviewed and interpreted. The distance over which the transmission can be made varies with the system but common to all telemetry systems is the need for the receiver to be relatively close to the subject. Shephard; (1987) indicates that telemetry is valuable for the transmission of electrocardiograph signals obtained from games monitored in a limited area, a view supported by Kemper and Farrally; (1984)

At the outset of this research two methods of heart rate telemetry were available. These were the Hewlett Packard 78351A telemetry system and the Sports Tester PE 3000 Training System.

The Hewlett Packard 78351A telemetry system is designed primarily for medical use. The subject wears three chest electrodes connected by wires to the transmitter pack which is carried in a pouch attached at the waist. The electrocardiograph signal is sent from the transmitter to the telemetry receiver which is in turn connected to the display unit. The display unit gives both an electrocardiogram and analogue read out. There is also a printer facility which provides a printout of the electrocardiogram. Having used the Hewlett Packard telemetry system on many occasions prior to this research a number of problems were encountered which led to inaccurate data being obtained.

One of the problems was poor electrode contact. This is also noted by Saris et al.; (1977) and Shephard; (1987) who states that

> "Erroneous counts owing to loose electrocardiogram (ECG) electrode contacts can be a serious problem."
>
> Shephard; (1987)

This problem was encountered despite careful preparation of the electrode site by wiping with an alcohol impregnated swab and abrading with the appropriate part of the electrode cover. The electrodes and leads were then taped to the subject to assist better contact and stability. Despite these efforts electrode contact was often lost, particularity when subjects were sweating during vigorous physical activity.

The second problem encountered was one of interference to the electrocardiogram as a consequence of upper body activity. Increased muscular contraction during exercise produces an increase in electromyographic interference on the electrocardiogram display. As a result of this electrical interference both the electrocardiogram and the numerical value on the display were distorted, often resulting in inaccurate data, which required considerable subjective interpretation.

A further limitation of this system lies in the fact that only one subject could be monitored at any one time.

> "Radio telemetric techniques for
> obtaining field measures of heart rates
> have the disadvantage of high cost and
> the limitation of testing being confined
> to one subject per session, since
> usually only one set of telemetry
> equipment is available."
>
> Brooke and Knowles; (1971)

2.09: SPORTS TESTER PE3000 HEART RATE MONITOR

The Sports Tester PE3000 heart rate monitor is also a form of telemetry system. The subject wears a thin, elasticated electrode belt around his chest. The belt is positioned with the back of the two electrode points in contact with chest slightly left of the base of the subject's sternum. A small transmitter unit is clipped to the electrode belt and this sends heart rate values to the sports tester unit which is worn on the subject's wrist. This unit displays and stores the heart rate and time data. The third and final component of the sports tester training system is a portable micro computer unit comprising the sports tester interface, a computer and printer.

Having monitored the subject the sports tester unit is placed in the interface, data is transferred into the micro computer which analyses and collates data. This is then presented as a graphical print out of heart rate over the time period monitored, giving a continuous record of activity levels.

The size and weight of the Sports Tester PE3000 make it well suited to use with children. The electrode belt is adjustable to fit subjects of all sizes from children to adults as is the receiver unit. This ability to adjust the belt and its secure method of fastening meant that there were very few interruptions to data obtained from the lessons monitored. The small size and weight of the electrode belt and wrist receiver also meant that the system was far less obtrusive that any other method considered. Indeed, due to the fact that there were no wires or separate chest electrode units the pupils felt far more at ease with the system, perceiving it as PE equipment and not as medical equipment which would have perhaps influenced their interpretation of the purpose of the study.

Another positive feature was the dimensions of the belt and receiver which placed very few limitations on the activities that could be monitored, indeed only swimming was excluded. The compact nature of the equipment made it very robust which in turn allowed for monitoring of the subjects in situations where contact could take place with others. In these activities subjects were well protected from any possible consequences of impact with fellow pupils. This protection consisted of the subject wearing two layers of long sleeved clothing to cover the electrode belt, transmitter and the wrist receiver. In addition the wrist receiver was covered with an elasticated gauze pad for added protection.

As there were no wires attached to separate chest electrodes then the source of many problems traditionally associated with these components, as discussed, were either greatly reduced or eliminated. One problem identified earlier was the problem of sweat affecting electrode contact. It appears that almost the opposite can be said of the Sports Tester as the sweat and moisture have no detrimental effect on electrode contact, indeed with some subjects there is enhancement of electrode pickup. This point is particularly relevant to this study as much of the monitoring was done outdoors in an area of the country well known for inclement weather. In fact the system was on some occasions, in very wet conditions with no problems encountered.

Another important benefit of the Sports Tester System is that more than one subject could be monitored in one session. With the Hewlett Packard system the subject wears only the transmitter equipment with the receiver and display units only able to deal with one subject at a time. The Sports Tester System is different in that the subject wears both the transmitter and receiver. Playback through the interface, computer and printer is separate and can be carried out at any time following data collection.

The Sports Tester transmitter has a relatively short range of approximately one to two metres. Consequently if a number of units were operating in the same area there was not a very large likelihood of interference to the data recording provided the individuals were not in close proximity. This was a major consideration in this study as it meant that three sets of transmitters and Sports Tester receiver units could be used without interference in any one lesson. Provided the three subjects being monitored worked in separate groups during lessons the analysis of the stored information following the session was clear of interference from other subjects.

A final, critical feature of the Sports Tester PE3000 Training System was the method by which data is recorded and displayed. The Sports Tester system analyses data in an analogue form which is then presented graphically as a computer printout. The experimenter has no input to the sampling or collection process other than to prepare the subject and end the recording. This greatly reduces the chance of any experimenter errors and provides a clear graph of the subject's heart rate during the course of the lesson.

The Sports Tester PE3000 Training system was adopted to monitor pupils heart rates in this research because it provided a compact, unobtrusive, flexible and clear method of recording and presenting data obtained during PE lessons. Pupils reacted well to the use of the system and were not apprehensive about its use which allowed total freedom to participate normally in the lessons.

The Sports Tester PE3000 Training System was a relatively new development at the start of this research. In a short space of time its use became widespread with it being adopted by a number of researchers for heart rate monitoring in both laboratory and field situations [(Maile and Campbell; (1986), Maile et al.; (1987), Squire and Peck; (1987) and Squire; (1988)]. In addition the Sports Tester PE3000 has been used extensively for the monitoring of heart rate in elite performers in the National Coaching Centres in both Glasgow and Edinburgh.

2.10: HEART RATE MONITORING - ADMINISTRATION

As with the administration of the fitness test items a standardised approach was adopted for the implementation of heart rate monitoring during PE lessons.

For the majority of this research three Sports Tester PE3000 units were used. Initially only one system was utilised since the focus of the study at that point was to establish the general effects of PE lessons in relation to the development of cardiorespiratory fitness.

Development of the research to investigate activity during lessons relative to different levels of cardiorespiratory fitness led to the use of three Sports Tester PE3000 units during the same lesson for analysis by portable computer following the lesson, thereby generating three separate subject printouts for each lesson.

SUBJECTS: In the first monitoring period of the research, from September to December, the subjects to be monitored during the lesson were selected at random as the class was changing into their PE kit at the start of the lesson. This avoided any problems of pre-selecting a subject and then discovering that he was either absent or late for the class.

During the second and the third monitoring periods, January to March and April to June, three subjects were selected at the start of the block of work and monitored in all sessions during the period. In the case of pupil absence from the lesson a replacement was used, selected on the basis of a similar cardiorespiratory endurance level as determined at the start of the block of work.

All lesson monitoring took place at the same time throughout the research; 09.10 to 11.00 on Tuesdays, and from 11.25 to 12.25 on Fridays.

Monitoring took place in the area where the lesson was being conducted. No special sessions were set up for the purpose of this research. All the data were obtained during normal PE class activities.

EQUIPMENT: Heart rate monitoring was conducted with the Sports Tester PE 3000 Training System. All monitoring was carried out using the same equipment on all occasions. Data analysis was conducted using the same micro computer unit and printer. All units were clearly labelled to avoid any error in analysis.

The Sports Tester PE 3000 Training System comprises the following elements.

i) An elasticated belt with integral electrodes is worn on the subject's chest.

ii) A transmitter unit clips onto the front of the electrodes to the left of the base of the subject's sternum.

iii) A receiver unit which is worn on the subject's wrist.

iv) A portable micro computer with an interface and integral printer.

Prior to the start of the session the receiver unit is set to record the subject's heart rate at five second intervals. This data is displayed and stored by the receiver unit.

On completion of the monitoring period the receiver unit was placed on the interface unit. The stored data was transfered to the computer and a graphical printout given. The graph shows a continuous heart rate value against the time duration of the session. The heart rate data on the graph was based on a five second sampling period.

FAMILIARISATION: As with the fitness monitoring, the subjects were all given familiarisation prior to the start of the lesson monitoring programme. This took the form of a demonstration and explanation of the equipment and procedures involved.

This proved to be worthwhile as it alleviated apprehension and helped build pupil confidence in the measures. Pupils quickly accepted the use of the Sports Testers and were soon totally familiar with its operation and sometimes were even able to detect slight malfunctions. For example one pupil suspected the the electrode belt had slipped during a twist and stretch exercise in a lesson warm up. The researcher though it unlikely, however examination of the electrode belt proved the pupil to be correct as it had been displaced slightly. This problem was easily rectified without any interruption to either the lesson or the data recording.

LESSON MONITORING PROTOCOL: A variety of activities (Rugby, HRPF, Basketball, Volleyball and Athletics) were monitored in this research. For all these activities the basic procedure followed was the same.

For reasons of safety subjects wore extra protection to cover the transmitter and receiver during lessons in Rugby, Basketball and Volleyball. This allowed pupils to participate freely in sessions in these and all other activities. The protection consisted of the subject wearing two layers of long sleeved clothing with an elasticated gauze pad for added protection of the receiver unit.

Heart rate monitoring of subjects during PE lessons was administered as follows;

1. While the class were changing the electrode belt, transmitter and wrist receiver were attached to the subject.

2. A brief explanation of the monitoring procedure was given. The subject was told to report directly to the researcher should the system be bumped or displaced. This system was agreed with the class teacher.

3. Data recording was started as the class left the changing room.

4. Subjects participated freely in lessons. In cases where more than one subject was wearing a Sports Tester Unit subjects were asked not to work close together in pairs or other group activities. This minimised interference to data recording.

5. At the end of the lesson the receiver unit was stopped and removed along with the transmitter and electrode belt. All units were kept separate until data had been transferred to the computer for analysis.

6. As soon as possible following the lesson the receiver unit was connected to the interface and the recorded heart rate data was transferred to the computer. Following this a graph of heart rate during the lesson was obtained.

In addition to the above procedures subjects were observed during the lesson for any signs of stress, atypical behaviour or problems associated with the monitoring equipment. No such signs were observed.

2.11: LESSON MONITORING - DATA INTERPRETATION

As has been indicated in previous sections of this research the focus for the monitoring of pupils during PE lessons was to judge whether or not pupils were sufficiently active in order to promote the development of cardiorespiratory fitness. This judgement is made relative to standardised guidelines for the improvement of cardiorespiratory fitness.

The development of cardiorespiratory fitness is, as with all other components of fitness, based on criteria referred to as conditioning principles. These principles form the basis for the enhancement of fitness and are common to everyone wishing to improve any or all fitness components, regardless of whether they are training for peak performance related fitness or simply wanting to get the most out of time engaged in health related exercise.

Fundamental to the development of cardiorespiratory fitness is the principle of overload, making the cardiorespiratory system work harder than normal.

> "Overload is fundamental to improving physical fitness. --- Unless training programs include activities that produce a stimulus above a certain intensity

> threshold, improvement in physical
> fitness will not occur."
>
> Pollock and Blair; (1981)

Overload of the cardiorespiratory system is based on a number of underlying conditioning principles which combine to provide the necessary training stimulus-frequency, duration, mode and intensity of activity.

> "With adequate intensity, duration
> and frequency of aerobic training
> one will obtain the "training effect"
> whereby the cardiorespiratory system
> and its underlying organs and mechanisms
> are operating more effectively, providing
> better transportation and utilization
> of oxygen."
>
> Hebbelinck; (1984)

In terms of establishing the standard reference criteria in order to monitor the effects of PE lessons the contributions of frequency, duration, mode and intensity have to be considered.

In attempting to establish the reference criteria for lesson monitoring the researcher had to review the available information and decide on the most appropriate levels for this work. This was not an easy task as much of the work in the area of exercise prescription has been conducted with adults, with very limited research having been conducted with children.

> "The age-related frequency, intensity
> and duration of exercise necessary for
> fitness in children is not well defined."
>
> Rowland; (1981)

The above quotation reinforces the lack of precise information available in this field and leads Rowland to the very general conclusion that children should participate in

> "vigorous aerobic exercise (enough to
> cause fatigue) for at least one-half
> hour on a minimum of three occasions
> per week."
>
> Rowland; (1981)

In relation to the present research it was important to consider the above points and to review the available information on adults and children to try to establish the most appropriate criteria for this research.

Frequency of activity in order to develop cardiorespiratory fitness in adults is generally accepted to be three sessions per week.

> "the minimum practical frequency for
> improving cardiorespiratory function is

three sessions per week."
Pollock and Blair; (1981)

The point that three sessions per week are the minimum for improved cardiorespiratory endurance is noted by several authors; [Lamb; (1978), American College of Sports Medicine; (1980), Hollman; (1980), Rowland; (1981), Watkins; (1981), Fox and Corbin; (1985), Armstrong and Bray; (1987)]

As indicated, most of the work conducted in this area was undertaken with adult groups and consequently the recommendation of three sessions per week for children is, in many cases, taken directly from adult findings and recommendations. Research into the number of sessions required per week to improve cardiorespiratory fitness in children is hard to find. General support can be interpreted from a review of cardiorespiratory endurance conducted by Cunningham et al.; (1984). This review indicates that significant changes in cardiorespiratory endurance were observed in children in cases where three or more exercise sessions were performed.

The basic requirement for at least three sessions to promote improved cardiorespiratory fitness is of significance to this study since pupils only received two PE lessons per week. On the basis of the preceding discussion it would appear that the PE programme would be unlikely to improve cardiorespiratory fitness.

It is important to remember that it was not the purpose of the PE programme to focus on fitness development. A number of other learning outcomes were also important. Also, less than three sessions per week need not be a limiting factor to fitness development since part of PE time could be devoted to the development of exercise promotion skills which the pupils could use outwith the PE curriculum. This point is discussed in more detail in a subsequent section.

Activity duration, like frequency, is also the subject of general agreement in adults, with 15 to 20 minutes recognised as the minimum duration of appropriate quality exercise. [American College of Sports Medicine; (1980), Pollock and Blair; (1981), Watkins; (1981), Kemper; (1983), Fox and Corbin; (1985), Farrally and Green; (1986), Armstrong and Bray; (1987)]. Relating this target value to the time available in PE lessons monitored in this study shows that lesson duration (60 and 120 minutes) quite clearly could accommodate activity of a suitable duration to improve cardiorespiratory fitness.

Information on appropriate activity duration for children is again limited. The general recommendations appear to be based on adult values being viewed as suitable for children. The researcher could find very little in the way of substantiated information. Looking again to the review by Cunningham et al.; (1984) it appears that 15 to 20 minute sessions on at least three occasions per week will help develop cardiorespiratory endurance in children.

The third principle relating to training overload is the mode, or type of activity. As discussed in the section on test methodology, for the cardiorespiratory system to be overloaded the large muscle groups of the body have to be working. Consequently the form that the exercise activity takes is subservient to the need to ensure the involvement of the body's large muscle groups over a sustained time period.

> "A great deal of latitude is permitted in selecting the mode of exercise --- When frequency, intensity and duration of different aerobic activities are the same, the results are the same. Thus, it is not what is done is the important factor, but how it is done."
>
> Pollock and Blair; (1981)

The above was an important consideration for this study as a broad spectrum of activities were monitored. In the light of the above comments it can be seen that it is not the activity which is the most important factor, rather, it is the quality of the subject's performance in the activity.

Participation in physical activity for cardiorespiratory fitness development is largely dependant on the intensity of exercise effort as it is the intensity which ultimately determines the quality of the session. The optimal exercise intensity is established using a target training range. This range, or training band, represents the optimal level of effort for an individual in relation to cardiorespiratory fitness development.

> "There is an intensity threshold below which little or no training effect will result and in some situations (eg. aerobic exercise) there is also an upper limit above which no further benefits will arrive."
>
> Armstrong and Bray; (1987).

The above concept of an optimal level of effort is widely supported by other authors [Siegel; (1988), Pollock and Blair; (1981), Burke; (1980), Fox and Corbin; (1985) and Watkins; (1981)]

For this research it was important to decide upon the most appropriate heart rate training band from the range of available methods and recommendations. The alternatives for the determination of the heart rate training band vary in relation to the amount of information required prior to calculation of the training band. The information required ranges from subject's age, resting heart rate, measured maximum heart rate and age predicted maximum heart rate.

In cases where the subject has undergone a maximal test, (for example, maximal oxygen uptake) then the highest heart rate value recorded in the test can be used as a maximum to form the basis for the calculation of the target heart rate band.

> "The "maximum" heart rate is the heart rate measured at the highest exercise intensity attained.
> American College of Sports Medicine; (1980).

The use of maximum heart rate, either measured or predicted, is common to the majority of methods for training band calculation. In cases where measured maximum heart rate is not available, as in this study, a simple formula can be used to predict maximum heart rate, bearing in mind that as already discussed in the section on test methodology, some variation exists in terms of maximum heart rate in people of the same age. [Astrand and Rodahl; (1987)].

Despite these reservations, the prediction of maximum heart rate is largely based on the age of the subject. Although some variations in formulae have been suggested [Armstrong and Bray; (1987) and Squire; (1988)] there is general agreement for the use of the following formula to calculate maximal heart rate: MAXIMAL HEART RATE = 220 - age. [Fox and Mathews; (1981), Siegel; (1988), Farrally; (1984) and Hebbelinck (1984)].The training band is then established relative to this predicted normal level.

Resting heart rate values have also been used to help calculate heart rate training bands. [Karvonen et al; (1957) and American College of Sports Medicine; (1980)]. These formulae utilize percentages of the heart rate reserve, the difference between resting and maximal heart rates, to establish the training intensity. This method was not adopted for this study since the researcher did not feel that the accurate measures of resting heart rate could be obtained from the children.

> "While educational, allowing the
> students to determine heart rates

> themselves will probably lead to some inaccurate calculations.
>
> Siegel; (1988)

This point was borne out through a task given to the class from which this research sample was drawn. The group were asked to record their resting heart rate immediately on waking in the morning. The values reported by the pupils ranged from less than 20 to greater than 250 beats/minute. Consequently the research did not feel it prudent to accept the resting heart rate values reported by research group subjects.

On the basis of the preceding information it was decided to utilize a heart rate training band using age predicted maximum heart rate values as the standard guideline for judging intensity of effort during PE lessons. The final value to establish was the actual heart range to use as the standard training band.

As with other principles of training for children the intensity of exercise has not been well researched and so recommendations have largely been based on adult data. These adult data give general broad guidelines but are not equivocal in their recommendations.

The American College of Sports Medicine; (1980) recommend a training range of 60% to 90% of maximal heart rate. Use of this is supported by Watkins; (1980) and Rowland; (1981). This range has been widely used, however closer examination of the American College of Sports Medicine publication, along with reports from other authors, reveals that modification of these broad figures may be appropriate for healthy individuals.

Further examination of the American College of Sports Medicine guidelines suggests that the lower limit of 60% is for those unaccustomed to exercise, or involved in rehabilitation programmes. For healthy asymptomatic individuals the suggested exercise intensity is within the 70% to 80% range. The use of 70% as the lower end of the heart rate training band is also recommended by Pollock and Blair; (1981) who stress that 60% is minimum with the suggestion of 70% to 85% as a realistic and comfortable training band to produce a cardiorespiratory training effect. Further support for 70% to 85% maximum heart rate as the heart training range comes from Burke; (1979).

> "it may be recommended that individuals
> work at an intensity equivalent to 70-85%
> of maximal heart rate.
>
> Burke; (1979).

Use of a heart rate training band of this order is also recommended by Farrally; (1984), Farrally and Green; (1986) Astrand and Rodahl; (1987) and Burke; (1980).

It should also be recognised that many of the recommendations made for exercise prescriptions in children are based largely on guidelines established for adults and adopted on this basis. [Rowland; (1981), Farrally; (1984) and Farrally and Green; (1986)]. Very little research has been done to identify the optimal heart rate training band for children. In a study by Siegel and Manfredi; (1984), boys showed improvement in cardiorespiratory fitness while exercising in the range of 73.1% to 87.7% of maximal heart rate. This range,although not providing precise support for a training band of 70% to 85% of maximum heart rate, does indicate that this range is relevant for use with children.

From the available evidence the researcher adopted a heart rate training band of 70% to 85% of age predicted maximal heart rate (146 to 176 beats/minute) as the standard criteria against which PE lesson intensity would be judged in relation to cardiorespiratory fitness development.

2.12: LESSON DATA ANALYSIS

The procedures for transferring data to the micro computer from the Sports Tester PE 3000 receiver unit have already been described. When the raw scores are in the computer the researcher is required to enter background information about the subject in order that the graph can be related to the standardised heart rate training band of 70% to 85% of maximum heart rate.

The graph which is printed out then provides the researcher with the following information:

- Lesson Duration
- %Time with Heart Rate: <70% maximum
  : >85% maximum
  : between 70-85%

From this information the time spent within each of the categories can be determined.

The purpose of the lesson monitoring was to examine the effects of PE lessons on cardiorespiratory fitness. Initially this was done by selecting a subject from the group on a random basis and then monitoring him throughout the lesson.

The sampling procedure for PE lesson monitoring changed as the research developed and more Sports Tester PE 3000 units became available. Increased Sports Tester PE 3000 availability afforded the opportunity to establish sub groups within the overall research group on the basis of differing levels of cardiorespiratory fitness. This provided the opportunity to investigate whether fitness level influenced the intensity of effort during PE lessons.

Sub division of the group was carried out using subject's performance on the PWC 170 test. Subjects were ranked on the basis of their PWC 170 Watts/kg score. Examination of this rank order led to the group being split into three groups (high, middle and low fitness) on the basis of cardiorespiratory endurance.

In the initial activities (Rugby and HRPF) subjects to be monitored were selected at random. For subsequent activities (Basketball, Volleyball and Athletics) one subject for each of the three fitness sub groups (high, middle, low) was pre-selected to be monitored in all lessons during the period from the initial test to the end of the block of lessons.

Information from individual lessons was collated and analysed using SPSS X on an IBM 4331 computer. The results of this analysis are presented in the results chapter.

Review of the results is restricted to the standard guidelines for cardiorespiratory fitness development. The wider implications of these fitness development principles along with the effects of lesson frequency are considered in the discussion section.

CHAPTER 3: RESULTS

3.01: DATA COLLECTION AND ANALYSIS

3.02: ANTHROPOMETRIC MEASURES

3.03: CARDIORESPIRATORY ENDURANCE MEASURES

3.04: LESSON MONITORING

3.05: RUGBY

3.06: HEALTH RELATED PHYSICAL FITNESS

3.07: BASKETBALL

3.08: VOLLEYBALL

3.09: ATHLETICS

3.10: SUMMARY OF ALL ACTIVITIES

CHAPTER 3: RESULTS

3.01: DATA COLLECTION AND ANALYSIS

The preceding chapter on research methodology identified two separate but complimentary strands in this study, the first relating to cardiorespiratory fitness and its assessment, the second concerned with the monitoring of pupils' heart rates to establish activity levels during PE lessons.

This chapter gives the results of both cardiorespiratory fitness and PE lesson monitoring. As in the previous chapter both research strands are reported separately. This allows for two fundamental questions to be answered; i) Did subjects cardiorespiratory fitness change during the period of the research ? ii) What effect did PE lessons have on cardiorespiratory fitness development ?

In general the implementation of the research programme was very satisfactory, both in terms of monitoring cardiorespiratory fitness and heart rate during PE lessons.

One difficulty that occurred early in the research was the reduction in the number of subjects from 12 to 9. This was due to three of the group being poor school attenders. The reduced group size allowed slightly more time to conduct the battery of tests, thereby aiding their implementation within the two hour period available. In this respect the reduction in group size actually helped as testing twelve subjects afforded little time to spare, nine subjects could be tested with less pressure on the experimenter, thus reducing the risk of experimenter error.

School based research would not be possible without the help and support of the school's staff. All staff in the school's PE department were extremely supportive. The principal teacher, who taught the lessons monitored, was especially accommodating as he allowed access to all lessons taught during the year. His support was critical to the research and was a major factor in its smooth administration. This was particularly beneficial as his acceptance of the research as a routine part of his teaching with the class rubbed off on the pupils who in turn were not distracted by the use of the heart rate monitors, or by the researcher being present at all lessons monitored.

The biggest limiting factor was the format in which the heart rate data was presented. A more complete review of this is presented in the discussion chapter. Briefly, the limitation was that the only way to view the data was from the graph printed out on the micro computer. This did not afford the opportunity to review the heart rate data in a form other than that given on the separate graphs. In the lessons where more than one subject was being monitored it would have been helpful if all graphs could have been presented in one summary as well as individually. Also it would have been useful to access raw scores, but this was not possible with the Sports Tester PE3000 Training System as it existed at that time. Subsequently, computer software and an interface has been developed for use with desk top microcomputers and this provides a listing of raw scores.

Having taught PE in a number of schools and having seen many colleagues teach, the experimenter is satisfied that the lessons monitored in this research were reasonably representative of PE as taught in many schools. This is not to overstate a subjective impression but it does support the validity of the investigative approach taken.

Most of the other studies in this area were cross-sectional with a wide age range being monitored, and only one test being administered. The sampling was usually carried out on the basis of age on or close to the date of testing [Farrally, Watkins and Ewing;

(1980)] or on the basis of school year grouping [Queens University; (1988)].

The group monitored in this research will be considered as being aged twelve (or a first year secondary class) for the purpose of comparisons with other groups on any of the components measured. During the research period the average age of this group of first year secondary schoolboys was 12 years six months.

Statistical analysis of fitness and anthropometric data was carried out using a number of computer programs on a BBC Microcomputer. The programs were used to establish descriptive and inferential statistics.

For each fitness parameter mean and standard deviation were calculated. Further analysis to differentiate between group performance in all seven tests was conducted using a One Way Analysis of Variance. In cases where difference between means was established using the One Way Analysis of Variance the Tukey Q test was used to identify which means were significantly different.

The above analysis was done using the National Coaching Foundation's Statistical Analysis Package (1987). This computer program is based on information contained in the text; Statistics for Education and Physical Education, Cohen and Holliday; (1979). The only exception was the Tukey Q Test which, when needed, was calculated by hand using the formula and tables from the above text.

3.02: ANTHROPOMETRIC MEASURES

The tables which follow in this section present the results of the anthropometric measurements obtained during the 12 month monitoring period.

HEIGHT:

TABLE 3.01: HEIGHT (cm) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	144.1	147.0	147.6	149.0	149.3	150.4	151.0
SD	7.7	6.7	6.9	6.9	7.1	6.9	6.9
RANGE	133 - 158	135 - 159	135 - 159	136 - 160	136 - 160	138 - 162	139 - 162

Height increased throughout the one year monitoring period. With the exception of the period between tests one and two there were no significant increases in height on consecutive tests. The increase in height is clearly to be expected due to the general growth rate in boys of this age.

If specific subjects are considered within this overall increase the rate of height increase varies considerably on an individual basis.

The increase in height over the monitoring period ranged from 4cm to 15cm with an average increase of 6.89cm. The increase of 15cm shown by one subject is considerable for a 12 year old boy. Increases in height are to be expected in the course of normal development, with concentrated growth spurts exhibited in both boys and girls. Such a growth spurt as described above is not abnormal but is however uncommon in a boy of 12 years. Kemper; (1983) indicates that on average, the peak increase in height tends to be at around 14 years of age, however it can occur at any time between approximately 10 and 18 years. This large variation reported by Kemper is consistent with the range of increase already identified.

WEIGHT:

TABLE 3.02: WEIGHT (Kg) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	34.7	35.6	36.4	37.4	37.4	39.2	39.3
SD	9.8	9.8	10.4	10.5	9.9	11.0	11.5
RANGE	24.0 - 60.0	25.0 - 61.0	27.0 - 63.0	28.0 - 65.0	28.0 - 63.0	28.0 - 68.0	28.0 - 70.0

Weight increased significantly over the period covering the tests, with a significant ($p<05$) increase between consecutive tests only occurring between April and June.

As with height an increase in weight is to be expected in boys of this age. Mirwald and Bailey; (1986) in a survey of Canadian children recorded an average weight of 38.1 Kg for 12 year old boys. They also reported a rate of weight gain of 3.9 1.7 Kg/year in their sample. Looking at this information in relation to this research sample the rate of weight gain is within the range indicated.

BICEPS SKINFOLD:

TABLE 3.03: BICEPS SKINFOLD (mm) [N = 9)

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\overline{X}$	6.2	6.1	6.4	6.7	6.8	7.3	7.0
SD	3.7	3.8	4.1	4.8	4.9	6.0	6.0
RANGE	3.0 - 16.0	3.2 - 16.6	3.4 - 17.6	3.8 - 20.2	3.6 - 20.3	3.5 - 24.0	3.1 - 23.5
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

There was no significant change in Biceps skinfold over the monitoring period. The spread of scores is much less and the mean values smaller than for any of the other skinfold measures.

At an individual level the changes shown were slight with the exception of the pupil whose initial value was the highest. This pupil showed an increase of 7.5mm over the monitoring period with Biceps skinfold rising from 16.0mm to 23.5mm. The change in this subject's value was largely responsible for the upward trend in the group results.

TRICEP SKINFOLD:

TABLE 3.04: TRICEPS SKINFOLD (mm) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	12.6	13.5	13.1	12.8	13.2	13.7	13.6
SD	8.2	8.2	7.2	6.6	8.2	8.2	9.6
RANGE	7.0 - 35.5	7.6 - 36.0	7.7 - 32.6	7.6 - 31.0	7.1 - 36.0	7.1 - 36.0	7.6 - 40.0
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

The table shows no significant change in Tricep skinfold during the monitoring period. The results do indicate a slight upward trend over the year with all but two of the group reflecting this. The two subjects who did not follow this trend showed very slight reductions.

SUB SCAPULAR SKINFOLD:

TABLE 3.05: SUB SCAPULAR SKINFOLD (mm) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	8.9	9.6	9.8	10.2	10.6	9.6	10.5
SD	9.4	9.7	9.4	10.7	11.6	9.3	10.9
RANGE	3.8 - 35.2	4.8 - 37.0	5.4 - 36.4	4.6 - 40.1	4.3 - 43.1	4.4 - 35.8	4.8 - 41.0
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

As shown above no significant change in sub scapular skinfold measure was observed. Again a slight upward trend over the year was apparent in the group with all individuals reflecting this change.

SUPRAILIAC SKINFOLD: As Table 3.06 indicates Suprailiac skinfold showed no significant change over the monitoring period.

Closer examination of individual data shows a slight reduction in Suprailiac skinfold took place over the monitoring period with individual values showing reductions of between 0.1mm and 6.5mm. Suprailiac skinfold showed greater intra subject variation than any other skinfold measure.

TABLE 3.06: SUPRAILIAC SKINFOLD (mm) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	9.6	8.3	7.9	7.2	7.8	8.7	8.3
SD	8.5	5.7	5.7	4.7	5.9	8.5	6.6
RANGE	4.0 - 33.0	4.1 - 24.0	3.9 - 23.6	4.0 - 20.2	4.4 - 24.0	4.2 - 32.5	4.0 - 26.5
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

SUM OF 4 SKINFOLDS: Summated skinfold values showed no significant change over the monitoring period. As with the preceding skinfold measures the mean values on each test occasion were similar with a very wide range of individual scores throughout the monitoring period.

TABLE 3.07: SUM OF 4 SKINFOLDS (mm) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\overline{X}$	36.3	37.2	37.1	36.8	38.3	39.3	39.4
SD	27.8	27.8	26.2	26.7	30.4	31.8	32.9
RANGE	17.8 - 113.7	20.8 - 113.6	20.8 - 110.2	22.2 - 111.5	22.1 - 123.4	20.5 - 128.3	20.9 - 131.0
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

The subject with the highest skinfold measure at the outset remained the highest and, in fact, increased his total by some 15%. Skinfold totals for the remainder of the group reflected the upward trend but there was no significant change in the mean value over the 12 month period.

% BODY FAT:

TABLE 3.08: %BODY FAT (%) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	18.1	18.6	18.6	18.5	18.7	18.9	18.7
SD	6.3	6.0	5.8	6.0	6.4	6.5	6.8
RANGE	11.3 - 34.7	13.2 - 34.7	13.2 - 34.3	14.0 - 34.5	13.5 - 35.8	13.0 - 36.3	13.3 - 36.6
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

Prior to the analysis of group results, individual scores were converted from skinfold measures in millimetres to a total percentage body fat value using the Body Composition computer software package from the Scottish Health Education Group; (1988).

This package uses the equations derived by Siri; (1956) and Durnin and Rahaman (1967). Siri's equation converts the total skinfold measure to a value representing body density, this value is then entered in Durnin's and Rahmans's formula to establish the subject's percentage body fat. Further consideration of the use of this method of analysing body composition is contained in the discussion.

Analysis of the data show no significant change in the group's %Body Fat over the monitoring period. On an individual basis the data shows only slight changes during the year, with the ranking of body fatness being similar for the group at the start and finish of the study.

The above results also show a very large range in %Body Fat within the group. It can be seen that these values range from an acceptable level to a value well in excess of the 25% body fat level considered to represent obesity in male subjects. [Fox and Corbin; (1985)].

WEIGHT OF FAT: Table 3.09 shows a significant increase in the group's weight of fat over the monitoring period. In group terms this increase is 1.3Kg of fat with individual values ranging from 0.2Kg to 4.8Kg. This increased weight of fat can be explained by the relatively consistent %Body fat level in relation to increased body weight, in that a steady percentage of an increasing weight value will yield a higher weight of fat. In other words as the children grew older the weight of fat increased commensurate with an increase in lean body mass

TABLE 3.09: WEIGHT OF FAT(Kg) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	6.8	7.1	7.3	7.5	7.6	8.1	8.1
SD	5.1	5.1	5.1	5.4	5.4	6.0	6.3
RANGE	3.3 - 20.8	4.0 - 21.2	4.1 - 21.6	4.1 - 22.4	4.5 - 22.6	4.2 - 24.7	4.4 - 25.6
SIGNIFICANT DIFFERENCES OBSERVED BETWEEN TESTS (P<05);2&6, 2&7 (P<01): 1&6, 1&7							

The parameters discussed so far in this section, although of value, are ancillary to the central issue of change in cardiorespiratory fitness as measured by the PWC 170 test. Data obtained from the PWC tests are presented and briefly reviewed in the tables which follow. General consideration of the PWC data is discussed in the next section.

3.03 CARDIORESPIRATORY ENDURANCE MEASURES

The tables which follow present the results of the cardiorespiratory endurance measurements obtained during the 12 month monitoring period.

PWC 170 (WATTS):

TABLE 3.10: PWC 170 (WATTS) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	85.3	79.6	80.4	81.3	85.0	92.5	87.1
SD	13.9	17.5	17.3	14.9	18.4	16.6	16.4
RANGE	59.7 - 102.7	59.7 - 110.3	56.4 - 114.5	59.0 - 107.4	56.3 - 122.1	61.9 - 120.6	44.1 - 102.7
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

The PWC 170 scores above are presented in WATTS giving an absolute value for the amount of work which subjects can perform at a heart rate of 170 beats/minute. This value gives no indication of PWC relative to the individual's weight.

Although statistical analysis shows no significant change in PWC 170 (WATTS) during the course of the year, there does appear to be a trend of declining PWC scores during the winter and a slight improvement in PWC scores at the start of the summer, the level declining again over the vacation period.

PWC 170 (WATTS/Kg):

TABLE 3.11: PWC 170 (WATTS/Kg) [N = 9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	2.6	2.3	2.3	2.3	2.4	2.5	2.3
SD	0.5	0.5	0.5	0.6	0.5	0.5	0.6
RANGE	1.6 - 3.5	1.4 - 3.1	1.2 - 2.9	1.1 - 3.0	1.2 - 3.1	1.1 - 2.9	1.1 - 3.1
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

The above PWC 170 scores provide an indication of the amount of work which the subject can perform at a heart rate of 170 beats/minute per unit of body weight, giving a value more directly related to the cardiorespiratory endurance of the subject in functional terms.

Statistical analysis shows no significant change in PWC 170 (WATTS/Kg) during the year but the results do suggest there may be an underlying trend which would perhaps be revealed if the sample size had been greater. An initial reduction in mean PWC 170 scores is followed by a levelling off between December and April before picking up again in June, perhaps reflecting less activity outwith school due to increased hours of darkness during the winter months.

PWC 170 [WATTS/Kg (Fat Free Weight)]: The presentation of PWC 170 scores in terms of Watts/Kg of fat free body weight provides an indication of cardiorespiratory fitness relative to lean body mass.

TABLE 3.12: PWC 170 [WATTS/Kg(Fat Free Weight)] [N=9]

	TEST1 AUG	TEST2 DEC	TEST3 JAN	TEST4 MAR	TEST5 APR	TEST6 JUN	TEST7 AUG
$\bar{X}$	3.1	2.8	2.8	2.8	2.8	3.1	2.8
SD	0.5	0.5	0.5	0.6	0.5	0.5	0.6
RANGE	2.4 - 4.0	2.1 - 3.5	1.8 - 3.4	1.7 - 3.5	1.9 - 3.6	1.8 - 3.7	1.8 - 3.6
SIG / N.SIG	NO SIGNIFICANT DIFFERENCES OBSERVED						

Statistical analysis shows no significant change in PWC 170 [Watts/Kg (Fat Free Body Weight)] over the year. As with the other PWC 170 results the trend is one of a reduction in mean score over the winter period followed by a rise in the summer months.

By viewing both sets of relative data for PWC 170 it can be seen from the standard deviation that the results are more closely grouped than the PWC 170 scores in absolute terms. This is an interesting point as it reinforces the use of relative values in the evaluation of cardiorespiratory fitness as a means of comparing and contrasting individuals on a common standard having made some allowance for weight and fat variations.

With heavier and fatter individuals an explanation of the difference between absolute and relative cardiorespiratory fitness can help motivate that person to greater commitment to physical activity and healthy eating as part of a weight control programme.

No significant change was observed in cardiorespiratory fitness as monitored by the PWC 170 test as expressed in either absolute or relative terms. It can therefore be concluded that Physical Education lessons had no effect on cardiorespiratory endurance.

Although the overall PE programme had no effect on cardiorespiratory fitness it can not be said that the same was true of all PE lessons. The section which follows shows that in all activities monitored there were cases where the lessons would have had a conditioning effect.

3.04: LESSON MONITORING

In this section the results of the PE lesson monitoring are given in relation to the time spent within the heart rate training band. The results are presented in general summary form in this section. A detailed results analysis for each activity monitored is contained in the appendix.

TABLE 3.13: SUMMARY OF PE LESSON MONITORING

ACTIVITY	# of PUPILS MONITORED	TIME IN TRAINING BAND (min & sec)	
		$\overline{X}$	SD
RUGBY	13	12 : 45	7.6
HRPF	14	9 : 30	3.5
BASKETBALL	27	10 : 00	4.0
VOLLEYBALL	21	4 : 10	4.0
ATHLETICS	21	11 : 55	8.1
ALL ACTIVITIES	96	9 : 25	6.3

3.05: RUGBY

Table 3.13 shows that the mean time spent within the training band during Rugby lessons was 12 minutes, 45 seconds. This shows that, on average, the required intensity of effort was not sustained for a sufficiently long time period.

Examination of individual results shows that of the 13 lessons monitored, 4 were of sufficient intensity for the required duration to develop cardiorespiratory fitness.

From the Rugby data in the appendix it can be seen that the largest amount of time (39 minutes, 05 seconds) was spent working at levels below the training band with, on average, 8 minutes, 10 seconds spent above the upper limit of the training zone. It is interesting to note that the period above the training band for Rugby is much larger than for any of the other activities monitored. A possible explanation for this may be that Rugby tends to be a rather discontinuous type of game with frequent bursts of high activity interspersed with player contacts, game situations and phases which necessitate stoppages. This is particularly true for beginners where the need to control the game is essential to establish good discipline and understanding of the game.

3.06: HEALTH RELATED PHYSICAL FITNESS

Table 3.13 shows that on average 9 minutes, 30 seconds was spent within the training band of 70% to 85% maximum heart rate (146 to 176 beats/minute).

The majority of time was spent below the training band's lower limit with very little time spent at levels in excess of the upper border of the zone. Examination of the HRPF data in the appendix shows that time spent in the training band ranged from 4 minutes, 30 seconds to 15 minutes.

In view of these results and the fact that in only one of the 14 lessons monitored was heart rate within the training band for the required duration it may appear rather disappointing that a block of lessons on HRPF was unlikely to directly improve cardiorespiratory fitness. However, this does not mean that the course would not have been successful in meeting its objectives in terms of educating pupils about HRPF. This point is developed further in the discussion.

RUGBY AND HEALTH RELATED PHYSICAL FITNESS: The sampling procedure for both Rugby and HRPF selected subjects on a random basis, therefore all subjects had an equal chance of being monitored. Initially one and then two Sports Tester PE 3000 units were in operation during each lesson.

Examination of the results from both activities shows average times within the training band to be below the required duration for the necessary intensity. Although on an average basis lessons were unlikely to have any effect on cardiorespiratory fitness this was not the case for each individual.

Overall in Rugby and HRPF 27 lessons were monitored. Of those 27, 5 showed pupils working sufficiently hard for at least the minimum duration. Perhaps, more interesting was the considerable variation in the time individuals spent within the training band. These times ranged from zero to 28 minutes, 30 seconds.

Part of the variation could be explained by the differing lesson lengths (60 minutes for Rugby and 44 minutes for HRPF), however as both activities showed considerable variation, 23 different values in 27 lessons, it seemed unlikely that time was a major influencing factor. Perhaps a more plausible explanation was the respective fitness levels of the pupils being monitored.

In response to these initial findings the researcher decided to sub-divide the group in order to investigate whether or not levels of cardiorespiratory fitness influenced the amount of time spent within the heart rate training band.

The availability of three Sports Tester PE 3000 units allowed for the complete sample to be sub divided into three groups as previously described. Following their PWC 170 test at the start of each block (Basketball, Volleyball and Athletics) subjects were ranked on their PWC 170 Watts/Kg results and allocated to either the High, Middle and Low fitness groups based on the homogeneity of results from the rank order.

One subject was selected from each of these sub groups and monitored throughout the block of lessons. This meant that in every lesson the same pupil from each of the three (High, Middle and Low) groups was monitored thereby providing a more consistent picture of activity levels during all lessons.

The tables contained in the appendix for Basketball, Volleyball and Athletics provide analysis of each of the sub groups and the group as a whole on each activity. Sub groups were compared on each activity using a t-test for correlated samples [Miller; (1978)].

3.07: BASKETBALL

Table 3.14 shows the results of monitoring the same three subjects in each Basketball lesson. The table also shows the combined analysis for all pupils lessons monitored.

TABLE 3.14: BASKETBALL LESSON MONITORING

FITNESS GROUP	# of PUPILS MONITORED	TIME IN TRAINING BAND (min & sec)	
		$\overline{X}$	SD
High	9	9 : 00	3.3
Middle	9	9 : 25	4.2
low	9	11 : 35	4.4
TOTAL	27	10 : 00	4.0

The table shows that overall the Basketball lessons monitored were not sufficiently intense to improve cardiorespiratory fitness. Only four of the 27 lessons monitored met the standard guidelines, with the majority of the time being spent working below the heart rate training band. A more detailed description of Basketball lesson data is contained in the appendix.

Results show that the mean value for time spent within the heart rate training band is less than that recommended, regardless of fitness level. The pupil with the lowest fitness spent slightly more time in the training band.

The largest difference between the three sub groups was in terms of time above the training band with the least fit pupil working for longer at this intensity. This can be explained by the nature of the game which requires regular bursts of intense effort. This demand would be harder for the less fit pupils as they would be less able to recover between bursts of effort and consequently their heart rates at the onset of the next exercise bout would be higher than a fitter pupil.

Within each of the sub groups there was a wide range of time spent in the heart rate training band by the individual subject being monitored. From this it can be seen that all subjects did exercise at the necessary intensity for the required duration during at least one of the lessons monitored. This shows that lessons did meet the standard guidelines on some occasions. Taking this into account it seems reasonable to conclude that lesson content was a major influencing factor in determining the cardiorespiratory effects of the lesson. Therefore by placing greater emphasis on the teaching methods and lesson content which achieved this outcome lessons could be taught in such a way as to help develop cardiorespiratory fitness. This point is developed further in the discussion.

In statistical terms, cardiorespiratory fitness had no effect on the amount of time spent exercising within the heart rate training band during Basketball lessons. Subjectively, however, the lessons may place greater demands on the least fit subjects since the subject with lowest fitness spent more time working above the bottom end of the heart rate training band, and more time above the upper limit.

3.08: VOLLEYBALL

Table 3.15 provides both a collective analysis of Volleyball lessons and data from each of the sub groups. The table shows that the Volleyball lessons monitored were not sufficiently intense to improve cardiorespiratory fitness. In fact, on no occasion did any Volleyball lesson meet the required standards. As with the other activities monitored the majority of time was spent below the heart rate training band. Of the three sub groups, the middle fitness subject appeared to work harder than the others. However, the data obtained would not indicate the prospect of cardiorespiratory fitness development for any of the three sub groups.

TABLE 3.15: VOLLEYBALL LESSON MONITORING

FITNESS GROUP	# of PUPILS MONITORED	TIME IN TRAINING BAND (min & sec)	
		$\overline{X}$	SD
High	7	3 : 30	3.5
Middle	7	6 : 40	4.2
low	7	2 : 20	2.0
TOTAL	21	4 : 10	4.0

No significant differences were shown between the three groups on the parameters reported. Therefore, cardiorespiratory fitness had no effect on the amount of time spent exercising within the heart rate training band during Volleyball lessons. A more detailed description of Volleyball lesson data is contained in the appendix.

When looked at in relation to the other activities monitored Volleyball required a lower intensity of effort from the pupils. The researcher believes that this can be largely explained by the teaching approach frequently adopted in Volleyball. Often Volleyball, as it was in this case, is taught in a rather static fashion with limited movement. New approaches to teaching Volleyball are being promoted which place greater emphasis on on movement in the game. These developments, although more in terms of movement quality rather than frequency would perhaps produce different results, although their value with regard to cardiorespiratory fitness development would require further investigation.

In relation to the terms of reference for this research Volleyball did not meet the criteria for cardiorespiratory fitness development. This does not mean that Volleyball, or any other activity monitored, was not of value in terms of the development of performance in that activity or the curriculum in general. Indeed, in terms of skill development, Volleyball was successful as the class showed considerable improvement during the block.

3.09: ATHLETICS

The results in Table 3.16 show that for Athletics lessons the average values for the time spent within the heart rate training band for subjects in each sub group were below the duration necessary to develop cardiorespiratory endurance. The results from each of the sub groups were very similar, there being no significant differences between the groups on any of the parameters. Therefore, cardiorespiratory fitness had no effect on the amount of time spent exercising within the heart rate training band during Athletics lessons. A more detailed description of Athletics data is contained in the appendix.

TABLE 3.16: ATHLETICS LESSON MONITORING

FITNESS GROUP	# of PUPILS MONITORED	TIME IN TRAINING BAND (min & sec)	
		$\overline{X}$	SD
High	7	11 : 20	8.4
Middle	7	13 : 30	9.9
low	7	11 : 00	7.0
TOTAL	21	11 : 55	8.1

The data obtained during Athletics lessons is reported in general terms. No account is taken of the events being performed within each lesson. The reason for this was that within each lesson a number of activities were covered. Also the teaching approach often involved group work which meant that there was variation in the tasks and activities performed in any one lesson. Over the period of the block all pupils covered the same range of events. As this study investigated the effects of PE lessons the researcher decided not to dwell on individual lesson content, and instead, to consider whole lessons in general.

3.10: SUMMARY OF ALL ACTIVITIES

Table 3.17 provides a summary of all lessons monitored in the course of the research. It combines the data from five different blocks taught to a first year boys class during one year of secondary school PE. Caution should be exercised in the interpretation of of the data in Table 3.17 as it is very much a summary of mean scores. However it does provide a useful indicator of the overall effects of the PE programme.

# of PUPIL LESSONS MONITORED		LENGTH OF LESSONS (MINUTES)	
96		$\overline{X}$ 55min 30sec SD 11.7 RANGE 31min 00sec - 83min 00sec	
LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]			
	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\overline{X}$	9:25	41:25	4:30	14:00
SD	6.3	13.3	6.0	9.1
RANGE	0:00 - 31:30	7:00 - 72:30	0:00 - 35:30	0:00 - 40:00

TABLE 3.14 SUMMARY OF TOTAL LESSONS MONITORED IN RUGBY, HRPF, BASKETBALL, VOLLEYBALL AND ATHLETICS

These results show an average duration of 9 minutes, 25 seconds of activity within the heart rate training band with the pupils spending the majority of the lesson working below this level. Of the 96 pupil lessons monitored, 14 met the standard guidelines for cardiorespiratory fitness development.

One important point can also be taken from Table 3.17, namely the considerable variation in the subjects' response to PE lessons.

Looking at the range of results in each of the fitness categories it can clearly be seen that the demands of PE lessons were wide ranging, showing considerable variation in terms of time spent within, below and above the training band. This point reinforces the need to consider individuals within the class and to remember that there is a wide range of heart rate responses to similar lesson content.

This point is highlighted in all activities with all levels of cardiorespiratory fitness. The time spent within the training band ranged from zero to in excess of half an hour, indicating that in some cases PE lessons could have a very positive influence on cardiorespiratory fitness. On the other hand the fact that considerably more time was spent below the training band, 72 minutes, 30 seconds in one case, shows that overall PE would be unlikely to have a fitness effect.

Another interesting point is the time spent above the training band. Although the mean value is small the table shows that one subject spent over 30 minutes working above his training band. The researcher believes that this reinforces the need for the development of better fitness development guidelines for children as it would not be possible for a child to sustain such high work intensity for this time period.

The data obtained from lesson monitoring reinforce the ineffectiveness of PE in relation to fitness development and supports the view that PE does not improve cardiorespiratory fitness.

The results of lesson monitoring show that for all activities, at each level of cardiorespiratory fitness there was wide variation for the same subject with regard to the time spent within the heart rate training band. Cardiorespiratory fitness level was not a factor in determining which lessons produced the sufficiently long and intense response from the subject. It appears logical to suggest that lesson content and teaching approach are important factors in determining the effectiveness of PE lessons in relation to cardiorespiratory fitness.

CHAPTER 4 : DISCUSSION

CHAPTER 4 : DISCUSSION

4.01: ANTHROPOMETRIC RESULTS

HEIGHT :When comparison is made with data reported from other studies it can be seen that the boys in this study were of a similar height to those measured elsewhere. Queens University; (1988) report a average height of 147.0cm for first year pupils in Belfast. Farrally, Watkins and Ewing; (1980) surveyed Scottish Schoolboys at ages 13, 15 and 17. Although the 13 year old category is older than the group measured in this research the mean value of 151.9cm for 13 year olds is just less than 5cm more than the mean value for this group. This 5cm difference over a one year period is of the expected average increase in height at age 12 years reported by Kemper; (1983).

Looking further at the data from the research the average height increase of 6.89cm shown over the one year period is larger than the rate reported above by Kemper but does fall within the rate of height increase of 5.4cm $\pm$ 1.50cm/year reported by Mirwald and Bailey; (1986).

From these other studies it appears that the subjects in this study are of the expected average stature for their age.

WEIGHT: When compared to Belfast schoolboys this group are lighter than their Northern Irish year counterparts.

If, as with height, the reported rate of weight gain is applied to this group for the purposes of a comparison with the 13 year olds monitored by Farrally, Watkins and Ewing; (1980) it can be estimated that this group will be similar in weight to the mean value of 42.2kg reported in the Scottish survey.

Examination of individuals within the group gives a wide range of weights. It is interesting to note that the pupil who was heaviest at the outset remained so over the year. The same pupil also had the greatest amount of body fat. His body fat did not increase by the same magnitude resulting in an increase in his lean body mass. His height also increased by 4cms.

At the other end of the class weight range continuum most pupils showed an increase in weight of between 2 and 5kg. One pupil showed an increase in weight of 7kg. Although this is a large increase it can easily be explained by the fact that this subject was the one who grew 15cm during the year.

SKINFOLD MEASURES: In the course of this discussion it will become apparent that there are almost as many variations in the use and reporting of skinfolds as there have been studies which have measured them. For this reason, evaluation and comparison of skinfold results obtained in this study are done in terms of both separate and summated skinfolds.

In their study of Scottish schoolboys Farrally, Watkins and Ewing; (1980) reported values for Tricep, Subscapular and Suprailiac skinfolds. Evaluation of these researchers' data shows that the skinfolds obtained from the group in this research were larger than those reported in 13 year old boys. Results from this research show that the subjects monitored were higher on all skinfolds when compared to their 13 year old Scottish counterparts.

When the separate skinfolds were summated the comparison between this group and other research was again unfavourable. Telford and Ellis; (1986) report an average of 32.1mm in their study of trained and untrained 12 year old boys. This value is below the range of mean values (36.84 to 39.87) observed at any time in this research.

%BODY FAT: Only limited comparative data is available for %Body fat from other studies however this group exhibits greater amounts of body fat than the average of 17.0% measured in first year boys in Belfast.

These changes in %body fat should also be considered in relation to the steady increases shown in both height and weight. As described both height and body weight increased at a rate in accordance with age. These data show therefore that as body dimension increases the component of body composition comprising fat remains at a consistent level.

Normally, having established %body fat, researchers use the values obtained either as a free standing figure and/or to calculate lean body mass. From the latter calculation a statement about functional body mass can be made for use in the interpretation of fitness test data.

Another use for the data is to calculate the weight of fat in subjects. This is not a value often reported, however, by plotting this figure over a year long period changes in the subjects' weight of fat can be monitored.

The researcher found no other studies reporting weight of fat data, therefore any interpretation of this data has to be of a rather subjective nature. Children are often referred to as having 'puppy fat' which they will somehow loose as they get older. Results from this study, which show an increase in mean weight of fat from 5.05 to 6.60 Kg refute this notion and indeed suggest the converse to be the more likely outcome. The cardiorespiratory fitness of the group did not change significantly over the year indicating that the group did not engage in physical activity of adequate duration, intensity and frequency. Considering this in relation to the weight of fat a logical explanation is that if fat stores increase they do not somehow disappear as the child develops, rather, as in adults, the fat stores simply enlarge with insufficient activity combined with an increase in food intake.

Looking at body composition from the cardiorespiratory fitness perspective then the relative amounts of body fat and lean body mass are important. Aerobic metabolic processes underpin cardiorespiratory fitness. Consequently although some fat is essential to body function, in exercise terms body fat is largely excess baggage. This metabolism occurs in the mitochondria at muscle level and so the effect of body fat on this process is not functional, rather it provides more weight for the contracting muscles to move therefore necessitating the production of more energy in order to continue muscle contraction to achieve the intended movement.

In recognition of the non-functional role of body fat in exercise and in order to judge effective body weight a measure of lean body mass can be calculated. This value can then be used to evaluate cardiorespiratory endurance relative to the subject's functional body weight. The data obtained are considered further in the discussion of cardiorespiratory fitness results.

Reservations concerning the accuracy of using skinfold measures to estimate %body fat in children have been expressed by several researchers; [Lohman; (1982), Lohman et al.; (1984), Telford and Ellis; (1986), Lohman; (1989)]. The basis for these reservations is the use of body density in the calculation of % body fat from the sum of four skinfold measures (biceps, tricep, subscapular and suprailiac).

Lohman et al.; (1984) expand this point indicating concern over the use of adult reference values with children.

> "by employing conventional methodological approaches to estimate body composition in children, that is, adult models, estimates of fat and fat-free body may be inaccurate."
>
> Lohman et al.; (1984)

Whereas it would be unwise to ignore the above researchers views, it is also worth considering the original research of Durnin and Rahaman; (1967). Their work was conducted in the Glasgow area with subjects ranging in height and weight from 139.1cm to 183.1cm and 34.2Kg to 73.9Kg respectively. Further, the mean values for the sum of four skinfolds measured in this group were also within the range reported by Durnin and Rahaman. The research group in this study were also Glaswegian and the group means for height and weight were also within the range originally monitored. It could therefore be the case that the estimation of %body fat for this group could be made with more accuracy than for other groups because of the geographic similarity with the original research to establish the formulae to convert skinfolds to %body fat.

In attempting to evaluate and compare the measures of body composition used in this research the foregoing discussion has identified a range of reported variations on the use of skinfolds either separately or collectively as skinfold scores or as the basis for the estimation of %body fat. Consideration of these different reporting methods leads the researcher to agree with Lohman; (1982).

> "Unfortunately, procedures are available which encourage the uninformed practitioner to predict the fat content of children from anthropometric dimensions. Caution should be exercised in this regard because of change in the relation of skinfolds to body density."
>
> Lohman; (1982)

In view of the above it is prudent to take account of the reservations expressed when interpreting this data, and also to be mindful of these points when examining the findings of other research.

Although caution is advised in the interpretation of body composition data in children the present sample were consistently higher on separate and summated skinfold measures and also on %body fat than has been reported in other research. It seems logical to suggest that the group exhibit greater than normal levels of body fat.

Obesity is well established as a major coronary heart disease risk factor [Fentem, Bassey and Turnbull; (1989), Armstrong; (1984)]. The fact that this group generally show increased levels of body fat is of concern in terms of current and future health status.

> "the longer a child remains obese through childhood, the greater the chance of becoming a fat adult, and by the time adolescence is reached there is an 80% chance that the fat child will remain fat rather than fit for life."
>
> Fox and Corbin; (1986)

A possible solution to this problem lies in directing attention to the need to regulate diet and to take regular exercise.

> "obese children can be motivated to increase their physical activity in their efforts to reduce weight, but a reduction of the energy intake is at least as important as intensified

physical activity in a weight-reduction programme."

Huttenen et al.; (1986)

This research has reinforced the need for appropriate education as to the combination of diet and exercise in both the prevention and amelioration of increased body fat.

4.02: CARDIORESPIRATORY ENDURANCE RESULTS

There were no significant changes in PWC 170 (WATTS), however the general trend showed decreasing scores during the period from August to March, followed by an increase prior to the summer vacation in June, with a further reduction shown over the holiday period to a level of fitness similar to that monitored in the previous August.

At an individual level the pupil who grew 15cm showed a 17% increase in PWC 170 (WATTS) over the year. Also the subject who increased in both weight and body fat showed a further unfavourable trend in that his PWC 170 (WATTS) showed a reduction of 16% in the twelve month period.

Perhaps the most interesting individual feature was shown by a subject who was a very talented footballer, (playing for the juvenile section of a professional club). At the start of the research his PWC 170 was 99.4 watts; in the 9 months period to April his PWC 170 rose to 122.1 watts. During this period he was involved in football training and playing usually two matches each weekend. His football season ended in May, just after the April test session, which meant he was no longer training and playing so frequently. As a result of this his PWC 170 (WATTS) fell by 24% over the period to August.

The other subjects all tended to reflect the general trend of the group.

PWC 170 (WATTS/Kg):PWC 170 in WATTS/kg provides an indication of cardiorespiratory endurance relative to the subject's body weight.

This point is expanded by Cunningham et al; (1984) who recognise that if absolute measures, for example PWC 170 in WATTS, are taken there are problems in

> "interpreting the results in which
> several variables are changing
> simultaneously, that is, body size

> as well as functional capacity."
>
> Cunningham et al; (1984)

As a consequence of this the need to take account of these factors is recognised by the use of a measure relating to the subject's body weight.

> "Traditionally, VO_2 max has been expressed as a ratio absolute VO_2 max divided by body weight, to provide a means of comparing individuals with different body weights and as an expression of the ability to mobilize one's body weight during activity."
>
> Mirwald and Bailey; (1986)

Although this quotation is stated in terms of maximal oxygen uptake the same rationale applies to PWC measures.

The results table showed no significant change in PWC 170 (Watts/kg) in the group monitored.

This was a particularly important factor when monitoring changes in children since, as already noted, body weight changed. This is of interest in this study because body weight and height have both been shown to increase, however subjects' PWC in Watts has shown no significant change.

Looking at the scores on an individual basis there is very little change during the monitoring period. The subject who showed a 24% fall PWC 170 (Watts) also showed a reduction in PWC 170 (Watts/kg) during the same period. This would appear to reaffirm the loss of fitness due to reduction in regular activity. The heaviest subject in the group who showed a 16% reduction in PWC 170 (Watts) also showed a reduction in PWC 170 relative to body weight.

Other subjects in the group again tended to mirror the general trend established by the group means although relatively constant absolute PWC 170 values coupled with an increase in body weight showed a slightly larger variation in relative PWC 170 scores than was shown in absolute terms.

PWC 170 [WATTS/Kg (Fat Free Weight)]:Judgement of cardiorespiratory fitness relative to fat free weight is supported by Zwirnen; (1989) who states that in terms of cardiorespiratory fitness reporting scores in relation to lean body mass.

> "does attempt to remove the confounding influence of body size and body composition."
>
> Zwirnen; (1989).

In terms of PWC scores it allows for conversion of an absolute value (watts) into a value representing cardiorespiratory fitness relative to the actual body structures responsible for the production of energy and the resultant execution of movement.

Again statistical analysis showed no significant change in PWC 170 [Watts/kg (fat free weight)]. As this measure effectively corrects an absolute value for the influence of weight and body fat it is not surprising that the PWC 170 [Watts/kg (fat free)] results show a higher mean value and narrower range of scores than PWC in Watts/kg. Although the range of scores is narrower than for the two previous PWC data the range still shows considerable variation between individuals with one pupil showing values in excess of 3.5 watts/kg.

A note of caution regarding the use of fat free measures of cardiorespiratory fitness in children is raised by Zwirnen; (1989) who states that where fitness levels have been

> "expressed relative to a fat free
> weight (FFW), the limiting factor
> appears to be the methods used to
> establish body composition."
>
> Zwirnen; (1989).

As has already been discussed, the accuracy of using skinfold measures to estimate body fat levels in children has been questioned although a case could be argued for its use on the basis that the current sample characteristics are similar to the original research group used to establish the formula used to estimate body fat levels.

The use of the lean body mass relative to cardiorespiratory fitness has not been widely adopted. There appears to be agreement that expressing cardiorespiratory fitness

> "relative to fat-free weight was
> probably the best available measure of
> cardiorespiratory capacity because it
> is not affected by body fatness."
>
> Cureton; (1982).

However despite support [Zwirnen; (1989), Lohman et al; (1984), and Mirwald and Bailey; (1986)] there is still a lack of clarity as to the precise nature of how cardiorespiratory fitness is influenced by growth and as a consequence the use of relative judgement of fitness using fat free weight has not been as widely used as other relative measures. This is also due to the need for accurate body composition assessment to accompany the chosen fitness measure.

PWC 170 TEST: In outlining the background to the selection of the PWC 170 test it was clear that although the test is well established there is considerable variation in its administrative protocol. This variety in test implementation should be borne in mind when interpreting test results with a view to comparison with other research.

Incorporation of the PWC 170 test by the Council of Europe into its EUROFIT test battery (1988) will extend its use. A further benefit will be that the test will be administered, and its results reported, in a standard format.

Comparison of group results from this study with PWC 170 values from other research has to be the subject of careful interpretation. Firstly, the researcher could find no other studies where a series of measures were administered on the same cohort over a one year period. Secondly, in any comparison the numerical format of results presentation has to be considered.

In order to establish some standardised values for comparative purposes the researcher in some cases had to use the data presented by other authors and convert them to provide appropriate comparable data. For example if a study presented mean values for body weight and PWC 170 watts then it was possible to calculate an average value for PWC 170 in watts/kg. In the table which follows results which have been established in this way are marked with an asterisk.

One further calculation was made to data from this research to facilitate a comparison. All other studies report one mean value for pupils of the same age at the time of monitoring whereas this study had seven measures of PWC 170 over a one year period. In order to evaluate this data in terms of other results an average value was calculated from the seven test results.

TABLE 4.01: COMPARISON OF PWC 170 TEST RESULTS

	MEAN PWC 170 VALUES WATTS	WATTS/Kg
This study (age 12)	84.46	2.37
Farrally;(1980) Scotland (age 13)	95.2	2.24*
Queens University (1988) Belfast (first year)	108.95*	2.69
Gauthier;(1983) Canada (age 13)	92.34*	2.18*
Telford;(1986) Melbourne (age 12)	104.5*	2.70*

(* data converted by the researcher to provide comparison)

Of the studies reported above only that of Queen's University; (1988)was conducted using the same protocol [EUROFIT; (1988)] as this study. Also, the degree of further calculation by this researcher on the results of other studies should be noted as this was on the basis of reported average scores and not directly measured data. Despite these restraints the above data do provide sufficient information to give an indication of the cardiorespiratory fitness of the subjects in this study relative to other boys of a similar age.

The results reported by Farrally, Watkins and Ewing; (1980), although obtained on 13 year olds indicate larger values in terms of PWC 170 watts, but when body weight is used to provide a relative value there is only a slight variation between the two groups. The larger PWC 170 absolute value can be accounted for on the basis that being a year older than the subjects in this study the sample were larger, having greater body mass and would be expected to do more work. This explanation is confirmed by the similarity in PWC 170 watts/kg scores between the two studies.

Of more significance is the somewhat larger difference between results of subjects in this study and those from Belfast. The Belfast pupils showed higher values in terms of both absolute and relative PWC 170 results. The largest difference was in terms of PWC 170 in watts with the Belfast boys showing a 28% higher value than subjects in this study. Relative PWC 170 scores show the Belfast group to have 13% higher results. The results, even when allowing for the slightly larger body weight of the Northern Irish subjects, shows a considerable difference in favour of the Belfast group.

In a review of children's fitness levels, Tuxworth; (1988) commented on the data obtained in the Belfast and Scottish surveys.

> "The mean scores for Belfast children, on the PWC 170 test, were much higher than were the values for Scottish boys ---. Possibly methodological differences --- could account for a small part of this difference which is a recurrent problem with all comparisons."
>
> Tuxworth; (1988)

As already indicated the results of this study appear relatively similar to those in the Scottish school boys survey. In the above explanation of the difference between the Scottish and Belfast groups test protocol is identified as a factor contributing to the observed difference. In view of the fact that this study used the same protocol as the Belfast research then it may be that the Northern Irish boys have greater levels of cardiorespiratory fitness. Clearly the sample monitored in this study can not be considered representative for the purposes of making objective comparison, however despite this limitation, research to date would support such a possibility.

Judgement of the results of this study relative to data obtained in Canada by Gauthier et al.; (1983) and in Melbourne, Australia by Telford and Ellis; (1986) shows the pupils in this study generally to have lower cardiorespiratory endurance.

Telford and Ellis's ; (1986) Australian group consisted of both trained and untrained subjects and gave better results in both absolute and relative PWC 170 values. The higher scores for both absolute and relative PWC 170 values could be partly due to protocol but it seems reasonable to explain at least some of the difference between the Australian group and this study's sample as resulting from greater cardiorespiratory endurance of the Australians.

Compared to Canadian children this research group receives a more favourable review. In absolute terms the values are similar but when body weight is taken into account the greater weight of the Canadian boys reduces their relative PWC 170 values. Consequently the sample in this research shows a greater level of cardiorespiratory endurance relative to body weight, although the significance of this difference cannot be established.

In broad terms it seems that the subjects in this study show levels of cardiorespiratory fitness consistent with those measured in the survey of Scottish schoolboys. Relative to boys in Belfast and Melbourne the boys monitored have lower levels of cardiorespiratory endurance in terms of both absolute and relative PWC 170. Comparison of these subjects to Canadian boys shows a slight balance in favour of this group, but, as with other comparisons no significant difference can be established due to variations in protocol and results presentation format.

Analysis of PWC 170 data in terms of Watts, Watts/Kg of Body Weight and Watts/Kg of Fat Free Weight shows no significant change in cardiorespiratory fitness during the monitoring period.

The results obtained show no significant change in cardiorespiratory fitness levels over the year. This indicates limited levels of physical activity outwith school throughout the year and also that the Physical Education programme did not improve cardiorespiratory endurance in this group of first year secondary schoolboys.

This is clearly a very important point in relation to the overall research. The purpose of this research was to monitor cardiorespiratory fitness and to assess the effects of PE lessons in relation to cardiorespiratory fitness development.

Results obtained from both these areas allow the researcher to draw three important conclusions. Firstly, pupils cardiorespiratory fitness showed no significant change over the monitoring period. Secondly this was reinforced by the finding that the PE programme was not sufficiently intense for the required duration to improve cardiorespiratory endurance.

The third conclusion can be made on the basis of the two previous points. The evaluation of PE lessons was very specific, looking in detail at an area of importance in terms of children's physical activity. However although PE provides an important exposure to activity it is obviously not the pupils only opportunity to be active.

On this basis it can be concluded that no significant change in fitness means that pupils activity levels outwith school were not of the appropriate intensity, duration and frequency in order to improve cardiorespiratory endurance.

This conclusion supports Tuxworth; (1988) who reviewed activity levels and reported watching television as the most frequently adopted leisure activity in children.

This lack of activity is reinforced by Gilliam and Macconie; (1984) who report that

> "voluntary activity patterns in children may be inadequate in terms of duration and intensity to promote cardiovascular health --- it is evident from these data children do not participate in a significant amount of regular vigorous physical activity."
>
> Gilliam and Macconie; (1984)

Results from this research support the above point.

4.03: LESSON MONITORING

The researcher could find no other work which had monitored a group over a year long period or which had looked at the same range of activities relative to cardiorespiratory fitness levels of the subjects. In the light of this only limited comparisons can be made with other research. Also differences in the method of heart rate monitoring used had to be considered, especially with regard to differences in the monitoring sample period or between continuous measures and those taken on cessation of the activity.

As discussed in relation to establishing the standard guidelines for the judgement of the heart rate data obtained in this research, there has been considerable variation in guidelines used by different researchers. Although this will not afford an ideal evaluation it will provide a general indication of how the data obtained by this researcher compares with other studies.

Hale and Bradshaw; (1978) monitored schoolgirls aged 12 to 16 years during seven PE lessons. No indication was given as to the age of subject in relation to the activity or to the measured heart rate. The results obtained by Hale and Bradshaw are summarised in the table which follows.

TABLE 4.02: HEART RATE RESULTS (HALE & BRADSHAW)

Activity	$\overline{X}$ Heart Rate (Beats/Min)
Badminton	134.1
Netball	130.5
Athletics	128.7
Keep Fit	121.4
All Activities	129.7

Only Athletics was common to the present research and the work of Hale and Bradshaw. Comparison is difficult due to the results format however the average heart rate of 129.7 falls well below the threshold value of 146 Beats/Minute used in the present study and indicates that improved cardiorespiratory fitness would be unlikely.

Table 4.02 shows the mean heart rates obtained during games (Badminton and Netball) to be higher than Athletics, with Keep Fit being the lowest. Trying to gauge these results relative to cardiorespiratory fitness it appears that games are more likely, although by no means certain, to be successful. Results of the current study would not support this suggestion, although the tentative nature of this conclusion must be stressed due to the variations in subjects, activities and methodology.

A further limitation is that heart rate is reported as a mean value measured throughout the lesson period. For comparative purposes these figures are of limited value since they do not give any indication of duration and only a restricted statement of intensity, and therefore, when judged in terms of the likely overall conditioning effect of the lesson they provide no more than a basic indication.

Knowles; (1978) monitored a first year boys class during one Gymnastics lesson, observed an average heart rate value of 122.5 Beats/Minute with results ranging from 96 to 151 Beats/Minute, and concluded that the lesson was unlikely to increase cardiorespiratory fitness.

Faulkner et al.; (1963) monitored a group of 14 boys aged 7 to 12 years during lessons in three activities; Gymnastics, Swimming and Sports Skills (games). The data obtained is summarised in Table 4.03.

TABLE 4.03: HEART RATE RESULTS (FAULKNER et al.)

Activity	$\overline{X}$ Heart Rate (Beats/Min)
Gymnastics	136
Swimming	139
Sports Skills	148

The above results suggest a higher mean intensity in effort in Gymnastics than those reported by Knowles; (1978) with Sports Skills (games) providing the greatest level of intensity.

A more recent investigation was conducted by Verabioff; (1988) using a mixed sample of 18 Junior High School subjects aged 13.8 1.3 years. Few details of the activities monitored are given other than an indication that the PE programme for Junior High School pupils included Volleyball, Indoor Hockey, Indoor Softball, Badminton and Dance. No results were presented relative to each activity. Results of the heart rate telemetry data showed an average value of 140.9 Beats/Minute in the overall group. Separate results for males and females were not given.

Verabioff also reported that in relation to a heart rate threshold value of 150 Beats/Minute, 64% of PE time was spent below this intensity with, on average, 36% at or above this threshold. No upper threshold was suggested. In response to these heart rate data and observational data obtained during the same lessons, Verabioff concluded that

> "The results of this study confirm the observational data of other studies that found inactivity to be a dominant feature in physical education classes."
>
> Verabioff; (1988)

This conclusion supports the findings of this research and other studies discussed in this section. Verabioff found that the highest heart rates were during the lesson warm up, with the parts of the lesson where the teacher was instructing the class producing the lowest heart rate values. This variation can be explained in that warm ups tend to utilise more sustained periods of vigorous activity, for example jogging, whereas walking and standing with limited upper body movement are commonplace during periods of instruction.

Although there were no significant differences between activities it could be suggested that activities where the predominant movements require the use of the body's major muscle groups, essentially in running based activities, may be inherently better for cardiorespiratory fitness development. Results from the present research indicated that lessons where running was the basic movement required for performance illicited longer periods within the heart rate training band than activities where different movement patterns and types were needed.

This differentiation between movement type is not to suggest a criteria on which to select or reject activities for inclusion in the PE curriculum. Rather it simply serves to identify general performance characteristics which may improve the prospect of cardiorespiratory fitness development. Although, as this and other research has shown, predisposing movement type does not ensure cardiorespiratory fitness development.

All the research reviewed in this discussion, including the current study, has drawn the common conclusion that Physical Education is unlikely to improve cardiorespiratory fitness. The researcher does not believe that this need always be the case and concurs with Verabioff; (1988) that

> "If physical fitness is going to be
> exposed as an objective then physical
> education classes need to be
> redesigned so that activity intensity

and duration are increased."

Verabioff; (1988)

Guidelines for increasing activity during PE lessons are provided by the Scottish Health Education Group's Guide to Teaching Health Related Physical Fitness, which lists the following points to assist teachers wishing to promote cardiorespiratory fitness development throughout a range of activities in the PE programme.

"Promoting Greater Activity Levels in Lessons.

-Think activity

-Think about increasing activity levels - encourage plenty of movement.

-Warm up should begin gradually and develop into more prolonged periods of high level activity such as running.

-Use skills practices/drills/small sided games that include greater running requirement; organise groups to promote movement.

-Use Mini-games and small sided games as they promote more activity and more individual involvement.

-Less teacher talk - more pupil action!

-Be aware of individual differences in effort required to perform a task.

-In the dressing room review and reinforce the importance of regular activity outwith school."

Scottish Health Education Group; (1988)

The above statements were based on teachers' comments following a school-based research project into teaching Health Related Physical Fitness [Farrally and Green; (1986)]. They suggest a positive way forward in terms of incorporating the prospects of improving cardiorespiratory fitness within the PE curriculum. Further support for this type of approach comes from Seliger et al; (1978), who showed that for their sample of 12 year old boys, lessons designed to produce higher heart rate responses were more successful in cardiorespiratory fitness development terms than those obtained during the standard PE lessons for the group. This difference was statistically significant and highlighted the benefits of modified lesson content and teaching method if cardiorespiratory fitness is to be improved.

The same researchers also compared three different age groups (6, 12 and 15 years) in terms of heart rate response to PE lessons. They found that 15 year old boys worked at higher heart rate levels than their 6 and 12 year old counterparts. As indicated earlier the reason for this may be that the older pupils had higher skill levels and so less emphasis was placed on the area of skill development within lessons.

It should be remembered that school PE is a combination of aims, objectives, content and methods and as such the focus in any one school, department, block or individual lesson can vary. This point is important as this research monitored PE lessons and interpreted them simply with regard to cardiorespiratory fitness development. This is only one way of examining a PE curriculum.

The Physical Education Association; (1987) report nine different objectives for PE. The two most widely perceived by PE teachers as the most important are motor skill development and physical fitness development. This report also indicates a current trend in PE staff towards greater consideration of the value of attending to physical fitness as part of the PE curriculum although no specific suggestion are made.

Looking at individual activity results from this research in the wider context of the overall PE programme throughout the school, it may not be surprising that these lessons did not meet the requirements for cardiorespiratory fitness development.

> "the reason for the lower intensity of
> exercise in younger age groups is the
> predominance of exercises demanding high
> coordination which require more time

consuming learning processes."

Seliger et al; (1978)

It may well have been the case that as all activities taught in this research were new to the class then more time would have been spent on skill development. Perhaps as the pupils' skills improve more sustained, intense performance can be attained during lessons without the detrimental effects of interrupted activity due to skill differences. Some work has been done in this area [Farrally and Green; (1986)] and is discussed later but further research is needed to examine the effects of PE for older, more skilful pupils with greater levels of physical skill.

Review of the data reported in this research shows that for all the activities monitored, regardless of cardiorespiratory fitness level, there was considerable variation in the physical demands of PE lessons. The implications of this finding are that lesson content and the teaching approach adopted influence the intensity and duration of effort during lessons. Therefore, by placing greater emphasis on the content and methods which can be developed to produce training effects, at least some part of PE lessons could, if desired, be used to promote cardiorespiratory fitness development.

These points are reinforced in a study reported by Farrally and Green; (1986). The study involved a comparison of two teaching approaches on basketball skill development. Both groups were matched on the basis of basketball skill. One group of 21 boys were taught a fitness based basketball course with the other group of 22 boys receiving a more traditional course emphasising skill development.

> "Content was similar for both groups the only difference being that the fitness-based group followed drills and practice game situations designed to produce sufficiently high levels of activity to promote aerobic fitness. ---- The control group were taught in the conventional way using demonstrations and low intensity practices to a much greater extent and interrupting games frequently to make teaching points."
>
> Farrally and Green; (1986)

Both classes each received three, 60 minute lessons per week for six weeks with additional time allocated for testing before and after the teaching block. Results of the study showed similar improvements but no significant differences between both groups in terms of skill test performance and game playing ability, as assessed by an independent observer. Cardiorespiratory fitness, as measured by the Six Minute Run Test (EUROFIT; 1983), did show variation in group performance. No significant difference was observed between the groups at the start of the course. At the end the skills-focused group showed no change whereas the fitness-based group showed a significant improvement in cardiorespiratory fitness.

The above findings are important for two reasons. Firstly, they reinforce the view that the adoption of suitable lesson content and teaching methods can lead to improved cardiorespiratory fitness through PE lessons. Secondly they introduce the further consideration that by focussing on cardiorespiratory fitness skill development and playing performance need not suffer as a consequence. The researcher is not aware of any other research in this area although clearly further investigation is required to see if other PE activities could, with some modifications to content and method, be taught with a view to improvement in both fitness and skill. Adoption of this approach is a challenge to traditional methods.

> "attempting to teach basketball with
> an emphasis on aerobic activity was
> a new venture and required
> considerable preparation by the staff.
> The greatest difficulty was trying to

> produce a coherent basketball course rather than an amalgam of basketball fitness training."
>
> Farrally and Green; (1986)

From the above it is clear that this approach would require careful lesson preparation but the researcher believes that the benefits for the pupils outweigh the drawbacks for the staff.

> " A teacher who wishes to raise the activity level of his/her class need not fear loss in skill learning and may well gain the added benefit of improving the fitness of the pupils."
>
> Farrally and Green; (1986)

This approach has much to offer Physical Education as it provides a means by which teachers can achieve a variety of desirable outcomes through a common approach. By teaching pupils knowledge and skills relating to the required intensity, duration and frequency of exercise for cardiorespiratory fitness development, the teacher can highlight the fact that a wide range of physical activities, perhaps not generally associated with fitness, can be used effectively to improve cardiorespiratory fitness.

In cases where the development of cardiorespiratory fitness was an objective for a particular lesson or course, the approach outlined above could be used by teachers to evaluate the effectiveness of lessons. In other words it could be used as part of a self-monitoring exercise by the teacher as a means of evaluating lesson organisation, content and teaching approach in relation to cardiorespiratory fitness development.

The preceding example showed that modification of teaching approach linked to lessons of the necessary intensity, duration and frequency can improve cardiorespiratory endurance. However, three sessions of PE per week, as was the case in the example given, is the exception rather than the rule. A recent survey states that

> "A quarter of the pupils in S1 and more than a third of the pupils in S2 received less than two hours of physical education per week and many within these categories received less than 80 minutes per week. All of these pupils were receiving less than the minimum 7% time allocation recommended by the Scottish Consultative Council on the Curriculum."
> Educational Institute of Scotland; (1989)

It could be argued that PE lessons in any school where less than three sessions per week is available would never be likely to have any substantial effect on cardiorespiratory fitness since the desired frequency of activity could not be realised. This does not mean that, if fewer than three sessions are available per week, PE cannot influence cardiorespiratory fitness.

The HRPF course taught in this research provided a good example of how limited time can be used to educate about HRPF and how to develop cardiorespiratory fitness. By introducing and developing the knowledge and skills for personal exercise prescription within the PE curriculum it was hoped that the pupils could then use the skills and information from the course to pursue appropriate physical activity outwith school.

The course had the following aims;

> "(i) Development of an understanding of HRPF with particular reference to aerobic fitness.
> (ii) Development of knowledge necessary to devise an individualised aerobic fitness programme.
> (iii) Ability to monitor pulse rate and relate this information to aerobic training intensity."
>
> Farrally and Green; (1986)

Such an approach is in accordance with the well supported views that the focus for Health Related Physical Fitness should be on the provision of knowledge and skills to allow the pupils to exercise outwith school and to begin to take more responsibility for their own physical activity. [Biddle; (1981) Fox and Corbin; (1985), Almond; (1986) and Farrally and Green; (1986)]

4.04: SUMMARY AND RECOMMENDATIONS

No significant change in cardiorespiratory fitness was measured by the PWC 170 test were observed during the 12 month monitoring period. It can therefore be concluded that the PE programme in general made no positive improvement in cardiorespiratory fitness. This was not the case for all lessons as there were instances in all five activities monitored where activity levels were sustained with sufficient intensity and duration to have a cardiorespiratory conditioning effect. Heart rate monitoring showed considerable intra-subject variation in response to similar lesson content. This highlighted the importance of teaching content and method in determining the effects of PE in terms of cardiorespiratory fitness development.

This research has indicated a number of issues which merit further consideration with regard to PE and physical activity in children. Some are issues with PE curriculum implications for teaching approach and time availability and others represent possible areas for new research. In either case further investigation is desirable.

One major area which should be researched is the quantification of physical activity with regard to the development of cardiorespiratory fitness in children. As the researcher indicated the standard criteria for children are based largely on adult recommendations. This situation is unsatisfactory and the researcher believes that investigation is needed in the area of exercise prescription for children.

Another issue discussed was the concept that younger children may be less active during PE lessons as a consequence of more attention being paid to skill development. This raises two further avenues for future research. Firstly, is this the case, and if so would a modification in teaching approach raise activity levels without jeopardising the important area of skill development or creating an imbalance in the PE programme? Secondly, do older children, with greater skill levels, exhibit higher activity rates during PE lessons? In response to both these points further research is required.

The question of modification in teaching approach is also important. The discussion identified one instance where the modification of teaching method and content led to increased levels of both skill and cardiorespiratory fitness. The researcher feels that this area could be of particular interest to the PE profession as this approach could ensure the maintenance of a balanced curriculum while also enhancing skill levels and developing cardiorespiratory fitness.

The researcher believes that more work in the area of modified teaching approach is required in relation to attempting to ensure the optimal intensity of activity in lessons.

Frequency of lesson is also an important factor in the relationship between PE and cardiorespiratory fitness development. The example discussed highlighted the possible benefits to both skill and fitness development when lesson frequency was three times per week. More research is needed into the area of frequency of lessons in relation to skill and cardiorespiratory fitness development. The evidence quoted in the research showed three lessons per week to be the exception rather than the norm for PE. Until such times as increased lesson frequency is normal practice Physical Educationalists will have to look to alternative strategies in order to encourage cardiorespiratory fitness development in children.

The promotion of a lifestyle incorporating regular exercise outwith school through the inclusion of HRPF in the PE programme represents an area which would benefit from increased attention and also a positive way ahead for PE, physical activity and cardiorespiratory fitness in children.

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APPENDIX

LESSON MONITORING RESULTS :

RUGBY

HRPF

BASKETBALL

VOLLEYBALL

ATHLETICS

LESSON MONITORING

ACTIVITY: RUGBY
TEACHING AREA: Playing Field
TIMETABLE INFORMATION: 1 double period of 120 minutes for 8 weeks (Lesson time of 120 minutes includes time for travel, changing and organisation)

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
13	$\bar{X}$ 60min 00sec SD 9.1 RANGE 43min 00sec - 71min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	12:45	39:05	8:10	20.9
SD	7.6	14.4	9.5	11.3
RANGE	0:00 - 28:30	7:00 - 60:00	0:00 - 35:30	0.0 - 40.0

LESSON MONITORING

ACTIVITY: HEALTH RELATED PHYSICAL FITNESS
TEACHING AREA: Gymnasium and Playground
TIMETABLE INFORMATION: 1 period of 60 minutes for 8 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
14	$\bar{X}$ 44min 00sec SD 5.4 RANGE 31min 00sec - 51min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	9:30	29:40	4:50	21.7
SD	3.5	10.2	6.7	8.0
RANGE	4:30 - 15:00	7:15 - 43:30	0:00 - 19:45	9.0 - 34.0

LESSON MONITORING

ACTIVITY: BASKETBALL (Total Lessons)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 9 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
27	$\bar{X}$ 52min 15sec SD 9.1 RANGE 35min 30sec - 59min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	10:00	38:05	4:10	19.3
SD	4.0	8.7	5.1	7.3
RANGE	3:45 - 19:45	22:30 - 52:30	0:00 - 19:00	8.0 - 35.0

LESSON MONITORING

ACTIVITY: BASKETBALL (High Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 9 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
9	$\bar{X}$ 52min 10sec SD 7.2 RANGE 35min 30sec - 59min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	9:00	40:40	2:30	17.6
SD	3.3	7.3	2.0	6.2
RANGE	5:30 - 16:15	28:45 - 50:00	0:00 - 4:45	10.0 - 31.0

LESSON MONITORING

ACTIVITY: BASKETBALL (Middle Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 9 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
9	$\bar{X}$ 53min 20sec SD 4.5 RANGE 46min 00sec - 59min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	9:25	39:10	4:45	17.4
SD	4.2	7.9	4.9	7.1
RANGE	3:45 - 17:45	26:00 - 49:30	0:00 - 15:15	8.0 - 30.0

LESSON MONITORING

ACTIVITY: BASKETBALL (Low Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 9 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
9	$\bar{X}$ 51min 10sec SD 6.9 RANGE 37min 00sec - 59min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	11:35	32:00	7:35	22.9
SD	4.4	10.4	6.4	7.8
RANGE	7:00 - 19:45	22:30 - 52:30	0:00 - 19:00	12.0 - 35.0

BASKETBALL

COMPARISON BETWEEN SUB GROUPS

PARAMETER	HIGH v MIDDLE	MIDDLE v LOW	HIGH v LOW
TIME IN TRAINING BAND	NS	NS	NS
TIME UNDER TRAINING BAND	NS	NS	NS
TIME OVER TRAINING BAND	NS	NS	NS
% TIME IN TRAINING BAND	NS	NS	NS

LESSON MONITORING

ACTIVITY: VOLLEYBALL (Total Lessons)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 7 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
21	$\bar{X}$ 51min 45sec SD 3.2 RANGE 47min 00sec - 56min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	4:10	47:00	0:35	8.2
SD	3.9	6.0	1.5	7.6
RANGE	0:00 - 13:30	35:45 - 54:30	0:00 - 6:45	0.0 - 24.0

LESSON MONITORING

ACTIVITY: VOLLEYBALL (High Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 7 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 51min 45sec SD 3.5 RANGE 47min 00sec - 56min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	3:30	48:00	0:15	6.9
SD	3.5	5.8	0.5	6.8
RANGE	0:00 - 7:45	39:15 - 54:30	0:00 - 1:15	0.0 - 16.0

LESSON MONITORING

ACTIVITY: VOLLEYBALL (Middle Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 7 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 51min 45sec SD 3.4 RANGE 47min 00sec - 56min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	6:40	43:50	1:15	12.9
SD	4.9	7.1	2.5	9.4
RANGE	0:00 - 13:30	35:45 - 54:00	0:00 - 6:45	0.0 - 24.0

LESSON MONITORING

ACTIVITY: VOLLEYBALL (Low Fitness Group)
TEACHING AREA: Gymnasium
TIMETABLE INFORMATION: 1 period of 60 minutes for 7 weeks

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 51min 45sec SD 3.4 RANGE 47min 00sec - 56min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	2:20	49:00	0:25	4.9
SD	2.0	4.3	0.7	3.8
RANGE	0:00 - 5:00	43:30 - 54:30	0:00 - 1:45	0.0 - 9.0

VOLLEYBALL

COMPARISON BETWEEN SUB GROUPS

PARAMETER	HIGH v MIDDLE	MIDDLE v LOW	HIGH v LOW
TIME IN TRAINING BAND	NS	NS	NS
TIME UNDER TRAINING BAND	NS	NS	NS
TIME OVER TRAINING BAND	NS	NS	NS
% TIME IN TRAINING BAND	NS	NS	NS

LESSON MONITORING

ACTIVITY: ATHLETICS (Total Lessons)
TEACHING AREA: Playing Field
TIMETABLE INFORMATION: 1 double period of 120 minutes for 7 weeks
(Lesson time of 120 minutes includes time for travel, changing and organisation)

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
21	$\bar{X}$ 68min 25sec SD 14.4 RANGE 47min 00sec - 83min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	11:55	50:10	6:20	17.2
SD	8.1	16.9	5.0	10.6
RANGE	1:30 - 31:30	24:30 - 72:30	0:00 - 20:00	3.0 - 40.0

LESSON MONITORING

ACTIVITY: ATHLETICS (High Fitness Group)
TEACHING AREA: Playing Field
TIMETABLE INFORMATION: 1 double period of 120 minutes for 7 weeks
(Lesson time of 120 minutes includes time for travel, changing and organisation)

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 68min 25sec SD 15.2 RANGE 47min 00sec - 83min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND
[70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	11:20	50:40	6:25	16.6
SD	8.4	20.3	6.8	10.9
RANGE	5:30 - 29:30	24:30 - 72:30	0:00 - 20:00	7.0 - 40.0

LESSON MONITORING

ACTIVITY: ATHLETICS (Middle Fitness Group)
TEACHING AREA: Playing Field
TIMETABLE INFORMATION: 1 double period of 120 minutes for 7 weeks (Lesson time of 120 minutes includes time for travel, changing and organisation)

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 68min 25sec SD 15.2 RANGE 47min 00sec - 83min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]

	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	13:30	48:25	6:30	19.3
SD	9.9	15.8	4.5	13.1
RANGE	1:30 - 11:45	30:30 - 70:45	1:30 - 11:45	3.0 - 39.0

LESSON MONITORING

ACTIVITY: ATHLETICS (Low Fitness Group)
TEACHING AREA: Playing Field
TIMETABLE INFORMATION: 1 double period of 120 minutes for 7 weeks (Lesson time of 120 minutes includes time for travel, changing and organisation)

# of PUPIL LESSONS MONITORED	TEACHING TIME (MINUTES)
7	$\bar{X}$ 68min 25sec SD 15.2 RANGE 47min 00sec - 83min 00sec

LESSON IN RELATION TO HEART RATE TRAINING BAND [70% to 85% maximum heart rate (146 - 176)]				
	Time IN (min)	Time UNDER (min)	Time OVER (min)	Time IN (%)
$\bar{X}$	11:00	51:30	5:55	15.9
SD	6.9	17.0	4.0	8.7
RANGE	4:45 - 24:30	32:45 - 71:30	0:45 - 11:45	8.0 - 33.0

ATHLEICS

COMPARISON BETWEEN SUB GROUPS

PARAMETER	HIGH v MIDDLE	MIDDLE v LOW	HIGH v LOW
TIME IN TRAINING BAND	NS	NS	NS
TIME UNDER TRAINING BAND	NS	NS	NS
TIME OVER TRAINING BAND	NS	NS	NS
% TIME IN TRAINING BAND	NS	NS	NS